This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

THE

CHEMISTS' MANUAL:

A

PRACTICAL TREATISE ON CHEMISTRY,

QUALITATIVE AND QUANTITATIVE ANALYSIS,
STOICHIOMETRY, BLOWPIPE ANALYSIS, MINERALOGY,
ASSAYING, TOXICOLOGY, ETC., ETC., ETC.

BY

HENRY A. MOTT, Jr., E. M., Ph. D.,
Mining Engineer and Analytical Chemist, Member of the American Chemical Society, Member of the New York Academy of Sciences, Fellow of the Geographical Society, Etc., Etc., Etc.

To T. B. Phelps Esq.
with the compliments of the
Author
H. A. Mott
Aug 4/81

NEW YORK:
D. VAN NOSTRAND, PUBLISHER,
23 MURRAY STREET & 27 WARREN STREET.
[illegible]

Electrotyped by
SMITH & McDOUGAL.

Printed by
J. J. LITTLE & CO.

1

THE literature of Analytical Chemistry, in the various branches of qualitative, quantitative, blowpipe and technical analysis, and assaying, has expanded to such a degree as to make it impossible for students, and even for most professional chemists, to possess a complete library in these departments of the science: moreover, much of the literature is sealed to many chemists by being published in French and German, or in journals and transactions of Societies which are inaccessible. A further embarrassment arises from the multiplicity of methods given in special works, from which few can select without first testing several.

This carefully prepared Manual of Dr. MOTT will prove especially valuable, as containing a judicious selection of the most important methods, most of which have been tested by laboratory experience, and found to give satisfactory results. These are presented in a concise form, with reference to original authors. The numerous tables of constants will also be found of great value.

This work will possess a special value for the student and laboratory worker, and will serve as a useful reference book for the general scientific reader.

CHAS. F. CHANDLER, PH.D., M.D., LL.D., F.C.S., ETC.

PREFACE.

ON the principle that every scientific man "should compile his own pocket-book, as he proceeds in study and practice, to suit his particular business," the Author accumulated from time to time a large number of valuable notes and tables, which became too voluminous to be carried in the pocket, and soon grew in the form of manuscript. After repeated requests by a number of prominent scientific men, the Author has decided to present the manuscript, greatly enlarged and improved, to the public. The object of the Author has been to accumulate only matter which has a practical value attached to it.

Under the *Department of Qualitative Analysis,* the Author has adopted the method or classification presented in a work commenced by Tuttle and Chandler, and has consulted various works on the subject, especially Fresenius' Qualitative Analysis and Watts' Dictionary of Chemistry. It has been the object of the Author to furnish formulæ for all compounds and precipitates considered, as they have recently been determined. The Schemes presented will be found very practicable and accurate, as has been demonstrated by frequent use.

Under the *Department of Mineralogy,* only the principal minerals of those elements which have found use in the Arts are considered. Free use has been made of Dana's Mineralogy, as also Egleston's Lectures on Mineralogy.

Under the *Department of Quantitative Analysis*, Schemes are presented for the most frequent occurring compounds met with in every-day analyses, all of which have been frequently tested and found accurate.

Under the *Department of Assaying*, brief and accurate methods are described for the assay of those ores usually met with in the laboratory. In preparing the method described for the assay of gold and silver ores, the Author was greatly assisted by a valuable pamphlet (reprint from the "American Chemist" for 1870) by T. M. Blossom, E.M.

In the *Miscellaneous Department*, the Author has compiled a large number of tables which cannot help but possess a practical value.

It has been the intention of the Author to furnish the authority for all analyses and tables presented in this work; and if any have been omitted, by communicating direct to the Author, all claims will be promptly acknowledged.

The various subjects considered in this work opens a channel for it among Chemists, Pharmaceutists, Physicians, and Scientific men in general.

The Author is quite familiar with the fact that a work of this character must open much room for criticism; still he hopes it will prove on the whole acceptable to all.

AUTHOR.

98 WALL STREET, *Feb. 7, 1877.*

TABLE OF CONTENTS.

I.—TABLE OF THE ELEMENTS.

PERISSADS.

	SYMBOLS.	EQUIVALENT OF ATOMS.	DISCOVERED IN	DISCOVERED BY	ATOMIC WEIGHTS. F. W. CLARK.*
Monads.					
Hydrogen,	H.		1776	Cavendish,	1.
Fluorine,	F.				19.
Chlorine,	Cl.	I. III. V. VII.	1774	Scheele,	35.5
Bromine,	Br.	I. III. V. VII.	1826	Balard,	80.0
Iodine,	I.	I. III. V. VII.	1812	Courtois,	127.
Lithium,	Li.		1817	Arfvedson,	7.
Sodium,	Na.	I. III.	1807	Davy,	23.
Potassium,	K.	I. III. V.	1807	Davy,	39.1
Rubidium,	Rb.		1860	Bunsen,	85.4
Cæsium,	Cs.		1860	Bunsen,	133.0
Silver,	Ag.	I. III.		Ancients,	108.0
Thallium,	Th.	I. III.	1862	Crookes,	204.
Triads.					
Nitrogen,	N.	I. III. V.	1772	Rutherford,	14.
Phosphorus,	P.	I. III. V.	1669	Brandt,	31.
Arsenic,	As.	I. III. V.	1733	Schrœder,	75.
Antimony,	Sb.	III. V.	1580	Basil Valentine,	122.
Bismuth,	Bi.	III. V.	1529	Agricola,	210.
Boron,	B.		1808	Davy,	11.
Gold,	Au.	I. III.		Ancients,	

* From "Constants of Nature."

	SYMBOLS.	EQUIVALENT OF ATOMS.	DISCOVERED IN	DISCOVERED BY	ATOMIC WEIGHTS.
Pentads.					
Columbium,	Cb.		1801	Hatchette,	94.
Tantalium,	Ta.		1802	Ekeberg,	172.
Vanadium,	V.	III. V. $(V_2)^{VIII.}$ $(V_2)^{IV.}$	1830	Sefstrom,	51.5

ARTIADS.

Dyads.					
Oxygen,	O.		1774	Priestley,	16.
Sulphur,	S.	II. IV. VI.		Ancients,	32.
Selenium,	Se.	II. IV. VI.	1817	Berzelius,	79.5
Tellurium,	Te.	II. IV. VI.	1798	Klaproth,	129.
Calcium,	Ca.	II. IV.	1808	Davy,	40.
Strontium,	Sr.	II. IV.	1808	Davy,	87.5
Barium,	Ba.	II. IV.	1808	Davy,	137.
Magnesium,	Mg.		1829	Bussy,	24.
Zinc,	Zn.			Paracelsus,	65.2
Cadmium,	Cd.		1818	Stromeyer,	112.
Glucinum,	G.		1828	Wohler,	9.8
Yttrium,	Y.			Wohler,	59.7
Cerium,	Ce.		1803	Berzelius,	92.
Lanthanium,	La.		1838	Mosander,	93.
Didymium,	D.		1841	Mosander,	96.
Erbium,	E.		1843	Mosander,	113.7
Mercury,	Hg.	$(Hg_2)^{II.}$ II.		Ancients,	200.
Copper,	Cu.	$(Cu_2)^{II.}$ II.		Ancients,	63.5

	SYMBOLS.	EQUIVALENT OF ATOMS.	DISCOVERED IN	DISCOVERED BY	ATOMIC WEIGHTS.
Tetrads.					
Carbon,	C.	II. IV.		Ancients,	12.
Silicon,	Si.		1810	Berzelius,	28.
Titanium,	Ti.	II. IV.	1789	Gregor,	50.
Tin,	Sn.	II. IV.		Ancients,	118.
Thorium,	Th.		1828	Berzelius,	234.
Zirconium,	Zr.		1824	Berzelius,	89.6
Aluminum,	Al.	(Al_2).$^{VI.}$	1828	Wohler,	27.4
Platinum,	Pt.	II. IV.	1741	Wood,	197.5
Palladium,	Pd.	II. IV.	1803	Wollaston,	106.6
Lead,	Pb.	II. IV.		Ancients,	207.
Indium,	In.		1863	Reich and Reichter,	113.4
Hexads.					
Molybdenum,	Mo.	II. IV. VI.	1782	Hjelm,	95.9
Tungsten,	W.	II. IV. VI.	1783	De Luyart,	184.
Ruthenium,	Ru.	II. IV. VI.	1846	Claus,	104.4
Rhodium,	Ro.	II. IV. VI.	1804	Wollaston,	104.4
Iridium,	Ir.	II. IV. VI.	1803	Tennant,	198.
Osmium,	Os.	II. IV. VI.	1803	Tennant,	199.2
Chromium,	Cr.	II. IV. VI.	1797	Vanquelin,	52.5
Manganese,	Mn.	II. IV. VI.	1774	Gahn,	55.
Iron,	Fe.	II. IV. VI.		Ancients,	56.
Cobalt,	Co.	II. IV.	1733	Brandt,	58.7
Nickel,	Ni.	II. IV.	1751	Cronstedt,	58.7
Uranium,	U.	II. IV.	1789	Klaproth,	120.

II.—TABLE OF THE ELEMENTS.

	SYMBOLS.	EQUIVALENT.	ATOMIC WEIGHTS.*	SPECIFIC GRAVITY.		MELTING POINT.		EQUIVALENT DETERMINED BY	ATOMIC WEIGHTS. (FROM WATT'S SUPPL. DIC. CHEMISTRY.)
				$H_2O = 1$.	AIR = 1.	C.°	FAH.°		
Aluminium, - - -	Al.	13.7	27.4	2.56	- -	- -	- -	Dumas, - - - - - - - - - -	27.4
Antimony, - - -	Sb.	122.	122.	6.72	- -	450°.	842°.	Dumas, - - - - - - - - - -	122.
Arsenic, - - - -	As.	75.	75.	5.63	10.40	180°.	357°.	Pelouze and Berzelius, - - -	75.
Barium, - - - -	Ba.	68.5	137.	4.00	- -	- -	- -	Dumas, - - - - - - - - - -	137.
Bismuth, - - - -	Bi.	210.	210.	9.80	- -	270°.	518°.	Dumas, - - - - - - - - - -	210.
Boron, - - - - -	B.	11.	11.	2.63	- -	300°.	572°.	Berzelius, - - - - - - - - -	11.
Bromine, - - - -	Br.	80.	80.	3.19	5.54	—12°.	10°.4	Marignac, - - - - - - - - -	80.
Cadmium, - - -	Cd.	56.	112.	8.45	- -	228°.	442°.4	C. Hauer, - - - - - - - - -	112.
Cæsium, - - - -	Cs.	133.	133.	- -	- -	- -	- -	Johnson, Bunsen, and Allen, -	133.
Calcium, - - - -	Ca.	20.	40.	1.5778	- -	- -	- -	Dumas, Erdmann, and Marchand, - - - - - - - -	40.
Carbon, - - - -	C.	6.	12.	2.27	- -	- -	- -	Dumas, Erdmann, and Marchand, - - - - - - - -	12.
Cerium, - - - -	Ce.	45.7	91.3	5.5 at 12°.	- -	- -	- -	- - - - - - - - - - - - - -	92.
Chlorine, - - - -	Cl.	35.5	35.5	1.33	2.47	- -	- -	- - - - - - - - - - - - - -	35.5
Chromium, - - -	Cr.	26.1	52.2	7.01	- -	- -	- -	- - - - - - - - - - - - - -	52.2
Cobalt, - - - -	Co.	30.	60.	8.71	- -	- -	- -	- - - - - - - - - - - - - -	58.8
Columbium, - - -	Cb.	94.	94.	6.47	- -	- -	- -	- - - - - - - - - - - - - -	94.
Copper, - - - -	Cu.	31.7	63.4	8.94	- -	1091°.	1995°.8	Erdmann and Marchand, - -	63.4
Didymium, - - -	D.	47.5	95.	- -	- -	- -	- -	- - - - - - - - - - - - - -	96.
Erbium, - - - -	E.	56.3	112.6	- -	- -	- -	- -	Bahr and Bunsen, - - - - -	112.6

---

* The Atomic Weights in this column have been carefully selected by Prof. CHANDLER for use of the students of the School of Mines, Columbia College.

TABLE OF THE ELEMENTS.

	SYMBOLS.	EQUIVALENT.	ATOMIC WEIGHTS.	SPECIFIC GRAVITY. H₂O = 1.	SPECIFIC GRAVITY. AIR = 1.	MELTING POINT. C.°	MELTING POINT. FAH.°	EQUIVALENT DETERMINED BY	ATOMIC WEIGHTS.
Fluorine,	F.	19.	19.	- -	0.0691	- -	- -	Louyet,	19.
Gallium,	G.	- -	4.7 at 15° C.	- -	- -	- -	86°.27	- -	
Glucinum,	Gl.	4.6	9.2	- -	2.10	- -	- -	- -	9.4
Gold,	Au.	197.	197.	19.26	- -	1102°.	2015°.6	- -	197.
Hydrogen,	H.	1.	1.	- -	- -	- -	- -	Dumas,	1.
Indium,	In.	56.7	113.4	7.421	- -	176°.	348°.8	- -	(198)75.63(Winkler)
Iodine,	I.	127.	127.	4.95	.872	107°.	224°.6	Marignac and Dumas,	127.
Iridium,	Ir.	99.	198.	21.15	- -	- -	- -	- -	198.
Iron,	Fe.	28.	56.	7.84	- -	1530°.	2786°.	Erdmann and Marchand,	56.
Lanthanum,	La.	46.	92.	0.83	- -	- -	- -	- -	93.6
Lead,	Pb.	103.5	207.	11.33	- -	325°.	617°.	Berzelius and Dumas,	207.
Lithium,	Li.	7.	7.	0.59	- -	180°.	356°.	C. Diehl and Troost,	7.
Magnesium,	Mg.	12.	24.	1.74	- -	433°.	811°.4	Marchand and Scheerer,	24.
Manganese,	Mn.	27.5	55.	8.02	- -	- -	- -	Hauer and Dumas,	55.
Mercury,	Hg.	100.	200.	13.59	6.976	Boils 346°.	Boils 654°.8	Erdmann and Marchand,	200.
Molybdenum,	Mo.	48.	96.	8.56	- -	- -	- -	- -	96.
Nickel,	Ni.	29.	58.	8.82	- -	- -	- -	- -	58.8
Nitrogen,	N.	14.	14.	- -	0.9713	- -	- -	Marignac,	14.
Osmium,	Os.	100.	200.	22.477	- -	- -	- -	- -	199.2
Oxygen,	O.	8.	16.	- -	1.1056	- -	- -	- -	16.
Palladium,	Pd.	53.	106.	11.80	- -	- -	- -	Berzelius,	106.5
Phosphorus,	P.	31.	31.	1.84	4.42	- -	- -	Schrötter,	31.
Platinum,	Pt.	98.7	197.4	21.50	- -	2533°.8	-	- -	197.4
Potassium,	K.	39.1	39.1	0.86	- -	62°.5	- -	Marignac and Stas,	39.1
Rhodium,	Ro.	52.	104.	11.00	- -	- -	- -	- -	104.4
Rubidium,	Rb.	85.4	85.4	1.52	- -	38°.5	- -	Bunsen and Picard,	85.4
Ruthenium,	Ru.	52.	104.	11.4	- -	- -	- -	- -	104.4
Selenium,	Se.	39.5	79.	4.28	8.20	103°.	- -	Mean from—Berzelius, Sacc, Erdmann, and Marchand,	79.4

TABLE OF THE ELEMENTS.

	SYMBOLS.	EQUIVALENT.	ATOMIC WEIGHTS.	SPECIFIC GRAVITY.		MELTING POINT.		EQUIVALENT DETERMINED BY	ATOMIC WEIGHTS.
				$H_2O = 1.$	AIR = 1.	C.°	FAH.°		
Silicon,	Si.	14.	28.	2.34	- -	- -	- -	Dumas,	28.
Silver,	Ag.	108.	108.	10.57	- -	1023°.	- -	- -	108.
Sodium,	Na.	23.	23.	0.97	- -	97°.6	- -	Pelouze and Stas,	23.
Strontium,	Sr.	44.	88.	2.54	- -	- -	- -	- -	87.5
Sulphur,	S.	16.	32.	1.98	6.62	115°.	- -	Erdmann and Marchand,	32.
Tantalum,	Ta.	182.	182.	10.78	- -	- -	- -	- -	182.
Tellurium,	Te.	64.	128.	6.24	- -	500°.	- -	- -	128.
Terbium,	Tb.	37.7	75.4	- -	- -	- -	- -	- -	
Thallium,	Tl.	204.	204.	11.80	- -	294°.	- -	- -	204.
Thorium,	Th.	59.2	118.4	7.7	- -	- -	- -	- -	
Tin,	Sn.	59.	118.	7.30	- -	246°.1	- -	Dumas,	118.
Titanium,	Ti.	25.	50.	- -	- -	- -	- -	Pierre,	50.
Tungsten,	W.	92.	184.	18.30	- -	- -	- -	- -	184.
Uranium,	U.	60.	120.	18.40	- -	207°.	- -	- -	120.
Vanadium,	V.	51.3	51.3	- -	- -	- -	- -	- -	51.2
Yttrium,	Y.	30.8	61.6	- -	- -	- -	- -	- -	61.6
Zinc,	Zn.	32.5	65.	7.13	- -	412°.	- -	- -	65.2
Zirconium,	Zr.	44.8	89.6	4.15	- -	- -	- -	- -	89.6

NOTE.—The Perissads are printed in *italics*, the Artiads in Roman.

To convert formulæ in the old system into the new, halve the atoms of the Artiads when possible; when not, double the atoms of the Perissads.

TABLE OF SPECIFIC HEATS OF ELEMENTARY SUBSTANCES.

NAME OF SUBSTANCE.	SPECIFIC HEAT.	AUTHORITY.
Aluminium,	0.202	Kopp.
Antimony,	.0495 .0523	Bunsen. Kopp.
Arsenic,	.0822	Neumann (Pogg. Ann. cxxvi. 137).
" (crystallized),	.0830	Bettendorff and Wüllner.
" (amorphous),	.0758	do. do.
Bismuth,	.0305	Kopp.
Boron (amorphous),	.254	do.
" (crystallized),	.230	do.
Cadmium,	.0542	do.
"	.0548	Bunsen.
Calcium,	.1670	do.
Carbon (natural graphite),	.2019	Regnault (Ann. Ch. Phys. [4], vii. 46).
" " " (purified),	.1977	Regnault.
" " "	.1955	Bettendorff and Wüllner
" " "	.174	Kopp.
" (gas carbon),	.1968	Regnault.
" " " (purified),	.2000	do.
" " " "	.2040	Bettendorff and Wüllner.
" " "	.185	Kopp.
" (iron graphite),	.1961	Bettendorff and Wüllner.
" " "	.166	Kopp.
" (diamond),	.1483	Bettendorff and Wüllner.
Copper,	0.0930	Kopp.
Indium,	.0570	Bunsen.
Iron,	.112	do.
Lead,	.0315	do.
Magnesium,	.245	do.
Ruthenium,	.0611	do.
Selenium, (crystalline),	.08401	Bettendorff and Wüllner.
" "	.0860	Neumann.
" (amorphous),	.0953	Bettendorff and Wüllner.
Silicon (graphitoïdal),	.181	Kopp.
" (crystalline),	.165	do.
" (fused),	.138	do.
Silver,	.0560	do.
"	.0559	Bunsen.
Sulphur (rhombic),	.163 (bet. 17° & 45°)	Kopp.
"	.1712	Bunsen.
Tellurium,	.0475	Kopp.
Tin,	.0548	do.
" (cast),	.0559	Bunsen.
" (allotropic),	.0545	do.
Zinc,	.0932	Kopp.
"	.0935	Bunsen.

TABLE OF SPECIFIC HEATS OF COMPOUNDS.

(WATT'S DIC. CHEM. SUPPL.)

FORMULA.	SPECIFIC HEAT.	AUTHORITY.	FORMULA.	SPECIFIC HEAT.	AUTHORITY.
Cu_2O,	0.111	Kopp.	HgC_2N_2,	0.100	Kopp.
CuO,	.128	do.	$ZnK_2C_4N_4$,	.241	do.
HgO,	.0530	do.	$FeK_3C_6N_6$,	.233	do.
PbO,	.0553	do.	$FeK_4C_6N_6.3H_2O$,	.280	do.
MgH_2O_2,	.312	do.	$PbCO_3$,	.0791	do.
Fe_3O_4,	.156	do.	$CaSiO_3$,	.178	do.
$MgAl_2O_4$,	.194	do.	$Ca_{\frac{1}{2}}Mg_{\frac{1}{2}}SiO_3$,	.186	do.
$Mg_{\frac{1}{2}}Fe_{\frac{1}{2}}Cr_{\frac{3}{2}}Al_{\frac{1}{2}}O_4$,	.159	do.	$CuSiO_3.H_2O$,	.182	do.
Cr_2O_3,	.177	do.	$Mg_{\frac{20}{11}}F_{\frac{2}{11}}SiO_4$,	.189	do.
Fe_2O_3,	.154	do.		.189	do.
$Fe_{\frac{5}{4}}Ti_{\frac{3}{4}}O_3$,	.177	do.	$Al_2K_2Si_6O_{16}$,	.183	do.
$Mn_2O_3.H_2O$,	.176	do.	$Al_2Na_2Si_6O_{16}$,	.190	do.
MnO_2,	.159	do.	$NaBO_2$,	.2364	Neumann.
SiO_2,	.186	do.	Na_2BO_7,	.229	Kopp.
$Si_{\frac{1}{2}}Zr_{\frac{1}{2}}O_2$,	.132	do.	$Na_2B_4O_7.10H_2O$,	.385	do.
SnO_2,	.0894	do.	$PbMoO_4$,	.0827	do.
TiO_2,	.157	do.	$CaWO_4$,	.0967	do.
TiO_2,	.161	do.	$Fe_{\frac{2}{5}}M_{\frac{3}{5}}WO_4$,	.0930	do.
MoO_3,	.154?	do	$PbCrO_4$,	.0900	do.
WO_3,	.0894?	do.	K_2CrO_4,	.189	
Sb_2O_3,	.0927	Neumann.		.1840	Neumann.
B_2O_3,	.2341	do.	$K_2Cr_2O_7$,	.186	Kopp.
Cu_2S,	.120	Kopp.		.1857	Neumann.
$Cu_{\frac{1}{2}}Fe_{\frac{1}{2}}S$,	.131	do.	$HKSO_4$,	.244	Kopp.
HgS,	.0517	do.	K_2SO_4,	.196	do.
PbS,	.0490	do.		.1860	Neumann.
ZnS,	.120	do.	Na_2SO_4,	.2293	Schüller.
FeS_2,	.126	do.		.227	Kopp.

FORMULA.	SPECIFIC HEAT.	AUTHORITY.
KCl,	.171	
	.1663	Neumann.
$NaCl$,	.213	Kopp.
	.219	
	.2070	Neumann.
NH_4Cl,	.373	Kopp.
	.3908	Neumann.
$AgCl$,	.0894	do.
$RbCl$,	.112	Kopp.
$BaCl_2$,	.0902	do.
$HgCl_2$,	.0640	do.
$MgCl_2$,	.191	do.
$PbCl_2$,	.0692	Neumann.
$BaCl_2.2H_2O$,	.171	Kopp.
ZnK_2Cl_4,	.152	do.
PtK_2Cl_6,	.113	do.
SnK_2Cl_6,	.133	do.
Cr_2Cl_6,	.143	do.
$AlNa_3Fl_6$,	.238	do.
K_2CO_3,	.206	do.
	.2046	Neumann.
NaI,	.0881	Schüller.
$CaFl_2$,	.209	Kopp.
Na_2CO_3,	.246	do.
Rb_2CO_3,	.123	do.
$CaCO_3$,	.206	do.
$CaCO_3$,	.203	do.
$CaMgCO_3$,	.206	do.
$Fe_{\frac{8}{11}}Mn_{\frac{2}{11}}Mg_{\frac{1}{11}}CO_3$,	.166	do.
$K_2ZnS_2O_8.6H_2O$,	.270	do.
$AlK_2S_4O_{16}.24H_2O$,	.371	do.
$Cr_2K_2S_4O_{16}.24H_2O$,	.324	do.

FORMULA.	SPECIFIC HEAT.	AUTHORITY.
Na_2SO_4,	.2280	Neumann.
$(NH_4)_2SO_4$,	.350	Kopp.
$BaSO_4$,	.108	do.
$CaSO_4$,	.178	do.
$MgSO_4$,	.225	do.
	.2165	Neumann.
$MnSO_4$,	.182	Pape.
$PbSO_4$,	.0827	Kopp.
$SrSO_4$,	.135	do.
$ZnSO_4$,	.174	Pape.
$CuSO_4.H_2O$,	.202	do.
$MgSO_4.H_2O$,	.264	do.
$ZnSO_4.H_2O$,	.202	do.
$CaSO_4.2H_2O$,	.259	Kopp.
$CuSO_4.2H_2O$,	.212	Pape.
$ZnSO_4.2H_2O$,	.224	do.
$FeSO_4.3H_2O$,	.247	do.
$CuSO_4.5H_2O$,	.285	Kopp.
	.316	Pape.
$MnSO_4.5H_2O$,	.323	Kopp.
	.338	Pape.
$FeSO_4.7H_2O$,	.346	do.
	.356	do.
$NiSO_4.6H_2O$,	.313	Kopp.
$CoSO_4.7H_2O$,	.343	do.
$MgSO_4.7H_2O$,	.362	do.
	.407	Pape.
$ZnSO_4.7H_2O$,	.347	Kopp.
	.328	Pape.
$NiSO_4.7H_2O$,	.341	do.
$K_2MgS_2O_8.5H_2O$,	.264	Kopp.
$K_2NiS_2O_8.6H_2O$,	.245	do.

FORMULA.		SPECIFIC HEAT.	AUTHORITY.
$Na_2S_2O_3$,		.221	Pape.
$K_2S_2O_3$,		.197	do.
BaS_2O_3,		.163	
PbS_2O_3,		.092	Pape.
H_2KAsO_4,		.175	Kopp.
Ag_3PO_4,		.0896?	do.
H_2KPO_4,		.280	do.
$NaPO_3$,		.217	do.
KNO_3,	fused,	.227	
	crystallized,	.232	
		.2343	Neumann.
		.265	Schüller.
$NaNO_3$,	fused,	.256	Kopp.
	crystallized,	.257	do.
		.2747	Neumann.
NH_4NO_3,		.455	Kopp.
BaN_2O_6,		.145	do.
		.1492	Neumann.
PbN_2O_6,		.110	Kopp.
		.1173	Neumann.
SrN_2O_6,		.181	Kopp.
$AgNO_3$,		.1395	Neumann.
$KClO_3$,		.194	Kopp.
$BaCl_2O_6$,		.157	do.
$KClO_4$,		.190	do.
$KMnO_4$,		.179	do.

FORMULA.		SPECIFIC HEAT.	AUTHORITY.
C_2Cl_6,	(between 18° and 37°)	.178	Kopp.
	(between 18° and 43°)	.194	do.
	(between 18° and 50°)	.277	do.
$C_{10}H_8$,	(between 26° and 18°)	.3096	Alluare.
	(between 0° and 20°)	.3208	do.
	(between 20° and 65°)	.3249	do.
$C_{10}H_{16}$,		.4087	Neumann.
CS_2,	(between 14° and 29.5°)	.2468	Schüller.
C_2H_6O,		.5748	Neumann.
C_2H_6O,	(between 17.5° and 20.5°)	.6019	Dupré. Page.
	(between 16° and 30°)	.609	Schüller.
$CHCl_3$,	(between 16° and 35°)	.2337	do.
$C_{12}H_{22}O_{11}$,	crystallized,	.301	Kopp.
	amorphous,	.342	do.
$C_6H_{14}O_6$,		.324	do.
$C_4H_6O_4$,		.313	do.
$C_4H_6O_6$,		.288	do.
$C_4H_6O_6.H_2O$,		.319	do.
$C_2H_2BaO_4$,		.143	do.
$C_2K_2O_4.H_2O$,		.236	do.
$C_4H_3KO_4.2H_2O$,		.283	do.
$C_4H_5KO_6$,		.257	do
$C_4H_4NaKO_6.4H_2O$,		.328	do.
$C_8H_{10}CaO_{10}.8H_2O$,		.338	do

NOTE.—The specific heats of Alcohol and Benzine at different temperatures have been determined by Schüller (Pogg. Ann., Ergänzungsbd. v. 116). For the mean specific heats of these liquids between 0°, and any other temperature t°, his experiments lead to the following results:

Alcohol, - - - - - - $0.5585+0.00098195t+0.0000008468t^2$. | Benzine, - - - - - - - - - - $0.3798+0.00072t$.

Qualitative Analysis.

- MOLECULES.*
  - LIKE ATOMS. - - - - - - - - - ELEMENTS.
  - UNLIKE ATOMS.
    - UNITED DIRECTLY. - - - - - - BINARY.
    - UNITED INDIRECTLY.
      - BY A DYAD.
        - $\bar{R}$ and H = ACID.
        - $\overset{+}{R}$ and H = BASE.
        - $\bar{R}$ and $\overset{+}{R}$ = SALT.
      - BY A TRIAD.
        - $\bar{R}$ and H = AMIDE.
        - $\overset{+}{R}$ and H = AMINE.
        - $\bar{R}$ and $\overset{+}{R}$ = ALKALAMIDE.

---

* From BARKER'S CHEMISTRY.

DEPORTMENT

OF

THE METALS AND THEIR SALTS

WITH REAGENTS.

GROUP I

Will contain Silver Salts, Mercurous Salts, and Lead Salts, the Chlorides of which, namely, Argentic Chloride, Mercurous Chloride, and Plumbic Chloride, are insoluble or but sparingly soluble in water and in dilute acids, and are therefore precipitated by Hydrochloric Acid.

SILVER.

Symbol Ag.—Atomic weight, 108.—Equivalence, I and III.—Positive Monad.—Electric conductivity at 32° F. 100.00.—Specific gravity, 10.53.—Specific heat, 0.0570.—Atomic volume, 10.04.—Fusing point, 1023° C.—Color, white.—Cut with a knife.—Order of malleability commencing with gold, second; ductility commencing with gold, second; tenacity commencing with (iron as 1000, silver as 349); heat-conducting power commencing with gold, third.

SILVER OXIDES.

There are three silver oxides known.

Argentic Oxide, Ag_2O, made by heating argentic carbonate to 200° C.; it is a brown-black powder, having a Sp. Gr. 7.143 (Herapath).

Argentic Dioxide, Ag_2O_2, formed when concentrated $AgNO_3$ is electrolyzed, with two thick platinum wires for poles, and is deposited in crystals on the positive pole, while metallic silver separates at the negative pole.

Argentous Oxide, Ag_4O,[*] is made by passing hydrogen gas over argentic oxalate or citrate heated to 100° C.; half the acid is set free, leaving the argentous oxide; remove the acid by water.

SILVER SALTS.

The silver salts are non-volatile and colorless; most of them acquire a black tint when exposed to the light. Vegetable colors are not altered by the soluble neutral salts, but the salts are decomposed at red heat.

METALLIC SILVER.

1. **Heated on Charcoal**, it fuses, and gives after a time a red incrustation of argentic oxide (Ag_2O).

2. **Hydrochloric Acid** has very little, if any, action on it.

3. **Nitric Acid** dissolves it slowly when cold, rapidly when hot, evolving nitrogen dioxide (N_2O_2).

$$6Ag+8HNO_3=6AgNO_3+\overbrace{N_2O_2}+4H_2O.$$

4. **Sulphuric Acid**, when concentrated, dissolves silver if heated, evolving sulphurous oxide (SO_2). The solution contains argentic sulphate (Ag_2SO_4). Dilute acid has no effect.

$$2Ag+2H_2SO_4=Ag_2SO_4+\overbrace{SO_2}+2H_2O.$$

Note.—The silver of commerce is usually alloyed with copper; it also contains a trace of gold, which remains behind as a black powder when the silver and copper are dissolved in nitric acid.—(Tuttle and Chandler.)

SALTS OF SILVER.

Solution best fitted for reaction:

Argentic Nitrate ($AgNO_3$).

5. **Hydrochloric Acid**, when added to argentic nitrate, produces a white precipitate of argentic chloride (AgCl) *insoluble* in *water* and in nitric acid; readily soluble in ammonic hydrate and reprecipitated by nitric acid.

$$AgNO_3+HCl=\underbrace{AgCl}+HNO_3.$$

---

[*] If this formula Ag_4O is correct, oxygen is a tetrad.

Note.—The argentic chloride becomes violet when exposed to the light. When mixed with a certain quantity of mercurous chloride or fuming sulphuric acid, this change of color does not take place.—(TUTTLE AND CHANDLER.)

6. SOLUBLE CHLORIDES, such as $NaCl$, KCl, etc., produce the same result as hydrochloric acid.

$$AgNO_3 + NaCl = \underbrace{AgCl} + NaNO_3.$$

SODIC THIOSULPHATE ($Na_2S_2O_3$) DISSOLVES argentic chloride, and prevents precipitation by potassic chloride; but potassic or sodic bromide or iodide added to the solution, precipitates ARGENTIC BROMIDE OR IODIDE.

$$\underbrace{2AgCl} + 2Na_2S_2O_3 = (Na_2S_2O_3 + Ag_2S_2O_3) + 2NaCl.$$

$$(Na_2S_2O_3 + Ag_2S_2O_3) + 2NaCl + 2\underbrace{NaBr} = 2AgBr + 2Na_2S_2O_3 + 2NaCl.$$

POTASSIC CYANIDE dissolves argentic chloride forming ARGENTO-POTASSIC CYANIDE.

$$\underbrace{AgCl} + 2KCN = AgCN, KCN + KCl.$$

7. HYDROSULPHURIC ACID produces a black precipitate of ARGENTIC SULPHIDE (Ag_2S) insoluble in dilute acids and in ammonic sulphide (NH_4HS), soluble in boiling nitric acid with separation of sulphur.

$$2AgNO_3 + H_2S = \underbrace{Ag_2S} + 2HNO_3.$$

8. AMMONIC SULPHIDE acts the same as hydrosulphuric acid.

$$2AgNO_3 + NH_4SH = \underbrace{Ag_2S} + NH_4NO_3 + HNO_3.$$

9. POTASSIC HYDRATE, when added, produces a light-brown precipitate of ARGENTIC OXIDE (Ag_2O), insoluble in excess, SOLUBLE IN AMMONIC HYDRATE.

$$2AgNO_3 + 2KHO = \underbrace{Ag_2O} + 2KNO_3 + H_2O.$$

10. AMMONIC HYDRATE added to neutral solutions produces a brown precipitate of ARGENTIC OXIDE soluble in excess. No precipitate is produced in acid solutions.

$$2AgNO_3 + NH_4OH = \underbrace{Ag_2O} + NH_4NO_3 + HNO_3.$$

11. Potassic Bromide precipitates argentic bromide ($AgBr$) yellowish in color, insoluble in water and acids, and much less soluble in ammonic hydrate than the chloride, soluble in sodic hyposulphite.

$$AgNO_3 + KBr = \underbrace{AgBr} + KNO_3.$$

12. Potassic Iodide produces a pale-yellow flocculent precipitate of argentic iodide (AgI), slowly acted on by light, insoluble in acids and almost so in ammonic hydrate, soluble in a concentrated solution of potassic iodide, and soluble in a solution of sodic hyposulphite.

$$AgNO_3 + KI = \underbrace{AgI} + KNO_3.$$

The following are a few miscellaneous reactions:

$$3AgNO_3 + Na_2HPO_4 = \underbrace{Ag_3PO_4} + 2NaNO_3 + HNO_3.$$

Ag_3PO_4 = Argentic Orthophosphate or Phosphate is a canary-yellow product. Solution is acid.

$$AgNO_3 + NaPO_3 = \underbrace{AgPO_3} + NaNO_3.$$

$\underbrace{AgPO_3}$ = Argentic Metaphosphate is a gelatinous mass.

$$4AgNO_3 + Na_4P_2O_7 = \underbrace{Ag_4P_2O_7} + 4NaNO_3.$$

$\underbrace{Ag_4P_2O_7}$ = Argentic Pyrophosphate is a white precipitate.

$$2AgNO_3 + K_2Cr_2O_7 = \underbrace{Ag_2Cr_2O_7} + 2KNO_3.$$

$Ag_2Cr_2O_7$ = Argentic Bichromate, red-brown.

$$2AgNO_3 + K_2CrO_4 = \underbrace{Ag_2CrO_4} + 2KNO_3.$$

$\underbrace{Ag_2CrO_4}$ = Argentic Chromate, dark-brown precipitate, soluble in ammonic hydrate and in dilute acids.

$$AgNO_3 + KCN = \underbrace{AgCN} + KNO_3.$$

$\underbrace{AgCN}$ = Argentic Cyanide is a white curdy precipitate, soluble in excess of reagent, insoluble in dilute acids.

$$2AgNO_3 + Na_2CO_3 = \underbrace{Ag_2CO_3} + 2NaNO_3.$$

$\underbrace{Ag_2CO_3}$=Argentic Carbonate, soluble in ammonic hydrate and ammonic carbonate.

$$2AgNO_3+C_2H_2O_4=\underbrace{Ag_2C_2O_4}+2HNO_3.$$

$\underbrace{Ag_2C_2O_4}$=Argentic Oxalate, white precipitate, soluble in ammonic hydrate and sparingly in nitric acid.

$$3AgNO_3+C_6H_5K_3O_7=\underbrace{C_6H_5Ag_3O_7}+3KNO_3.$$

$\underbrace{C_6H_5Ag_3O_7}$= Argentic Citrate, white powder.

$\underbrace{C_6H_4Ag_2O_6}$= Argentic Tartrate, curdy precipitate, produced by mixing a dilute solution of argentic nitrate with a dilute solution of Rochelle-salt ($C_8H_4KNaO_6.4H_2O$ potassio-sodic tartrate) slightly acidulated with nitric acid.

Metallic Silver is precipitated by Zn, Cu, Fe, Hg, P, etc., $SnCl_2$, $FeSO_4$, etc.

$$2AgNO_3+Zn=\underbrace{2Ag}+Zn2NO_3..$$

$$2AgNO_3+Cu=\underbrace{2Ag}+Cu2NO_3.$$

$$\underbrace{4AgCl}+2Na_2Co_2+\triangle\delta^{*}=\underbrace{4Ag}+4NaCl\overbrace{+2CO_2}+\overbrace{O_2}.$$

$$AgNO_3+C+\triangle\delta=\underbrace{Ag}+\overbrace{CO_2}+\overbrace{NO}.$$

13. Blowpipe.—Dry compounds of silver, mixed with sodic carbonate and fused before the blowpipe on charcoal, yield malleable, metallic globules of pure silver without forming an incrustation.—Characteristic Reaction, No. **5.**

LEAD.

Symbol, Pb.—Atomic weight, 207.—Equivalence, II and IV.—Color, bluish white.—Cut by a knife.—Specific gravity, 11.36.—Fuses at 325° C. (or 617° F.—Rudberg).—Specific Heat, 0.0314.—Atomic volume, 18.24.—Electric conductivity at 32° F. 8.32.—Order of malleability commencing

---

[*] $\triangle\delta$—Heat or fuse.

with gold, is the seventh; for ductility commencing with gold, is the eighth.—Tenacity, iron as 1000,—$Pb = 50$.—Order of heat-conducting power commencing with gold, is the seventh.

LEAD OXIDES.

Lead unites with oxygen to form five oxides:

Plumbic oxide, PbO; Plumbous oxide, Pb_2O;
Plumbic peroxide, PbO_2; Plumbic orthoplumbate, Pb_3O_4;
Plumbic meta plumbate, Pb_2O_3.

Pb_2O Plumbous oxide may be produced if plumbic oxalate is heated in a retort from which air is excluded, viz.:

$$2PbC_2O_4 = Pb_2O + \overbrace{CO} + \overbrace{3CO_2}.$$

PbO Plumbic oxide (Litharge) may be obtained pure by igniting basic nitrate or the carbonate or oxalate in a platinum crucible in contact with air, taking care the oxide does not fuse, otherwise it would take up the metal from the crucible. Pure oxide, lemon-yellow color, Sp. Gr. 9.4214.

PbO_2 Plumbic peroxide may be formed by exposing the protoxide (PbO) suspended in water to the action of a stream of chlorine gas. It is a brown powder; when heated gives off oxygen, and is converted into red lead or protoxide.

Pb_3O_4 Plumbic orthoplumbate $= (2PbO.PbO_2$ or $PbO.Pb_2O_3)$ Pb_2PbO_4, and is sometimes called red oxide; it is formed when the protoxide is kept at a low red heat for a considerable time in contact with air. It is a scarlet crystalline granular powder, Sp. Gr. 8.62 (Karsten).

Pb_2O_3 Plumbic meta plumbate ($Pb.PbO_3$) may be obtained by precipitating a solution of red oxide in acetic acid with caustic alkalies or alkaline carbonate. It is a reddish-yellow precipitate.

LEAD SALTS.

The salts of lead are non-volatile; most of them are colorless; the neutral soluble salts redden litmus-paper, and are decomposed at a red heat.

Plumbic chloride, when heated with access of air, partially volatilizes, and oxychloride of lead remains behind.

METALLIC LEAD.

14. Heated on charcoal, it fuses and gives an incrustation of plumbic oxide, which is deep-yellow when hot, pale-yellow when cold.

15. Hydrochloric acid has very little action on lead.

16. Nitric acid, when concentrated, acts very slowly on lead; but if it be diluted, especially if heated, it rapidly dissolves it, forming plumbic nitrate, which separates from the solution sometimes in white crystals.

$$3Pb+8HNO_3=3Pb2NO_3+\overbrace{N_2O_2}+4H_2O.$$

17. Sulphuric acid, when hot and concentrated, dissolves lead and forms plumbic sulphate with evolution of sulphurous oxide. Dilute acid does not act on lead.

$$Pb+2(H_2SO_4)=PbSO_4+\overbrace{SO_2}+2H_2O.$$

LEAD SALTS.

Solution best fitted for the reactions:

Plumbic Nitrate (Pb_2NO_3).

18. Hydrochloric acid, when added to a solution of plumbic nitrate, produces a white precipitate of plumbic chloride ($PbCl_2$), which is soluble in a large amount of water; there is therefore no precipitate found in dilute solutions of lead. In every case a little lead escapes precipitation. Ammonic hydrate does not dissolve or blacken the precipitate.

$$Pb2NO_3+2HCl=\underbrace{PbCl_2}+2HNO_3.$$

19. Hydrosulphuric acid produces a black precipitate of plumbic sulphide, which is insoluble in *cold* dilute acids, in alkalies, alkaline sulphides, and potassic cyanide.

Hot dilute nitric acid dissolves (if dilute enough) the precipitate, forming plumbic nitrate, and separates sulphur. Fuming nitric acid oxidizes the sulphur and converts the precipitate into insoluble plumbic sulphate. If in the solution to be precipitated from, there is any excess of concentrated mineral acid, such acid must be neutralized by the addition of water or an alkali before the hydrosulphuric acid will precipitate the lead.

If the solution contains an excess of free hydrochloric acid the precipitate may be red, consisting of plumbic sulphide and plumbic chloride, which in time, with the addition of hydrosulphuric acid in excess, will be converted into plumbic sulphide.

$$Pb2NO_3 + H_2S = \underbrace{PbS} + 2HNO_3.$$

20. AMMONIC SULPHIDE acts the same as hydrosulphuric acid.

$$Pb2NO_3 + NH_4SH = \underbrace{PbS} + NH_4NO_3 + HNO_3.$$

21. SULPHURIC ACID produces a white precipitate of plumbic sulphate, which is nearly insoluble in dilute acids and water; concentrated nitric acid partially dissolves it; concentrated hydrochloric acid, when boiling, dissolves it with difficulty; a solution of potassic hydrate dissolves it more readily. Ammonic acetate or citrate dissolves it, and dilute sulphuric acid precipitates it again. In very dilute solutions of lead an excess of dilute acid should be added, as the precipitate only forms after standing. Precipitate is blackened by hydrosulphuric acid, which distinguishes it from baric and strontic sulphate, which are insoluble. Plumbic sulphate, in the cold, is soluble in water to the extent of $\frac{1}{22800}$ Fresenius; in dilute sulphuric acid, $\frac{1}{26500}$ Fresenius; almost absolutely insoluble in alcohol.

$$Pb2NO_3 + H_2SO_4 = \underbrace{PbSO_4} + 2HNO_3.$$

22. POTASSIC HYDRATE produces a white precipitate of plumbic hydrate (Pb_2HO), readily soluble in excess, and almost insoluble in ammonic hydrate.

$$Pb2NO_3 + 2KHO = \underbrace{Pb2HO} + 2KNO_3.$$

23. AMMONIA produces a white precipitate of plumbic hydrate (Pb2HO), insoluble in excess, but readily soluble in nitric acid. In solutions of plumbic acetate, ammonic hydrate (free from carbonate) does not immediately produce a precipitate, owing to the formation of a soluble plumbic triacetate.

The filtrate from the precipitation should be examined, for it will contain some lead if the ammonic hydrate is in excess and there are ammonic salts present.

$$Pb2NO_3+NH_4HO=\underbrace{Pb2HO}+NH_4NO_3+HNO_3.$$

24. Potassic Chromate or **Dichromate** produces a yellow precipitate of plumbic chromate ($PbCrO_4$) which is insoluble in acetic acid; sparingly soluble in dilute nitric acid, but readily so in potassic hydrate.

$$Pb2NO_3+K_2CrO_4=\underbrace{PbCrO_4}+2KNO_3.$$

$$2Pb2NO_3+K_2Cr_2O_7+H_2O=\underbrace{2PbCrO_4}+2KNO_3+2HNO_3.$$

25. Sodic Carbonate produces a white precipitate of PLUMBIC CARBONATE, together with PLUMBIC HYDRATE, which is insoluble in excess of the precipitant, and also in potassium cyanide.

$$7Pb2NO_3+7Na_2CO_3+H_2O=(\underbrace{6PbCO_3+Pb2HO)}+14NaNO_3$$
$$+\overbrace{CO_2}.$$

26. Potassium Iodide precipitates plumbic iodide as a beautiful light-yellow precipitate.

$$2KI+Pb2NO_3=\underbrace{PbI_2}+2KNO_3.$$

Metallic lead is precipitated by zinc and iron out of its soluble salts.

$$Pb2NO_3+Zn=\underbrace{Pb}+Zn2NO_3.$$

$$Pb2NO_3+Fe=\underbrace{Pb}+Fe2NO_3.$$

When plumbic sulphate is heated with carbon in the right proportion, metallic lead is produced.

$$PbSO_4+C=\underbrace{Pb}+\overbrace{CO_2}+\overbrace{SO_2}.$$

27. Blowpipe.—Dry compounds of lead, when fused with sodic carbonate on charcoal in the inner (reducing) flame, furnishes very soft, MALLEABLE globules of METALLIC LEAD, which produces a mark on paper like a pencil. A yellow incrustation is formed at the same time, which becomes quite pale when cold.

LIMIT OF REACTIONS OF TESTS FOR LEAD.

ONE PART OF	IN WATER.	REAGENT.	AUTHORITY.
Lead....................	100,000 or more.	Sulphydric Acid.	A. S. Taylor.
Lead as Nitrate.........	200,000	" "	Lassaigne.
Oxide of Lead as Nitrate	350,000	" "	Harting.
Nitrate of Lead.........	100,000	" "	Pfaff.
Oxide as Nitrate........	20,000	H_2SO_4 in excess.	Pfaff & Harting.
Lead as "	25,000	Na_2SO_4 in 15 min.	Lassaigne.
Oxide as "	70,000	Chromate of Potassium.	Harting.

CHARACTERISTIC REACTIONS, 18, 21, 27.

MERCURY.

Symbol Hg (Hydrargyrum from ὑδωραργυρον, liquid silver or quicksilver).—Atomic weight, 200.—Equivalence (Hg_2) and II.—Density, 100.—Molecular weight, 200.—Molecular volume, 2.—One litre of mercury vapor, weight 8.96 grains (100 criths).—Specific gravity, 13.596 at 32° F.—Solidifies at −40° F.; boils at 350° F.—Vapor, Sp. Gr. 6.976.—Electric conductivity, 1.63 at 73° F.—Atomic volume, 14.56.

MERCURY OXIDES.

There are TWO MERCURY OXIDES known:

MERCURIC OXIDE HgO, or red mercuric oxide, also called binoxide and deutoxide.

When mercurous or mercuric nitrate is exposed in a glass vessel surrounded with sand, to heat, as long as nitrous oxide is evolved, mercuric oxide is formed. The commercial oxide has a bright brick-red color, shining crystalline grains. Sp. Gr. 11.074 (Herapth) of precipitated.

MERCUROUS OXIDE Hg_2O. Black mercurous oxide, also called dioxide and suboxide.

When a solution of mercurous salt is mixed with an excess of caustic alkali, mercurous oxide is precipitated. Brown-black powder. Sp. Gr. 10.69 (Herapth) of that obtained from calomel.

METALLIC MERCURY.

28. HEATED IN A TUBE, having one end closed, it boils, and in the cool part of the tube minute shining particles condense.

29. HYDROCHLORIC ACID does not attack metallic mercury.

30. NITRIC ACID, if dilute and cold, dissolves the metal slowly, and the solution contains MERCUROUS NITRATE.

$$6Hg+\overset{\text{Dilute.}}{8HNO_3}=3Hg_2(NO_3)_2+\overbrace{N_2O_2}+4H_2O.$$

Concentrated acid, when hot, dissolves the metal rapidly, forming MERCURIC NITRATE.

$$3Hg+\overset{\text{Conc.}}{8HNO_3}=3Hg(NO_3)_2+\overbrace{N_2O_2}+4H_2O.$$

31. SULPHURIC ACID, when concentrated and in excess, if heated, dissolves the metal with evolution of sulphurous oxide, forming MERCURIC SULPHATE.

$$Hg+2H_2SO_4=HgSO_4+\overbrace{SO_2}+2H_2O.$$

When the metal is in excess of the acid, a mixture of mercurous and mercuric sulphate is obtained. Dilute acid does not act upon the metal.

SALTS OF MERCUROUS OXIDE.

The mercurous salts volatilize on ignition; most of them are decomposed by this process. Mercurous bromide and chloride volatilize unaltered. Mercurous nitrate is decomposed on the addition of much water into a pale-yellow insoluble basic and soluble acid salt. The soluble salts in the neutral state redden litmus-paper. Most of the salts are colorless.

Solution best fitted for reactions:

MERCUROUS NITRATE $Hg_2(NO_3)_2$.

32. HYDROCHLORIC ACID precipitates a powder of dazzling whiteness, MERCUROUS CHLORIDE (Hg_2Cl_2) (calomel).

$$Hg_22NO_3+2HCl=\underbrace{Hg_2Cl_2}+2HNO_3.$$

Insoluble in water and dilute acids. Hydrochloric and nitric acids, after long boiling, dissolves it. Nitrohydrochloric acid and chlorine dissolve it readily, converting it into *mercuric chloride.* Ammonic hydrate and potassic hydrate *blacken* mercurous chloride; when potassic hydrate is used, the black mercurous oxide is precipitated (§ 36); when ammonic hydrate is used, mercurous-ammonium chloride $(NH_3Hg)_2Cl_2$ is produced.

$$Hg_2Cl_2+2NH_4OH=(NH_3Hg)_2Cl_2+2H_2O.$$

33. Soluble chlorides produce the same precipitate as hydrochloric acid.

$$Hg_2(NO_3)_2+2NaCl=\underbrace{Hg_2Cl_2}+2NaNO_3.$$

34. Hydrosulphuric acid produces a black precipitate of mercurous sulphide (Hg_2S); insoluble in ammonic sulphide, dilute acids, and potassic cyanide; easily soluble in nitrohydrochloric acid, but not by *boiling concentrated* nitric acid, which does not attack it.

$$Hg_2(NO_3)_2+H_2S=\underbrace{Hg_2S}+2HNO_3.$$

35. Ammonic sulphide produces the same precipitate as hydrosulphuric acid.

$$Hg_2(NO_3)_2+NH_4HS=\underbrace{Hg_2S}+NH_4NO_3+HNO_3.$$

36. Potassic hydrate produces a black precipitate of mercurous oxide.

$$Hg_2(NO_3)_2+2KOH=\underbrace{Hg_2O}+2KNO_3+H_2O.$$

Precipitate is insoluble in excess. Sodic hydrate produces the same precipitate.

37. Ammonic hydrate produces a black precipitate of $2NH_3.3Hg_2O.N_2O_5$, which is a hydrated trimercurous ammonium nitrate. $2(NHHg_3)NO_3.2H_2O$ (according to C. G. Mitscherlich), but according to Kane, $2(NH_2Hg_2)NO_3.H_2O$ (dimercurous ammonium nitrate). The precipitate is velvet-black, and is known as "Hahnemann's Soluble Mercury."

METALLIC MERCURY PRECIPITATED.

38. Stannous chloride produces a gray precipitate of metallic mercury, which may be united into globules by boiling the metallic deposit, after decanting the fluid with hydrochloric acid, to which a drop of stannous chloride may be added with advantage.

39. Metallic copper, when introduced into a solution of mercury, becomes covered with a lustrous coating of metallic mercury. If the coated copper be dried and heated, it assumes its original color, the mercury being volatilized.

$$Hg_2 2NO_3 + Cu = \underbrace{2Hg}_{} + Cu2NO_3.$$

"Copper wire or foil, in pieces about one inch in length, may be used for this test. They should be first dipped into strong nitric acid, and well washed. The mercurial solution should be acidulated with a few drops of dilute nitric acid, and then boiled for a few minutes with the strips of copper. These are then to be removed, washed, dried between folds of paper, and gently heated in a small glass tube, closed at one end. A shining ring of minute globules of mercury will condense above the copper, which now resumes its original color. This method is often used to separate mercury from organic substances, in examining vomited matter, and in case of poisoning."—(Tuttle and Chandler.)

40. Potassic cyanide precipitates mercury.

$$\left\{\begin{array}{l} Hg_2 2NO_3 + 2KCN = Hg_2(CN)_2 + 2KNO_3. \\ Hg_2(CN)_2 = \underbrace{Hg}_{} + Hg(CN)_2. \end{array}\right.$$

There is first formed $Hg_2\,(CN)_2$, which is resolved into mercuric cyanide $Hg(CN)_2$ and metallic mercury.

Metallic mercury is separated as a gray powder by zinc, sulphurous acid, and phosphorous acid.

41. Nitric Acid converts all mercurous salts into mercuric by boiling.

A FEW MISCELLANEOUS REACTIONS.

Potassic iodide, when added to mercurous nitrate, forms a greenish-yellow precipitate of mercurous iodide (always, however, mixed with mercuric iodide), soluble in excess.

Potassic ferrocyanide, when added to mercurous nitrate, forms a white, and potassic ferricyanide a reddish-brown precipitate.

Sodic phosphate and oxalic acid form white precipitates with mercurous nitrate.

$$Hg_2 2NO_3 + C_2H_2O_4 = \overbrace{C_2HgO_4} + 2HNO_3.$$

$$3Hg_2 2NO_3 + 2Na_2HPO_4 = \underbrace{2Hg_3PO_4} + 4NaNO_3 + 2HNO_3.$$

Potassic chromate produces a brick-red precipitate when added to mercurous nitrate.

Gallic acid produces a brownish-yellow precipitate when added to mercurous nitrate.

42. Blowpipe.—Dry compounds of mercury mixed with ten to twelve parts of dry sodic carbonate, and heated in a dry glass tube, closed at one end, yield metallic mercury, which condenses in minute globules in the cool part of the tube. These may be united together into larger globules by rubbing with a glass rod.

"To make this test more delicate, the mercury compound should be carefully dried; the sodic carbonate should be ignited (on platinum foil) just previous to use. To prevent sublimation of any undecomposed mercury compound, a layer of sodic carbonate should be placed above the mixture." —(Tuttle and Chandler.)

Characteristic Reactions, **32, 39, 42.**

DETECTION OF MEMBERS OF GROUP I.

Having noticed the different respective behaviors of the chlorides of the members of this group, with water and ammonic hydrate, we are able to make a scheme for their separation and detection.

SCHEME FOR THE SEPARATION AND DETECTION OF MEMBERS OF GROUP I.

The solution to be examined is supposed to contain a salt of silver, mercurous oxide, and lead.

Add to the solution hydrochloric acid; there is produced a precipitate of argentic, plumbic, and mercurous chloride.

$$\underbrace{AgCl + PbCl_2 + Hg_2Cl_2}.$$

Filter the precipitate and wash it, then boil the precipitate in water and filter:

<table>
<tr><th>FILTRATE.</th><th colspan="2">RESIDUE.</th></tr>
<tr><td rowspan="3">The filtrate will contain $PbCl_2$ in solution. Add sulphuric acid if a precipitate is produced; it is plumbic sulphate $PbSO_4$. (See § 18; § 27.)</td><td colspan="2">The residue will contain $AgCl + Hg_2Cl_2$. Add ammonic hydrate, and filter.</td></tr>
<tr><td>Solution.</td><td>Residue.</td></tr>
<tr><td>Solution will contain the silver salt. Add nitric acid, which will precipitate $\underbrace{(AgCl)}$ argentic chloride. (See § 5.)</td><td>If black (see § 32) dissolve in $(3HCl + HNO_3)$ nitrohydrochloric acid. Add stannous chloride $(SnCl_2)$ in excess, which will deposit metallic mercury $\underbrace{(Hg)}$. (See § 33.)</td></tr>
</table>

GROUP II.

This group contains the metals NOT PRECIPITATED by HYDROCHLORIC ACID, but precipitated from their acid solutions by HYDROSULPHURIC ACID.

FIRST DIVISION.

Salts of the metals, the sulphides of which are INSOLUBLE IN AMMONIC SULPHIDE.

SECOND DIVISION.

Salts of the metals, the sulphides of which are SOLUBLE IN AMMONIC SULPHIDE.

FIRST DIVISION.

Salts of Lead,* Mercury, Copper, Cadmium, and Bismuth.

SALTS OF MERCURIC OXIDE.

Solution best fitted for the reactions:

MERCURIC CHLORIDE ($HgCl_2$).

The SALTS of MERCURIC OXIDE volatilize upon ignition; most of them are decomposed by this process. Mercuric chloride, bromide, and iodide volatilize unaltered. Mercuric nitrate and sulphate are decomposed by water (added in large quantity) into soluble acid and insoluble basic salts. The soluble neutral salts redden litmus-paper. Most of the salts of mercuric oxide are colorless.

---

* The reactions of the salts of lead have been given § 18 et seq.; it is introduced here for the reason that very dilute lead solutions give no precipitate with hydrochloric acid, but are precipitated by hydrosulphuric acid.

43. **Hydrosulphuric acid**, when added to a solution of mercuric chloride in small quantities, produces a white or yellow precipitate ($HgCl_2+2HgS$). On the addition of more of the precipitant, the precipitate formed passes from white to yellow, to orange, to brownish-red color, and finally to black if enough has been added. *This distinguishes the mercuric oxide from all other bodies.*

$$HgCl_2+H_2S=\underbrace{HgS}_{}+2HCl.$$

Mercuric sulphide is not dissolved by ammonic sulphide, potassic hydrate, or potassic cyanide; insoluble in boiling nitric or hydrochloric acid. Dissolves completely in potassic sulphide, and is readily decomposed and dissolved by nitrohydrochloric acid.

44. **Ammonic sulphide** produces the same precipitate as hydrosulphuric acid.

$$HgCl_2+NH_4HS=\underbrace{HgS}_{}+NH_4Cl+HCl.$$

45. **Potassic hydrate**, added in small quantities to a neutral or slightly acid solution, produces a reddish-brown precipitate, which acquires a yellow tint, if reagent is added in excess. The *reddish-brown* precipitate is a **basic salt**; the *yellow* precipitate consists of mercuric oxide.

$$HgCl_2+KHO=\underbrace{HgO}_{}+KCl+HCl.$$

In very acid solution the precipitation is very incomplete. When the solution of mercuric chloride contains an excess of ammonic chloride, the precipitate is analogous to that produced in §40.

46. **Ammonic hydrate** produces a white precipitate, if ammonic hydrate be in excess [$HgCl_2(NH_2)_2$]; if mercuric chloride be in excess [$2HgCl_2(NH_2)_2$].

47. **Potassic iodide** produces a scarlet precipitate of mercuric iodide (HgI_2).

$$HgCl_2+2KI=\underbrace{HgI_2}_{}+2KCl.$$

Soluble in excess of either salt. This difficulty may be avoided by adding a drop of potassic iodide to the white precipitate by ammonic hydrate, § 40, which will change to a chocolate-red HgI_2.

48. Stannous chloride, when added in small quantities, produces a precipitate of mercurous chloride.

$$2HgCl_2 + SnCl_2 = \underbrace{Hg_2Cl_2} + SnCl_4.$$

If added in excess and boiled, the mercurous chloride at first formed is reduced to metal.

$$Hg_2Cl_2 + SnCl_2 = \underbrace{Hg_2} + SnCl_4.$$

The metal may be united into globules by boiling with hydrochloric acid and some stannous chloride.

49. Blowpipe.—The behavior of the mercuric salts is the same as the mercurous salts; therefore see § 36.

Characteristic Reaction, 39, 43, 47, 42, 49.

A FEW MISCELLANEOUS REACTIONS.

Formic acid reduces *mercuric chloride* to *mercurous chloride.*

Ammonic carbonate produces a white precipitate with mercuric nitrate.

Potassic carbonate produces a yellow precipitate of HgO.

Hydro-potassic carbonate and **hydrosodic carbonate** produces a brown-red precipitate in *mercuric nitrate,* and a white precipitate turning red in *mercuric chloride.* Precipitate $(2HgO, HgCl_2)$.

Sodic phosphate produces a white precipitate.

Potassic ferrocyanide produces in solutions not too dilute a white precipitate turning blue, *prussian blue* being formed while filtrate contains mercuric cyanide.

Potassic ferricyanide produces a white precipitate with mercuric nitrate, and none with mercuric chloride.

Tincture of galls forms an orange-yellow precipitate in all solutions except *mercuric chloride.*

COPPER.

Symbol, Cu. (Latin, Cuprium, Cuprus).—Atomic weight, 63.5.—Equivalence $(Cu_2)^{II}$ and II.—Color, flesh-red.—Crystals, isometric.—Specific gravity, 8.952.—Atomic volume, 7.10.—Specific heat, 0.0951.—Fusing point, 1996° F. —Electric conductivity at 32° F. is 99.95.—Order of malleability commencing with gold is third; Ductility, fifth; Heat-conducting power, fourth.—Tenacity=550.

COPPER OXIDES.

There are two well-determined copper oxides, and two uncertain oxides.

Cuprous oxide, Cu_2O, also called dioxide, suboxide, and red oxide of copper. Found native in two forms as (rothkupferey and) *red copper* and *copper bloom*, chalotrechite (kupferblüthe). Ignite 29 pts. copper-filings with 24 pts. anhydrous cupric sulphate, and cuprous oxide is obtained. Hydrochloric acid forms, with cuprous oxide, cuprous chloride, which is easily decomposed by water. Nitric acid converts it into cupric nitrate; most other acids decompose it, forming cupric salts and depositing metallic copper. Very few oxygen salts known; sulphites and double sulphites with alkaline metals.

Cupric oxide, CuO, black oxide of copper. Found native as malaconite. Prepared by exposing cupric sulphate to an intense heat, or cupric carbonate or nitrate to a moderate heat. Reduced to metal by hydrogen, when ignited with it, or charcoal. Potassium or sodium also reduce it to a metallic state.

Sesquioxide of copper, Cu_2O_3; not known in a separate state. Mix chloride of lime with a solution of cupric nitrate and there is formed calcic cuprate, a beautiful rose-colored substance; it decomposes but slowly. Most other salts are decomposed with violent evolution of oxygen, soon after formation.

Peroxide of copper, CuO_2; formed by agitating cupric hydrate with a large excess of hydrogen peroxide at 0° C. It is a yellowish-brown powder. Insoluble in water, with acids it forms ordinary cupric salts and hydrogen peroxide. It may only be a compound of cupric oxide and hydrogen peroxide.—(Thenard.)

METALLIC COPPER.

50. Heated on charcoal it becomes coated with cupric oxide; it fuses with difficulty, and gives no incrustation.

51. Hydrochloric acid has very little action on metallic copper.

52. Nitric acid dissolves it readily, forming cupric nitrate and evolving nitrogen dioxide.

$$3Cu+8HNO_3=3Cu2NO_3+\overbrace{N_2O_2}+4H_2O.$$

53. Sulphuric acid, when hot and concentrated, rapidly dissolves copper, forming blue cupric sulphate ($CuSO_4$), and evolving sulphurous oxide. Dilute acid has but little action on copper.

$$Cu+2H_2SO_4=CuSO_4+\overbrace{SO_2}+2H_2O.$$

54. Nitrohydrochloric acid dissolves copper, forming cupric chloride and evolving nitrogen dioxide (N_2O_2).

$$3Cu+2(3HCl+HNO_3)=3CuCl_2+\overbrace{N_2O_2}+4H_2O.$$

SALTS OF COPPER.

"Most of the neutral salts are soluble in water; the soluble salts redden litmus-paper, and suffer decomposition when heated to gentle redness, with the exception of the sulphate, which can bear a somewhat higher temperature. They are usually white in the anhydrous state; the hydrated salts are usually of a blue or green color, which their solutions continue to exhibit even when much diluted."

Solutions best fitted for the reactions:

Cupric Sulphate ($CuSO_4$).

55. Hydrosulphuric acid produces a black precipitate of cupric sulphide.

$$CuSO_4+H_2S=\underbrace{CuS}+H_2SO_4.$$

Cupric sulphide is slightly soluble in ammonic sulphide, completely soluble in boiling nitric acid, and dissolves completely in potassic cyanide; not soluble in dilute sulphuric or hydrochloric acid.

56. Ammonic sulphide produces the same precipitate as hydrosulphuric acid.

$$CuSO_4+NH_4HS=\underbrace{CuS}+NH_4HSO_4.$$

57. Potassic hydrate produces a light-blue bulky precipitate of cupric hydrate ($Cu2HO$).

$$CuSO_4+2KHO=\underbrace{Cu2HO}+K_2SO_4.$$

Insoluble in excess. When heated, turns black, forming cupric oxide.

"The presence of fixed organic matters (sugar, tartaric acid) causes the hydrate to redissolve in excess of potassic hydrate with a deep-blue color."—(Tuttle and Chandler.)

58. Ammonic hydrate produces a greenish-blue precipitate of a basic salt ($CuSO_4+2Cu2HO$), when added in a small quantity; in a large quantity the precipitate dissolves, imparting to the liquid a deep azure-blue color, forming $(NH_3)_2 CuO+(NH_4)_2SO_4$. This test distinguishes copper from most other substances.

$$3CuSO_4+4NH_4HO=\underbrace{2Cu2HO+CuSO_4}+2(NH_4)_2SO_4.$$

59. Sodic carbonate produces a greenish-blue precipitate of cupric carbonate and cupric hydrate ($CuCO_3+Cu2HO$), with the evolution of carbonic oxide.

$$2CuSO_4+2Na_2CO_3+H_2O=\underbrace{CuCO_3+Cu2HO}+\overbrace{CO_2}+2Na_2SO_4.$$

This precipitate, on boiling, is converted into cupric oxide.

60. Potassic ferrocyanide produces a chocolate-colored precipitate of cupric ferrocyanide ($Cu_2FeC_6N_6$).

$$2CuSO_4+H_4FeC_6N_6=\underbrace{Cu_2FeC_6N_6}+2H_2SO_4.$$

Insoluble in dilute acids, but readily soluble in ammonic hydrate. Decomposed by potassic hydrate, with the formation of cupric hydrate and potassic ferrocyanide.

To very dilute solutions of copper, potassic ferrocyanide imparts a reddish color, which is a more delicate indication than the ammonic hydrate reaction, being still visible in a solution containing 1 pt. of copper in 400,000 pts. of liquid (Lassaigne), and in 1,000,000 pts. (Sarzeau).

Dissolves in ammonic hydrate, and forms on evaporation, which produces a most delicate test. Thus, if a solution containing copper and iron be treated with ammonic hydrate in excess, a few drops of potassic ferrocyanide added, the liquid filtered, and filtrate evaporated in a small porcelain crucible or capsule, cupric ferrocyanide is left behind, exhibiting characteristic red color (Warrington Chem. Soc., Qu. J. v. 137). Before applying the test, the solution should be acidulated with acetic acid. If strong mineral acids present, they should be neutralized by adding excess of potassic or sodic acetate.

61. Potassic cyanide produces a precipitate of cupric cyanide $Cu(CN)_2$, which is yellow-green.

$$CuSO_4+2KCN=\underbrace{Cu(CN)_2}+K_2SO_4.$$

Soluble in *excess.* Hydrochloric acid throws down from *this* solution cuprous cyanide soluble in excess of acid; hydrosulphuric acid and ammonic sulphide produces no precipitate with *this* solution.

62. Potassic iodide produces a yellow precipitate of cupric iodide with separation of iodine.

63. Metallic iron, when introduced into a solution of copper, acidulated with a few drops of hydrochloric acid, becomes coated with a characteristic film of metallic copper of coppery-red color.

$$CuSO_4+Fe=\underbrace{Cu}+FeSO_4.$$

If the solution containing copper be introduced into a platinum dish with a little free hydrochloric acid and a piece of zinc introduced, the platinum becomes rapidly covered with a coating of copper.

$$Pt+CuSO_4+Zn=ZnSO_4+Pt+\underbrace{Cu}.$$

64. BLOWPIPE.—If a dry compound of copper is fused with a little sodic carbonate and potassic cyanide on charcoal in the reducing flame of the blowpipe, there is produced a globule of METALLIC COPPER. No incrustation is formed. If the fused mass is triturated with water in a mortar, the charcoal particles are washed off, leaving shining scales of metallic copper perfectly visible when only a minute quantity of the compound is used.

65. BORAX and SODIC PHOSPHATE readily dissolve cupric oxide in the outer flame. Beads are green while hot, and blue when cold. Any compound of copper imparts to borax bead fused on platinum wire in the outer flame, a *green* color while hot, and *blue* when cold. If this bead is detached and heated, on charcoal, with a little metallic tin, the bead becomes *red* and *opaque*, and colorless when only a minute quantity of copper is present.

In the inner flame the borax bead is made colorless, that produced with sodic phosphate and ammonia turns dark-green; both acquire a brownish-red tint upon cooling.

CHARACTERISTIC REACTIONS, **58, 60, 63, 64, 65.**

CADMIUM.

Symbol, Cd. (Greek, Cadmia—Calomine).—Atomic weight, 112.—Equivalence, II.—Density, 56.—Molecular weight, 112.—Molecular volume, 2.—Discovered in 1817 by Hermann and also by Stromeyer.—Specific gravity, 8.604.—Becomes brittle at 82° C.—Boiling point, 1580° F.—Fusing point, 442° F.—Calculated Sp. Gr. of vapor, 3,869; observed specific gravity, 3.94.—Atomic volume, 12.96.—Electric conductivity, at 32° F., 23.72.—Order of ductility commencing with gold, eleventh.—Color, grayish-white.

CADMIUM OXIDES.

Cadmium forms *two oxides*, viz.: Cd_2O and CdO.

CADMOUS OXIDE Cd_2O, or suboxide. This oxide may be obtained by heating the oxalate to about the melting-point of lead.

$$2C_2CdO_4+\Delta\delta=Cd_2O+\overset{\frown}{CO}+\overset{\frown}{3CO_2}.$$

It is a *green powder* resembling chromic oxide, and is resolved by heat or by acids into metallic cadmium and cadmic oxide. It does not yield metallic cadmium with mercury, hence it appears to be a *definite compound* and not merely a mixture of the metal with cadmic oxide.

Cadmic oxide, CdO, or protoxide, may be obtained by heating metallic cadmium in the air, when it takes fire and is converted into cadmic oxide. Formed also by igniting the hydrate, carbonate, or nitrate. Sp. Gr. 6.9502. Insoluble in water.

METALLIC CADMIUM.

66. Hydrochloric acid, when hot, converts the metal into cadmic chloride ($CdCl_2$), liberating at the same time hydrogen gas.

$$Cd + 2HCl = CdCl_2 + \overbrace{2H}.$$

67. Sulphuric acid, when dilute, converts the metal into cadmic sulphate and liberating hydrogen gas.

$$Cd + H_2SO_4 = CdSO_4 + \overbrace{2H}.$$

68. Nitric acid is the best solvent for the metal, converting it into cadmic nitrate ($Cd2NO_3$) and liberating at the same time nitrogen dioxide.

$$3Cd + 8HNO_3 = 3Cd(NO_3)_2 + \overbrace{N_2O_2} + 4H_2O.$$

69. Heated on charcoal, it fuses and deposits a reddish-brown incrustation of cadmic oxide.

CADMIUM SALTS.

Most of the cadmium salts are colorless; they have a disagreeable metallic taste, and act as emetics. The solutions, even of the neutral salts, redden litmus-paper. The salts are decomposed by heat.

Solution best fitted for the reactions:

Cadmic Nitrate ($Cd2NO_3$).

70. Hydrosulphuric acid produces in a solution of cadmic nitrate a bright-yellow precipitate of cadmic sulphide (CdS).

$$Cd2NO_3 + H_2S = \underbrace{CdS} + 2HNO_3.$$

The solution, if acid, must be largely diluted, as the precipitate CdS is soluble in concentrated hydrochloric acid; not soluble in *very* dilute hydrochloric, sulphuric, or nitric acid, but soluble in boiling hydrochloric and sulphuric acids; not soluble in alkalies or ammonic sulphide. Cadmic sulphide is the only *yellow* sulphide *not soluble* in *ammonic sulphide.*

71. Ammonic sulphide produces the same precipitate as hydrosulphuric acid.

$$Cd2NO_3+NH_4HS=\underbrace{CdS}+HNO_3+NH_4NO_3.$$

72. Potassic hydrate produces a precipitate of cadmic hydrate, which is white; insoluble in excess of precipitant.

$$Cd2NO_3+2KHO=\underbrace{Cd2HO}+2KNO_3.$$

73. Ammonic hydrate produces a white precipitate of cadmic hydrate, soluble in excess.

$$Cd2NO_3+2NH_4HO=\underbrace{Cd2HO}+2NH_4NO_3.$$

74. Ammonic carbonate produces a white precipitate of cadmic carbonate, insoluble in excess. Dissolves readily in potassic cyanide.

$$Cd2NO_3+(NH_4)_2CO_3=\underbrace{CdClO_3}+2NH_4NO_3.$$

75. Sodic phosphate precipitates cadmic orthophosphate ($Cd_3P_2O_8$). A white powder.

$$3Cd2NO_3+2Na_2HPO_4=\underbrace{Cd_3P_2O_8}+4NaNO_3+2HNO_3.$$

76. Ammonic oxalate produces a white precipitate when added to cadmic chloride of cadmic oxalate ($CdC_2O_4.3H_2O$); soluble in ammonic hydrate.

$$CdCl_2+C_2(NH_4)_2O_4+3H_2O=\underbrace{CdC_2O_4.3H_2O}+2NH_4Cl.$$

77. Potassic ferrocyanide produces a white precipitate.

$$2Cd2NO_3+K_4Cfy=\underbrace{Cd_2Cfy}+4KNO_3.$$

78. Potassic ferricyanide produces a yellow precipitate, soluble in hydrochloric acid.

$$3Cd2NO_3+K_6Fe_2C_{12}N_{12}=\underbrace{Cd_3Fe_2C_{12}N_{12}}+6KNO_3.$$

METALLIC CADMIUM PRECIPITATED.

Zinc precipitates metallic cadmium from its salts (in dendrites).

$$Cd2NO_3+Zn=\underbrace{Cd}+Zn2NO_3.$$

79. Blowpipe.—When a cadmium compound is mixed with sodic carbonate and fused on charcoal in the inner flame of the blowpipe, there is produced a reddish-brown incrustation of cadmic oxide, which becomes very distinct on cooling; no metal is produced.

Characteristic Reactions, **70, 79.**

BISMUTH.

Symbol, Bi. (German, *wismat*).—Atomic weight, 210.—Equivalence, III and V.—Specific gravity of solid, 9,830.—Fusing point, 507° F.—Atomic volume, 21.84.—Specific heat, 0.0308.—Electric conductivity at 32° F., 1.245.—Order of brittleness commencing with antimony is third.

BISMUTH OXIDES.

Bismuth forms two definite oxides, and two others.

Bismuthous oxide, Bi_2O_3, or trioxide.—Formed when bismuthous nitrate is gently ignited. It is a pale-yellow powder, which melts at red-heat. It occurs native as bismuth ochre.

Bismuthic oxide, Bi_2O_5, or protoxide.—Prepared by passing chlorine through a concentrated solution of potassic hydrate which contains bismuthous hydrate ($BiHO_3$, or $Bi_2O_3.H_2O$) in suspension; a blood-red substance then separates, which is a mixture of hydrated bismuthic acid and bismuthic oxide. This is treated with dilute nitric acid, which dissolves the oxide, but in the cold does not attract the acid. Bismuthic oxide is a bright-red powder. "Bismuthates are but little known. Hydropotassic bismuthate, $Bi_2KHO_6=BiKO_3\ BiHO_3$, is known."—Arppe.

Bismuth dioxide, Bi_2O_2.—This oxide is formed when a solution of a bismuth-salt is treated with stannous chloride. (A corresponding sulphide is known.)

Bismuthate of bismuth, Bi_2O_4.—When bismuthic oxide is heated to 100° C. it becomes converted into bismuthate of bismuth ($Bi_2O_3.Bi_2O_5=2Bi_2O_4$).

METALLIC BISMUTH.

80. Heated on charcoal it fuses and deposits a deep-yellow incrustation of bismuthous oxide (Bi_2O_3).

81. Hydrochloric acid does not act upon bismuth.

82. Nitric acid dissolves it rapidly, converting it into bismuthous nitrate ($Bi3NO_3$).

$$2Bi+8HNO_3=2Bi(NO_3)_3+\overbrace{N_2O_2}+4H_2O.$$

If water is added to the solution, a white basic nitrate ($Bi_2O_3.N_2O_5+H_2O=Bi_2N_2O_8+H_2O$) is precipitated.

83. Sulphuric acid dissolves it when concentrated and aided by heat, forming bismuthous sulphate, $Bi_2(SO_4)_3$, and liberating sulphurous oxide. Dilute sulphuric acid does not dissolve bismuth.

$$2Bi+6H_2SO_4=Bi_2(SO_4)_3+\overbrace{2SO_2}+6H_2O.$$

BISMUTH SALTS.

The salts of bismuthous oxide are non-volatile, with the exception of a few (bismuthous chloride). The soluble salts, in the neutral state, redden litmus-paper, and are decomposed when treated with a large amount of water, insoluble basic salts separating, the greater portion of the acid and a small quantity of bismuth remaining in solution.

Solution best fitted for the reactions:

Bismuthous Nitrate, $Bi\ (NO_3)_3$.

84. Hydrosulphuric acid produces a black precipitate of bismuthous sulphide (Bi_2S_3).

$$2Bi(NO_3)_3+3H_2S=\underbrace{Bi_2S_3}+6HNO_3.$$

Insoluble in alkalies, alkaline sulphides, and potassic cyanide. Nitric acid decomposes and dissolves it when hot. If the solutions to be precipitated from are very acid from the presence of free hydrochloric or nitric acid, they must be first diluted.

85. Ammonic sulphide produces the same precipitate as hydrosulphuric acid.

86. Potassic hydrate precipitates a white bismuthous hydrate ($Bi_2O_3.H_2O$).

$$2Bi(NO_3)_3 + 6KHO = \underbrace{Bi_2O_3.H_2O}_{} + 6KNO_3 + 2H_2O.$$

Insoluble in excess, but soluble in dilute acids.

87. Ammonic hydrate produces the same precipitate as potassic hydrate.

$$2Bi(NO_3)_3 + 3NH_4HO = \underbrace{Bi_2O_3.H_2O}_{} + 3NH_4NO_3 + 3HNO_3.$$

88. Sodic carbonate produces a precipitate of basic bismuthous carbonate.

$$2Bi(NO_3)_3 + 3Na_2CO_3 = \underbrace{Bi_2O_3.CO_2}_{} + 6NaNO_3 + \overbrace{2CO_2}.$$

The precipitate is white; insoluble in excess and in potassic cyanide.

89. Potassic dichromate, or chromate, produces a yellow precipitate; when in excess it has the composition of $3Bi_2O_3.2Cr_2O_3$. If this be treated with a small quantity of acid, a yellow salt remains undissolved, consisting of $Bi_2O_3.2Cr_2O_3$; this may be precipitated when bismuth salt is in excess.—(Löwe.) This last precipitate, according to Pearson, consists of $Bi_2O_3.Cr_2O_3$. Compare § 89 with § 24.

90. Water, when added to solutions of bismuth, precipitate white basic salts. ($Bi_2O_3.N_2O_5 + H_2O = 2BiNO_4 + H_2O$) is precipitated from the nitrate; from the chloride a basic chloride ($Bi_2Cl_6.2Bi_2O_3 + 6H_2O$) is precipitated.

“ This reaction is very characteristic, and distinguishes bismuth from all other metals, except *antimony*. Bismuthous chloride exhibits this reaction in the most striking manner, and it is best to convert the bismuth compound into this salt by adding an excess of hydrochloric acid and evaporating to dryness. The residue is dissolved in as little hydrochloric acid as possible, and the solution poured into a large quantity of water.

"Bismuthous sulphate is not decomposed by hydrochloric acid. When a solution is to be tested, therefore, which is known to contain sulphuric acid, it is best to precipitate bismuthous oxide by an excess of ammonia, filter, wash, and dissolve in hydrochloric acid, and then proceed as above." —(TUTTLE AND CHANDLER.)

A FEW MISCELLANEOUS REACTIONS.

PYROPHOSPHORIC ACID, when added to a solution of bismuthous nitrate, produces a precipitate of BISMUTHOUS DIPHOSPHATE ($2Bi_2O_3.3P_2O_5=Bi_4P_6O_{21}$).

$$4Bi(NO_3)_2+3H_4P_2O_7=\underbrace{Bi_4P_6O_{21}}+12HNO_3.$$

PHOSPHORIC ACID produces a precipitate of bismuthous phosphate (orthophosphate) when nitric acid is present.

$$Bi(NO_3)_3+H_3PO_4+HNO_3=\underbrace{BiPO_4}+4HNO_3.$$

OXALIC ACID precipitates BISMUTHOUS OXALATE; a white precipitate ($Bi_3C_6O_{12}.15H_2O$).

$$3Bi(NO_3)_3+3C_2H_2O_4+15H_2O=\underbrace{C_6Bi_3O_{12}.15H_2O}+6HNO_3.$$

TARTARIC ACID added to hot moderately strong bismuthous nitrate, produces a white precipitate of BISMUTHOUS TARTRATE.

$$C_{12}H_{12}.Bi_2O_{18}.6H_2O=Bi_2O_3.3C_4H_4O_5.6H_2O.$$

METALLIC BISMUTH PRECIPITATED.

Metallic bismuth is precipitated from its solutions by metallic iron, copper, lead, and tin, viz.:

$$2Bi(NO_3)_3+3Pb=\underbrace{2Bi}+3Pb2NO_3.$$

$$2Bi(NO_3)_3+3Cu=\underbrace{2Bi}+3Cu2NO_3.$$

91. BLOWPIPE.—When solid compounds of bismuth are fused with sodic carbonate in the reducing flame of the blowpipe, BRITTLE METALLIC GLOBULES of metal are produced, as also an incrustation of BISMUTHOUS OXIDE, which is yellow.

CHARACTERISTIC REACTIONS, **89, 90, 91.**

SCHEME FOR THE SEPARATION AND DETECTION OF THE MEMBERS OF THE FIRST DIVISION OF GROUP II.

The solution to be examined is supposed to contain a salt of mercuric oxide, copper, cadmium, lead, and bismuth.

Add hydrochloric acid—no precipitate. Add to the solution hydrosulphuric acid (H_2S); there is produced a precipitate of bismuthous sulphide (Bi_2S_3), plumbic sulphide, (PbS), cadmic sulphide (CdS), mercuric sulphide (HgS), and cupric sulphide (CuS).

$$\underbrace{Bi_2S_3 + PbS + HgS + CdS + CuS.}$$

Wash completely to expel the chlorine in the mixture; add moderately strong nitric acid (free from hydrochloric), and warm, then filter.

<table>
<tr><th>Residue.</th><th colspan="4">Solution.</th></tr>
<tr><td rowspan="7">Is composed of $\underbrace{HgS+S}$. "Black."
Dissolve in a little aqua-regia. Add stannous chloride; a precipitate is mercuric chloride, Hg_2Cl_2. Heat. Metallic mercury is formed. See § 48.</td><td colspan="4">The solution contains the Pb. Cu, Bi, and Cd. Add dilute sulphuric acid; concentrate solution to expel HNO_3; add H_2O and filter.</td></tr>
<tr><td><i>Residue.</i></td><td colspan="3"><i>Solution</i></td></tr>
<tr><td rowspan="5">$\underbrace{PbSO_4.}$
See § 21.</td><td colspan="3">Contains the Cu, Bi, and Cd. Add NH_4HO and filter.</td></tr>
<tr><td><i>Precipitate.</i></td><td colspan="2"><i>Filtrate Blue</i></td></tr>
<tr><td rowspan="3">$Bi_2O_3.H_2O$. Wash, dissolve in HCl. Test as § 90.</td><td colspan="2">Contains the Cu and Cd. Divide.</td></tr>
<tr><td><i>1st Part.</i></td><td><i>2d Part.</i></td></tr>
<tr><td>Acidulate with acetic acid. Add K_4Cfy, a precipitate Cu_2Cfy. See § 60.</td><td>Add KCN to destroy blue color, then H_2S. Precipitate $\underbrace{CdS.}$
See § 70.</td></tr>
</table>

SECOND DIVISION OF GROUP II.

Metals, the sulphides of which are SOLUBLE IN AMMONIC SULPHIDE.

ARSENIC, ANTIMONY, TIN, GOLD, PLATINUM.

ARSENIC.

Symbol, As. (Greek, *arsenicon*, potent).—Atomic weight, 75.—Equivalence, III and V.—Density, 150.—Molecular weight, 300.—Molecular volume, 2.—1 litre of arsenic vapor weighs 13.44 grams (150 criths).—Specific gravity, 5.7 to 5.959 (Miller).—Atomic volume, 12.96.—Specific heat, 0.0814.—Electric conductivity at 32° F., 4.76.—Volatilizes at 356° F.—Order of brittleness commencing with antimony, second.—Color, dark-gray; bright only when freshly fractured.

ARSENIC OXIDES.

Arsenic forms two well-defined oxides, viz.: Arsenious oxide As_2O_3, and arsenic oxide As_2O_5. The black film which forms on the surface of the metal is supposed to be a sub-oxide, but it is more probably a mixture of metallic arsenic with arsenious oxide.

Arsenious oxide, As_2O_3, in the *hydrated* state arsenious acid. Occurs native in the mineral arsenite or arsenolite. Formed when arsenic is volatilized in contact with free oxygen, as when the metal is heated in a glass tube through which a current of air is passing.

$$2As+O_3+\Delta\delta=As_2O_3.$$

It is a white solid. Sp. Gr. 3.7385 (Güibourt). Volatilizes at about 218° C. Insoluble in ether; nearly so in alcohol.

Arsenic oxide, As_2O_5, in the *hydrated* state arsenic acid. This compound is formed by oxidizing arsenious oxide or arsenious acid with nitric acid, aqua-regia, hypochlorous acid, or other oxidizing agents. Dissolve As_2O_3 in hot HCl and oxidize by adding HNO_3, the latter being added as long as red vapors are produced, the whole then cautiously evaporated to complete dryness, and the residue heated to low redness. Arsenic oxide is produced as a white anhydrous mass which has no action on litmus-paper. Strongly-heated arsenious oxide and free oxygen are produced.

$$As_2O_5+\Delta\delta=As_2O_3+\widetilde{2O}.$$

METALLIC ARSENIC.

92. Heated on charcoal, it does not fuse, but gives off fumes of arsenious oxide (As_2O_3), a portion of which is deposited as a white incrustation. A peculiar alliaceous odor is emitted at the same time.

93. Heated in a tube which has one end closed, the arsenic sublimes, forming a *black*, shining metallic ring on the glass.

94. Hydrochloric acid does not attack metallic arsenic.

95. Sulphuric acid, dilute, does not attack metallic arsenic, but boiling concentrated acid oxidizes it to arsenious oxide, evolving sulphurous oxide.

$$2As + 2H_2SO_4 = As_2O_3 + \overbrace{2SO_2} + H_2O.$$

96. Nitric acid, when dilute, converts arsenic by the aid of heat into arsenious acid.

$$2As + 2HNO_3 = As_2O_3 + \overbrace{N_2O_2} + H_2O.$$

Concentrated nitric acid converts the metal partially into arsenic oxide (As_2O_5).

$$6As + 10HNO_3 = 3As_2O_5 + \overbrace{5N_2O_2} + 5H_2O.$$

Arsenious acid ($2H_3AsO_3 = 3H_2O.As_2O_3$).

Solution best fitted for the reactions:

Arsenious Acid, H_3AsO_3.

97. Hydrosulphuric acid produces no precipitate with arsenious acid, but imparts to the solution a yellow color. If *hydrochloric acid* be added, a precipitate of arsenious sulphide (As_2S_3) is produced, which is soluble in ammonic sulphide, from which it may be reprecipitated by acids.

$$2H_3AsO_3 + 3H_2S + HCl = \underbrace{As_2S_3} + 6H_2O + HCl.$$

Ammonic carbonate dissolves arsenious sulphide, especially when heated, from which it can be reprecipitated by means of acids. It is readily dissolved by hot nitric acid; also by hydrochloric acid, with potassic chlorate.

98. AMMONIC SULPHIDE produces no precipitate; simply imparts to the solution a yellow color. If hydrochloric acid be added, a yellow precipitate of ARSENIOUS SULPHIDE is produced, soluble in excess.

$$2H_3AsO_3+3NH_4HS+3HCl=\underbrace{As_2S_3}+3NH_4Cl+6H_2O.$$

99. ARGENTIC NITRATE produces no precipitate in arsenious acid, but if *ammonic hydrate* be cautiously added, a yellow precipitate of ARGENTIC ARSENITE is produced, which dissolves easily in excess of ammonic hydrate and in nitric acid.

$$2H_3AsO_3+4AgNO_3+2NH_4HO=\underbrace{Ag_4As_2O_5}+2NH_4NO_3+2HNO_3 +3H_2O.$$

"In making this test, add the argentic nitrate, and then (incline the test-tube) let one or two drops of ammonia run down so as to form a layer on the surface of the liquid to be tested. Where the two liquids are in contact a bright yellow ring of argentic arsenite ($2Ag_2O.As_2O_3=Ag_4As_2O_5$) will be seen."—(TUTTLE AND CHANDLER.)

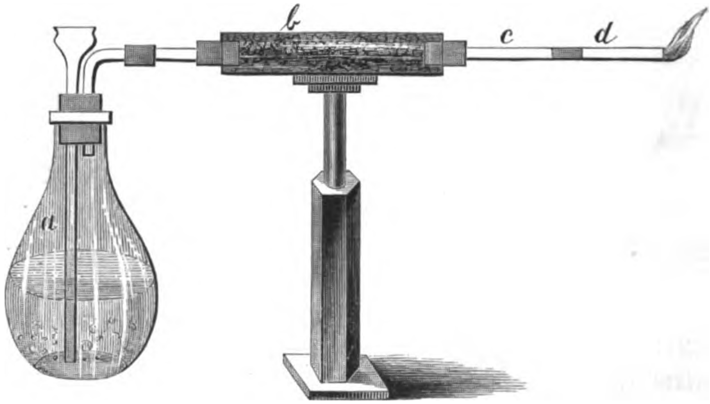
100. CUPRIC SULPHATE produces no precipitate, but if *ammonic hydrate* be added, as in § 94, a YELLOWISH-GREEN CUPRIC ARSENITE (Scheele's green; $2CuO.As_2O_3=Cu_2As_2O_5$) is precipitated.

$$2H_3AsO_3+2CuSO_4+2NH_4HO=\underbrace{Cu_2As_2O_5}+(NH_4)_2SO_4+H_2SO_4 +3H_2O.$$

101. REINSCH'S TEST.—If a solution of arsenious acid, mixed with hydrochloric acid, be heated with a clean strip of METALLIC COPPER, an iron-gray film or incrustation is deposited on the copper even in highly diluted solutions, which is METALLIC ARSENIC; this film may be detached in black scales by long boiling. The thickness of the film depends on the concentration of the solution and the amount of arsenious acid present. The film may be separated from the copper by boiling the strips in ammonic hydrate, when minute spangles separate. If the film separated by boiling water be dried, and introduced into a tube closed at one end, on the application of heat the arsenic is caused to sublime as a shining ring, if much is present, or as a white crystalline ring of arsenious oxide, if the quantity is small.

102. Metallic Zinc.—If arsenious acid is introduced into a flask in which hydrogen gas is being evolved from pure zinc and dilute sulphuric acid, the zinc oxidizes not only at the expense of the oxygen of the water, but also at the expense of that of the arsenious acid, and the arsenic separates accordingly in the metallic state; but a portion of the metal combines in the moment of its separation with the liberated hydrogen of the water, forming HYDROGEN ARSENIDE or ARSINE (H_3As). This reaction affords a means for the detection of even the most minute quantities of arsenic.

103. Marsh's Test.—This experiment is best conducted in the apparatus here figured. Into the flask (*a*) containing granulated (pure) zinc and distilled water, dilute sulphuric acid is introduced. Hydrogen is liberated, which, passing through the calcic chloride tube (*b*), where it is dried, escapes at the extremity of the apparatus. As soon as the air is completely expelled the hydrogen may be ignited.



If the solution containing the arsenic be now poured into the flask, hydrogen arsenide will be evolved, and the flame changed to a *livid blue*.

104. 1. If a piece of cold porcelain (the cover of a porcelain crucible) be held in the flame, a BLACK DEPOSIT of metallic arsenic is produced. The stain DISAPPEARS when moistened with calcic hypochlorite ($Ca2ClO$).

105. 2. If one or two drops of strong nitric acid be poured on an arsenic stain, and then gently evaporated, it is converted into arsenic oxide. By adding a drop of argentic nitrate, and cautiously neutralizing with ammonic hydrate, a brick-red argentic arseniate ($3Ag_2O.As_2O_5 = Ag_6As_2O_8 = 2Ag_3AsO_4$) is produced. An excess of ammonic hydrate dissolves the red arseniate.

106. 3. If tube *c*, *d*, (which should be of hard glass and free from lead) be strongly heated between the points *c* and *d*, the hydrogen arsenide is decomposed, METALLIC ARSENIC being deposited in the form of a SHINING BLACK MIRROR on the cold part of the tube.

107. 4. If a short tube be adjusted, by means of a caoutchouc connector, to the extremity of the tube *c*, *d*, and the gas passed into a solution of ARGENTIC NITRATE, a BLACK PRECIPITATE of metallic silver is produced, while the arsenic passes into solution. On neutralizing the filtered liquid (see § 99) with AMMONIA, the YELLOW ARGENTIC ARSENITE is precipitated.

$$12AgNO_3 + 2AsH_3 + 3H_2O = 12Ag + As_2O_3 + 12HNO_3.$$

108. FLEETMAN'S TEST.—If a solution containing arsenic be mixed with a large excess of a concentrate solution of potassic hydrate, and boiled with granulated ZINC, hydrogen arsenide is evolved. A piece of filter-paper moistened with a solution of ARGENTIC NITRATE, assumes a PURPLISH-BLACK color if exposed to this gas. This experiment may be conducted in a small flask, or large test-tube, supplied with a cork, through which passes a small tube, drawn to a point.

109. BLOWPIPE.—Dry compounds of arsenic, when heated with sodic carbonate on charcoal in the inner flame of the blowpipe, emit a peculiar GARLIC ODOR. This odor has its origin in the reduction and re-oxidation of the arsenic; very minute quantities may be detected in that way.

110. Heated with sodic carbonate and a little potassic cyanide, in a dry tube closed at one end, a black mirror of METALLIC ARSENIC sublimes.

Characteristic Reactions, **92, 93, 100, 101, 104, 105, 106, 107, 109, 110.**

Arsenic Acid, H_3AsO_4.

Solution best fitted for the reactions:

Arsenic Acid $H_3AsO_4.(3H_2O.As_2O_5=2H_3AsO_4)$.

111. Hydrosulphuric acid fails to produce a precipitate in arsenic acid, but if the acid be acidified with hydrochloric acid and the solution warmed and allowed to stand, a yellow precipitate of ARSENIC SULPHIDE, As_2S_5, is produced, which is soluble in ammonic sulphide. It is re-precipitated from this solution by acids.

$$2H_3AsO_4+5H_2S+HCl=\underbrace{As_2S_5}+8H_2O+HCl.$$

112. "In order to separate arsenic oxide completely by hydrosulphuric acid, it is necessary first to reduce it to arsenious oxide by adding a little *sodic sulphite* to the solution. The excess of sulphurous acid is then to be removed by boiling the liquid."—(Tuttle and Chandler.)

113. Ammonic sulphide produces ARSENIC SULPHIDE, which is held in solution as ammonic-arsenic sulphide.

$$2H_3AsO_4+6NH_4HS=NH_4HS.As_2S_5+5NH_4HO+3H_2O.$$

If to this solution an acid be added, the double sulphide is decomposed and arsenic sulphide is precipitated; this precipitate separates more rapidly than in the case of hydrosulphuric acid (§ 111).

$$2H_3AsO_4+5NH_4HS+5HCl=\underbrace{As_2S_5}+5NH_4Cl+8H_2O.$$

114. Argentic nitrate produces, under the circumstances stated in § 105, a brick-red precipitate of ARGENTIC ARSENIATE, easily soluble in nitric acid and in ammonic hydrate. When free nitric acid is present, therefore, it is necessary to neutralize very carefully with ammonic hydrate. As ARGENTIC ARSENIATE is slightly *soluble* in *ammonic nitrate* the precipitate is not always produced.

$$2H_3AsO_4 + 6AgNO_3 + 3NH_4HO = \underbrace{2Ag_3AsO_4} + NH_4NO_3 + 3HNO_3 + 3H_2O.$$

115. Hydrochloric acids or chlorides, if present, should be removed by precipitation with argentic nitrate, a little nitric acid being added to retain the arseniate in solution. If ammonic hydrate is now added to the filtered liquid, the brick-red argentic arsenite ($3Ag_2O.As_2O_5 = 2Ag_3AsO_4$) is precipitated.

116. CUPRIC SULPHATE, under the same circumstances as in § 95, produces a greenish-blue precipitate of cupric arseniate ($2CuO.H_2O.As_2O_5 = Cu_2H_2As_2O_8 = 2CuHAsO_4$), soluble in nitric acid and in ammonic hydrate.

117. METALLIC ZINC behaves the same as with arsenious acid. (See § 97, 98.)

118. METALLIC COPPER (Reinsch's test) acts as with arsenious acid, except that much more hydrochloric acid is to be added in order to insure reduction. (See § 96.)

119. AMMONIO-MAGNESIC ARSENIATE [$2MgO.(NH_4)_2O,As_2O_5 + 12H_2O = Mg_2(NH_4)_2As_2O_8 = 2Mg(NH_4)As.O_4$) is precipitated when arsenic acid is added to a clear mixture of (magnesic sulphate, ammonic chloride, and a sufficient quantity of ammonia). It separates from concentrated solutions immediately, from dilute solutions after some time.

$$2H_3AsO_4 + 2MgSO_4 + NH_4Cl + 6NH_4HO = \underbrace{2Mg(NH_4)AsO_4} + NH_4Cl + 2(NH_4)_2SO_4 + 6H_2O.$$

The above magnesia mixture may be prepared by dissolving in water 24.6 grams of crystallized magnesic sulphate and 33 grams of ammonic chloride, adding some ammonic hydrate and diluting to the volume of a litre.

120. BLOWPIPE.—(See Arsenious Acid, § 109, 110.)

ANTIMONY.

Symbol, Sb. (Arabic, *al-ithruidem*).—Atomic weight, 122.—Equivalence, III and V.—Density, 244 (?)—Molecular weight, 488 (?)—Molecular volume, 2. —1 litre of antimony vapor weighs, 21.86 grams (244 criths) (?)—Sp. Gr. 6.715. —Melts at 450° C.—Atomic volume, 18.16.—Specific heat, 0.0508.—Fusing point, 1150° F.—Electric conductivity at 32° F., 4.65.—Order of brittleness, first.—Bluish-white color.

ANTIMONY OXIDES.

Antimony unites with oxygen to form THREE definite compounds, Sb_2O_3; Sb_2O_4; Sb_2O_5.

ANTIMONIOUS OXIDE, Sb_2O_3, occurs as a natural mineral (Valentinite, white antimony, antimony-bloom, weisspiessglanzez). It may be prepared by burning the metal in the air.

$$2Sb+3O=Sb_2O_3.$$

Easiest mode of obtaining it is to heat antimonious sulphide with strong hydrochloric acid, as long as hydrosulphuric acid goes off, and pour the resulting solution of antimonious chloride into a boiling solution of sodic carbonate. A crystalline powder is then deposited consisting (according to Graham) of antimonious oxide.

$$Sb_2S_3+6HCl=2SbCl_3+\overbrace{3H_2S}.$$

$$2SbCl_3+2Na_2CO_3=\underbrace{Sb_2O_3}+6NaCl+\overbrace{3CO_2}.$$

Regnault, however, states ("Cours de Chimie," iii., 239) that the oxide obtained is a hydrate containing Sb_2O_3, H_2O, or $SbHO_2$ (meta-antimonious acid).

Antimonious oxide dissolves sparingly in water; more freely in strong hydrochloric acid. Dissolves when boiled with AQUEOUS TARTARIC ACID, and very easily in hydropotassic tartrate (cream of tartar), forming antimonio-potassic-tartrate $C_4H_4KSbO_7$ (tartar emetic). It is quite insoluble in *nitric acid* of ordinary strength, but dissolves in cold fuming nitric acid, forming a solution which deposits pearly scales of a nitrate ($N_2O_5.2Sb_2O_3=Sb_4N_2O_{11}$). It dissolves in *fuming sulphuric acid*, the solution depositing shining scales of a sulphate containing $3SO_3.Sb_2O_3=Sb_2S_3O_{12}$.

Antimonic oxide, Sb_2O_5; in the hydrated state antimonic acid. This compound is obtained as a hydrate by treating antimony with nitric acid, or with aqua-regia containing an excess of nitric acid; by precipitating a solution of potassic antimonate with an acid; by decomposing antimonic chloride with water. The hydrate oxide obtained by either of these methods gives off its water at a heat below redness, and yields antimonic oxide as a yellowish powder.

The hydrated oxides obtained by the three methods given above are by no means identical. That obtained by the first and second methods is monobasic, and, according to *Berzelius*, contains $Sb_2O_5.H_2O$, or $SbHO_3$; according to *Fremy*, $Sb_2O_5.5H_2O$, or SbH_5O_5, when dried at mean temperature; but the acid obtained by the action of water on antimonic chloride is dibasic, and contains, according to *Fremy*, $Sb_2O_5.4H_2O$. The acids are antimonic $HSbO_3$; met-antimonic, pyro-antimonic, or di-antimonic, $H_4Sb_2O_7$; ortho-antimonic, H_3SbO_4.

Antimonoso-antimonic oxide, Sb_2O_4.—Some consider this oxide as ($Sb_2O_3+Sb_2O_5=2Sb_2O_4$) a compound of the antimonious and antimonic oxides. This oxide forms salts with the alkalies (often called antimonites), which may be obtained solid. Potassic antimonite, $K_2O.Sb_2O_4$, by mixing the solution of this salt with hydrochloric acid, a precipitate of hydrated antimonoso-antimonic oxide, $H_2O.Sb_2O_4$, is produced. The salt $K_2O.Sb_2O_4$ may be regarded as $(K_2O.Sb_2O_3)+(K_2O.Sb_2O_5)$ or $KSbO_2.KSbO_3$.

METALLIC ANTIMONY.

121. **Heated on charcoal** it burns brilliantly, emitting copious white inodorous vapors, and if left to cool before it is completely burnt away, becomes covered with a white network of the crystallized antimonious oxide. The white fumes form an incrustation on the charcoal.

122. **Hydrochloric acid** does not attack antimony in the solid (compact) state even on boiling; but if the antimony is in a fine powder it is dissolved by the boiling acid, and hydrogen gas is given off.

123. Nitric acid rapidly oxidizes it, forming a white powder, which differs in composition according as the acid used is dilute or concentrated.

Moderately dilute acid, the product consists of antimonious oxide mixed with antimonic oxide ($Sb_2O_3.Sb_2O_5$).

$$12Sb+16HNO_3=3(Sb_2O_3.Sb_2O_5)+8N_2O_2+8H_2O.$$

Dilute acid converts it almost entirely into antimonious oxide.

Concentrated acid converts it almost entirely into antimonic oxide. The acid oxidizes it, but does not dissolve it.

124. Nitrohydrochloric acid dissolves the metal when hot, forming antimonious chloride ($SbCl_3$) when the acid is not very concentrated, and antimonic chloride ($SbCl_5$) when the acid is very concentrated.

$$2Sb+2(3HCl+HNO_3)=2SbCl_3+4H_2O+\overbrace{N_2O_2}.$$

125. Sulphuric acid, when dilute, does not attack antimony; but if heated concentrated acid be employed, the metal is converted into antimonious sulphate ($Sb_2O_3.SO_3=Sb_2SO_6$) with evolution of sulphurous oxide.

$$2Sb+4H_2SO_4\ (conc.)+\Delta\delta=Sb_2SO_6+\overbrace{3SO_2}+4H_2O.$$

SALT OF ANTIMONIOUS OXIDE.

Most of the salts of this oxide are decomposed upon ignition. The soluble neutral salts redden litmus-paper. When heated with a large amount of water, they are decomposed into basic salts and acid solutions. Thus: water precipitates from a hydrochloric acid solution of antimonious chloride ($SbCl_3$), antimonious oxychloride ($2SbCl_3.5Sb_2O_3$) (powder of algaroth). This precipitate is soluble in tartaric acid, therefore it is not precipitated in the presence of this acid.

Solution best fitted for the reactions:

Antimonious Chloride, $SbCl_3$.

126. HYDROSULPHURIC ACID produces an orange-red precipitate of ANTIMONIOUS SULPHIDE (Sb_2S_3) when added to an acid solution of antimonious salts.

$$2SbCl_3 + 3H_2S = \underbrace{Sb_2S_3} + 6HCl.$$

From alkaline and neutral solutions the ANTIMONIOUS SULPHIDE is only partially precipitated.

ANTIMONIOUS SULPHIDE dissolves readily in potassic hydrate and ammonic sulphide, sparingly soluble in ammonic hydrate. Boiling hydrochloric acid (concentrated) dissolves it with evolution of hydrosulphuric acid gas. Boiling nitric acid dissolves a portion, and converts the rest into a white insoluble powder.

127. AMMONIC SULPHIDE produces an orange-red precipitate of antimonious sulphide.

$$2SbCl_3 + 3NH_4HS = \underbrace{Sb_2S_3} + 3HCl + 3NH_4Cl.$$

This precipitate is soluble in excess, especially when the precipitant is rich in sulphur.

128. WATER, when added in large quantities, produces a white precipitate of antimonious oxychloride ($2SbCl_3.5Sb_2O_3$) (according to Duflos and Bucholz), which is soluble in tartaric acid, whereby it is distinguished from bismuth (§ 85). The formation of this precipitate is prevented if tartaric acid or much free hydrochloric acid is added before the addition of the water.

129. POTASSIC HYDRATE produces a white precipitate of antimonious acid ($HSbO_2$ or $Sb_2O_3.H_2O$), which is soluble in excess. This solution precipitates from argentic nitrate, black, metallic silver—the antimonious oxide being changed into antimonic oxide.

This precipitate is readily distinguished from that which is produced by potassic hydrate alone, in silver solutions, by its insolubility in ammonic hydrate. (See § 9.) The presence of tartaric acid prevents the precipitation.

130. AMMONIC HYDRATE produces the same precipitate as potassic hydrate.

131. AMMONIC CARBONATE produces a precipitate of white HYDRATED ANTIMONIOUS OXIDE or ANTIMONIOUS ACID, $HSbO_2$.

$$2SbCl_3 + 3(NH_4)_2CO_3 + H_2O = \underbrace{2HSbO_2} + 6NH_4Cl + \overbrace{3CO_2}.$$

The precipitate is partially soluble in excess. The presence of tartaric acid prevents the precipitation.

132. SODIC CARBONATE produces the same precipitate as ammonic carbonate, viz.: $HSbO_2$.—(REGNAULT.)

$$2SbCl_3 + 3Na_2CO_3 + H_2O = \underbrace{2SbHO_2} + 6NaCl + \overbrace{3CO_2}.$$

133. METALLIC ZINC precipitates antimony from its solution in the form of a BLACK POWDER. If free acid be present, ANTIMONIOUS HYDRIDE, SbH_3, (Stibine) is evolved. This experiment is conducted precisely as in the case of arsenic (§ 102).

134. 1. If a piece of cold porcelain is held in the flame, a BLACK DEPOSIT of metallic antimony is produced, which does not dissolve when treated with calcic hypochlorite (Ca2CO).

135. If one or two drops of nitric acid be poured on the antimony stain, and gently evaporated, it is converted into white ANTIMONIC OXIDE. ARGENTIC NITRATE produces no change. (See § 100.)

136. If the tube *c*, *d*, be strongly heated, a metallic ring is deposited, as in the case of arsenic (§ 101).

137. If ANTIMONIOUS HYDRIDE be passed into a solution of ARGENTIC NITRATE, A BLACK PRECIPITATE of argentic antimonide is produced ($SbAg_3$).

$$3AgNO_3 + SbH_3 = \underbrace{SbAg_3} + 3HNO_3.$$

On neutralizing the filtered liquid by AMMONIC HYDRATE, no precipitate is produced. (Comp. ARSENIC, § 107.)

To detect antimony in argentic antimonide it should be washed, boiled with nitric acid (which dissolves only the antimony), and filtered. Hydrosulphuric acid should then be added to the filtrate, and on boiling, orange-red antimonious sulphide separates.

138. Metallic *zinc* boiled with a solution of antimony, to which a very large excess of POTASSIC HYDRATE has been added, liberates pure hydrogen, which does NOT DISCOLOR paper moistened with a solution of argentic nitrate. (See § 103.)

139. AURIC CHLORIDE, when added to a solution of antimonious chloride or other antimonious salts, forms a YELLOW precipitate of METALLIC GOLD, antimonic oxide at the same time being precipitated as a white powder, unless the solution contains a large excess of hydrochloric acid.

$$4AuCl_3 + 3Sb_2O_3 + 6H_2O = \underbrace{4Au} + 12HCl + 3Sb_2O_5.$$

The reduction is slow at ordinary temperatures, but is accelerated by heating. In a solution of antimonious acid in potassic hydrate, auric chloride produces a black precipitate which forms a very delicate test for antimonious oxide.

140. METALLIC COPPER precipitates antimony from its solutions, in the form of a bright metallic film, which may be dissolved off by a solution of potassic permanganate, yielding a solution which will give the characteristic red precipitate with hydrosulphuric acid.—(ODLING.)

141. BLOWPIPE.—Solid compounds of antimony, mixed with sodic carbonate (and potassic cyanide), and fused on charcoal in the inner flame, yield BRITTLE GLOBULES of METALLIC ANTIMONY, forming at the same time a WHITE INCRUSTATION of antimonious oxide.

CHARACTERISTIC REACTIONS, **123, 128, 129, 134, 135, 136, 137.**

ANTIMONIC OXIDE.

Antimonic oxide (Sb_2O_3) is pale-yellow, its hydrates or acids (H_5SbO_5 ortho-antimonic acid; $HSbO_3$ dimeta-antimonic acid; $H_4Sb_2O_7$ diantimonic acid) are white. The oxide and acids are slightly soluble in water, and almost insoluble in nitric acid, but dissolves pretty readily in hot concentrated hydrochloric acid, forming antimonic chloride, which becomes turbid on addition of water.

Solution best fitted for the reactions:

POTASSIC ANTIMONIATE, $K_2Sb_2O_6$.

142. NITRIC ACID produces a white precipitate of HYDRATED ANTIMONIC ACID ($Sb_2O_5.4H_2O$).

143. HYDROCHLORIC ACID precipitates the same as with nitric acid soluble in excess.

144. HYDROSULPHURIC ACID, in a neutral solution, produces no precipitate. If an excess of hydrochloric acid is present, an orange-red precipitate of antimonic sulphide (Sb_2S_5) is produced.

$$K_2Sb_2O_6 + 5H_2S + 2HCl = \underbrace{Sb_2S_5} + 2KCl + 6H_2O.$$

ANTIMONIC SULPHIDE is soluble in ammonic sulphide, from which it may be precipitated by acids.

145. POTASSIC HYDRATE in ACID solutions precipitates a white hydrate of antimonic acid ($Sb_2O_5.4H_2O$), soluble in excess.

146. ARGENTIC NITRATE produces in solutions of ANTIMONIC OXIDE to which an excess of potassic hydrate has been added, a black precipitate of argentic oxide, which is readily soluble in AMMONIC HYDRATE. This reaction distinguishes antimonic oxide from the salts of antimonious oxide. (See § 129.)

147. ANTIMONIC OXIDE, when boiled with hydrochloric acid and potassic iodide, liberates IODINE, which dissolves in the hydriodic acid present, giving a BROWN COLOR to the solution.

148. POTASSIC METANTIMONIATE ($K_2H_2Sb_2O_7.6H_2O$) is a soluble salt, whilst sodic metantimoniate ($Na_2H_2Sb_2O_7.6H_2O$) is insoluble. This difference in the two salts make the potassic metantimoniate valuable as a test for sodic salts.

149. METALLIC ZINC acts as with antimonious salts (§ 137).

150. BLOWPIPE.—See Antimonious Salts. (See § 141.)

TIN.

Symbol, Sn.—Atomic weight, 118.—Equivalence, II and IV.—Molecular weight, 236.—Brilliant white metal.—Specific gravity, 7.292.—Melts at 230° C.—Atomic volume, 16.20.—Specific heat, 0.0562.—Fusing point, 442° F.—Electric conductivity at 32° F., 12.36.—Order of malleability commencing with gold, fourth; of ductility, seventh; heat-conducting power, seventh.—Tenacity, 63 (iron as 1000).

TIN OXIDES.

Tin unites with oxygen to form three oxides, SnO; Sn_2O_3; SnO_2.

Stannous oxide, SnO, or protoxide, may be prepared by heating stannous oxalate out of contact with the air (Liebig). By precipitating stannous chloride with sodic carbonate, and heating the washed and dried precipitate of stannous hydrate in an atmosphere of hydrogen or carbonic oxide to a temperature not exceeding 80° C., the anhydrous oxide is thus obtained as a brown or black powder (Berzelius). According to Otto, the hydrate sometimes changes to the black oxide on the filter, or the sides of the precipitating vessel, whence it is touched with a glass rod. Stannous oxide is a black powder of specific gravity 6.666 (Berzelius). Permanent in the air at ordinary temperatures, but easily oxidized to stannic oxide when heated. Stannous hydrate, $Sn_2H_2O_3 = 2SnO.H_2O$.

Tin sesquioxide, Sn_2O_3.—This oxide was obtained by Fuchs in combination with water, by diffusing recently-precipitated ferric oxide in a solution of stannous chloride not containing an excess of acid, and afterward boiling the mixture. Sesquioxide of tin is then precipitated.

$$2SnCl_2 + Fe_2O_3 = \underbrace{Sn_2O_3} + 2FeCl_2.$$

Thus obtained is a slimy gray matter; ammonic hydrate dissolves it readily (not so stannous oxide). This oxide produces a purple precipitate with auric chloride (not so stannic oxide).

Stannic oxide, SnO_2, or dioxide, occurs native in tinstone or cassiterite. May be prepared by burning metallic tin in contact with the air. May also be prepared by igniting either of the other oxides or their hydrates in contact with the air. It is a white or yellowish powder, assuming when heated a darker color. Specific gravity, 6.6 to 6.9.

Stannic acid, $SnO_2.H_2O = H_2SnO_3$.

Metastannic acid, $Sn_5O_{10}.5H_2O = H_{10}Sn_5O_{15}$.

The first acid is capable of exchanging the whole of its hydrogen for a metal, and forming stannates, whereas the latter exchanges only one-fifth of its hydrogen metals forming metastannates.

METALLIC TIN.

151. Heated on charcoal, in the outer flame of the blowpipe, it is converted into stannic oxide (SnO_2); in the inner flame it remains unchanged.

$$Sn + O = SnO_2.$$

152. Hydrochloric acid, when dilute and cold, dissolves tin but slowly; when hot and concentrated it is easily dissolved, forming stannous chloride, and liberating at the same time hydrogen.

$$Sn + 2HCl = SnCl_2 + \overbrace{2H}.$$

The presence of much stannous chloride in the solution retards the action of the hydrochloric acid to some extent.

153. Nitric acid when concentrated (Sp. Gr. 1.5) does not act on tin, the metal even preserving its metallic brilliancy; but if the acid be diluted it attacks the metal very violently, converting it, when heated, entirely into metastannic acid =

$$Sn_5H_{10}O_{15} = Sn_5O_{10}.5H_2O + 5SnO_2.5H_2O.$$

According to *Weber*, nitric acid of Sp. Gr. 1.2 converts tin at ordinary temperatures into stannous nitrate, stannic acid, and metastannic acid, which is colored yellow by admixed stannous metastannate.

With nitric acid Sp. Gr. 1.2 it converts tin into (if the liquid is well cooled) metastannic acid [stannic ?] and stannic nitrate; by dilution and heating the stannic acid is converted into *insoluble* metastannic acid, which indeed is always produced under influence of heat. When this product is heated to redness it is converted into stannic oxide.

154. Sulphuric acid, when dilute, dissolves tin slowly (with the aid of heat), and converts it into stannous sulphate, $SnSO_4$, and liberates hydrogen at the same time.

$$Sn + H_2SO_4 = SnSO_4 + \overbrace{2H}.$$

When the acid is concentrated and hot (with plenty of tin) it is dissolved, and converted into STANNIC SULPHATE, and liberating SULPHUROUS OXIDE at the same time.

$$Sn+4H_2SO_4=Sn(SO_4)_2+\overbrace{2SO_2}+4H_2O.$$

STANNOUS SALTS.

The stannous salts are colorless and are readily decomposed by heat. The soluble salts in the neutral state redden litmus-paper. The stannous salts, when exposed to the air, rapidly absorb oxygen, and are converted into salts of stannic oxide. The crystallized stannous chloride only dissolves to a clear liquid in water acidulated with hydrochloric acid.

Solution best fitted for the reactions:

STANNOUS CHLORIDE, $SnCl_2$.

155. HYDROSULPHURIC ACID produces, when added to stannous chloride, a brown precipitate of STANNOUS SULPHIDE (SnS).

$$SnCl_2+H_2S=\underbrace{SnS}+2HCl.$$

The precipitate is dissolved by ammonic sulphide (in excess), which first converts it into stannic sulphide, from which solution it may be precipitated by acids. Nitric acid converts it into insoluble metastannic acid. In alkaline solution, the tin is only partially precipitated by hydrosulphuric acid.

156. AMMONIC SULPHIDE produces the same precipitate as hydrosulphuric acid, soluble in excess if the ammonic sulphide contains an excess of sulphur (known by its bright-yellow color).

157. POTASSIC HYDRATE precipitates STANNOUS HYDRATE ($2SnO.H_2O$) as a white compound which is soluble in excess.

$$2SnCl_2+4KHO=\underbrace{2SnO.H_2O}+4KCl+H_2O.$$

158. AMMONIC HYDRATE produces the same precipitate as potassic hydrate ($2SnO.H_2O+Sn_2H_2O_3$).

$$2SnCl_2+2NH_4HO+H_2O=\underbrace{2SnO.H_2O}+2HN_4Cl+2HCl.$$

The precipitate is insoluble in excess of ammonic hydrate.

159. Sodic carbonate produces the same precipitate as ammonic hydrate.

$$2SnCl_2 + 2Na_2CO_3 + H_2O = \underbrace{2SnO.H_2O} + 4NaCl + CO_2.$$

160. Mercuric chloride produces a white precipitate of mercurous chloride.

$$2HgCl_2 + SnCl_2 = \underbrace{Hg_2Cl_2} + SnCl_4.$$

When much stannous chloride is present, the precipitate is reduced to metal.

$$Hg_2Cl_2 + SnCl_2 = \underbrace{Hg_2} + SnCl_4.$$

This is a very delicate reaction for salts of stannous oxide. (See § 42.)

161. Potassic ferricyanide and ferric chloride, when added to a solution of stannous chloride in hydrochloric acid, produces a precipitate of prussian blue, owing to the reduction of the ferricyanide to ferrocyanide.

$$\left\{\begin{array}{l} K_6(FeC_6N_6)_2 + Fe_2Cl_6 = Fe_2(FeC_6N_6)_2 + 6KCl. \\ K_6Cfy_2 + Fe_2Cl_6 + Fe_2Cfy_2 + 6KCl. \end{array}\right.$$

$$\left\{\begin{array}{l} 2Fe_2(FeC_6N_6)_2 + 2SnCl_2 + 4HCl = \underbrace{Fe_4(FeC_6N_6)_3} + 2SnCl_4 + H_4 \\ \qquad (FeC_6N_6). \\ 2Fe_2Cfy_2 + 2SnCl_2 + 4HCl = \underbrace{Fe_4Cfy_3} + 2SnCl_4 + H_4Cfy. \end{array}\right.$$

The reaction is extremely delicate, but it can be held to be decisive only in cases where no other reducing agent is present.

162. Metallic zinc produces a gray precipitate of tin (Sn), soluble in hydrochloric acid after the removal of the zinc.

163. Blowpipe.—If solid compounds of tin be fused on charcoal with sodic carbonate (and potassic cyanide) in the reducing or inner flame, metallic globules of tin, which are white and malleable, are produced.

Characteristic Reactions, **153, 160, 163.**

STANNIC SALTS.

The salts of stannic oxide are colorless; they are decomposed at red heat. Anhydrous stannic chloride is a volatile liquid, strongly fuming in the air. The soluble salts of stannic oxide in the neutral state redden litmus-paper.

Solution best fitted for the reactions:

Stannic Chloride, $SnCl_4$.

164. Hydrosulphuric acid produces in neutral or acid solutions a yellow precipitate of stannic sulphide (SnS_2).

$$SnCl_4 + 2H_2S = \underbrace{SnS_2}_{} + 4HCl.$$

The precipitate dissolves readily in potassic hydrate, ammonic sulphide, concentrated hydrochloric acid, and aqua-regia. Soluble with difficulty in ammonic hydrate, and insoluble in ammonic carbonate and dilute acids. If the precipitate contains arsenic sulphide, ammonic carbonate will dissolve it. Boiling nitric acid converts it into insoluble stannic oxide, but is dissolved by hot hydrochloric acid to which a little nitric acid has been added.

165. Ammonic sulphide produces the same precipitate as hydrosulphuric acid, soluble in excess, reprecipitated by acids unaltered.

$$SnCl_4 + 2NH_4HS = \underbrace{SnS_2}_{} + 2NH_4Cl + 2HCl.$$

166. Potassic hydrate and sodic hydrate produce a white precipitate of stannic acid ($SnO_2.H_2O = SnH_2O_3$) if acid be present, soluble in excess of potassic or sodic hydrate.

$$SnCl_4 + 4KHO + HCl = \underbrace{SnO_2.H_2O}_{} + 4KCl + H_2O + HCl.$$

$$SnCl_4 + 4NaHO + HCl = \underbrace{SnO_2.H_2O}_{} + 4KCl + HCl + H_2O.$$

167. Ammonic and sodic carbonate produce a white precipitate of an acid stannate.

168. Baric or calcic carbonate produces a precipitate of stannic acid (SnH_2O_3), soluble in excess.

$$SnCl_4+2BaCO_3+H_2O=\underbrace{SnH_2O_3}+2BaCl_2+\overbrace{CO_2}.$$

$$SnCl_4+2CaCO_3+H_2O=\underbrace{SnO_2.H_2O}+2CaCl_2+\overbrace{CO_2}.$$

169. Sodic sulphate produces a white precipitate of stannic acid hydrate, insoluble in excess.

$$SnCl_4+4Na_2SO_4+4H_2O=\underbrace{SnO_2.2H_2O}+4NaCl+4(NaHSO_4).$$

170. Blowpipe.—Same as § 163.

PLATINUM.

Symbol, Pt.—Atomic weight, 197.—Atomic volume, 9.12.—Specific heat, 0.0324.—Specific gravity, 2.15.—Equivalence, II and IV.—Electric conductivity at 69.2° F., 10.53.—Order of malleability commencing with gold, sixth ; of ductility, third ; of heat-conducting power, second.—Tenacity, 494. —Color, white.

PLATINUM OXIDES.

Platinum forms two oxides, $Pt^{II}O$ and $Pt^{IV}O_2$, both of which are *salifiable* bases. According to E. Davy, there is also an oxide of intermediate composition.

Platinous oxide, PtO, is obtained as hydrate ($PtO.H_2O$ or PtH_2O_2) by digesting platinous chloride in a warm solution of potassic hydrate, and washing the precipitate formed.

$$PtCl_2+2KHO+\Delta\delta=\underbrace{PtO.H_2O}+2KCl.$$

Part of the hydrate remains dissolved in the alkali, and may be precipitated by neutralizing the liquid with sulphuric acid. According to Berzelius, it may be converted by a gentle heat into anhydrous platinous oxide (PtO_2).

Dissolves slowly in acids forming unstable salts. Boiling hydrochloric acid resolves it into platinic chloride and metallic platinum. When recently precipitated, it dissolves in potassic hydrate or sodic hydrate, forming platinites, which are formed when metallic platinum is treated with caustic alkalies.

Platinic Oxide, PtO_2.—Döbereiner mixes platinic chloride with an excess of sodic carbonate, evaporates to dryness, heats the mixture gently, and dissolves out the chloride and excess of sodic carbonate with water. There then remains a sodic platinate containing $Na_2O.3PtO_2.6H_2O$, from which nitric acid removes the soda without dissolving the platinic oxide. When platinic hydrate ($PtO_2.2H_2O$) is gently heated, it is converted into anhydrous PtO_2, which is a black powder. Platinic oxide unites with strong bases, forming salts called platinates

PLATINUM SALTS.

The platinic salts are decomposed at a red heat. The solutions redden litmus-paper. Platinic chloride, if heated, is resolved into platinous chloride, then into metallic platinum. The color of most of the salts, yellow; platinic chloride, a reddish-brown; solution, reddish-yellow.

METALLIC PLATINUM.

171. Heated on charcoal, it does not fuse, nor does its surface become tarnished.

172. Hydrochloric acid has no effect on platinum when pure.

173. Nitric acid has no effect on platinum.

174. Nitro-hydrochloric acid dissolves the metal slowly, forming a reddish-yellow solution of platinic chloride ($PtCl_4$).

$$3Pt + 4(3HCl + HNO_3) = 3PtCl_4 + \overbrace{2N_2O_2} + 8H_2O.$$

175. Sulphuric acid has no effect on metallic platinum.

176. Silver alloyed with platinum, the alloy becomes soluble in nitric acid.

PLATINUM SALTS.

Solution best fitted for the reactions:

Platinic Chloride, $PtCl_4$.

177. Hydrosulphuric acid produces a brownish-black precipitate of Platinic sulphide (PtS_2), slowly when cool, rapidly when hot.

$$PtCl_4+2H_2S=\underbrace{PtS_2}+4HCl.$$

The precipitate is soluble with difficulty in ammonic sulphide; insoluble in dilute acids, but soluble to some extent in concentrated nitric acid, and completely dissolved by nitro-hydrochloric acid.

178. Ammonic sulphide precipitates platinic sulphide (PtS_2), soluble in excess.

$$PtCl_4+4NH_4HS=\underbrace{PtS_2}+2NH_4Cl+2HCl.$$

Acids reprecipitate the sulphide unaltered.

179. Ammonic chloride produces a yellow crystalline precipitate of ammonic chloro-platinate [$(NH_4Cl)_2PtCl_4=(NH_4)_2PtCl_6$], slightly soluble in water, *insoluble* in *alcohol.*

$$PtCl_4+2NH_4Cl=\underbrace{(NH_4)_2PtCl_6}.$$

If the solution be very dilute, the precipitate does not appear for some hours.

Ignite the precipitate, and metallic platinum is left in a spongy state.

180. Stannous chloride produces a deep brown-red color (if acid be present), due to the formation of platinous chloride ($PtCl_2$).

If the platinum solution be very dilute, the color is yellow, becoming darker on standing.

Very minute quantities of platinum may be detected by this test.

181. Potassic iodide first colors platinum solutions deep-red; then, on standing, or on the application of heat, a brown precipitate of platinic iodide separates.

$$PtCl_4+4KI=\underbrace{PtI_4}+4KCl.$$

182. Metallic copper or zinc (or formic acid on heating) precipitates platinum as a black powder (Pt), soluble in aqua-regia, but insoluble in either hydrochloric, nitric, or sulphuric acid. It is not removed from the copper by heat. (See § 33, 96.)

Characteristic Reactions, **170, 172, 173, 175, 176, 182.**

GOLD.

Symbol, Au.—Atomic weight, 197.—Equivalence, I and III.—Specific gravity, 19.26.—Orange-yellow metal.—Fuses at 1102° C. (2015.6° F).—Atomic volume, 10.04.—Specific heat, 0.0548.—Electric conductivity at 32° F., 77.96. —Order of malleability, first; ductility, first; heat-conducting power, first.— Tenacity, 273 (iron, as 1000.)

GOLD OXIDES.

Gold forms two well-defined oxides, Au_2O, Au_2O_3, and one of uncertain composition (AuO?).

Aurous oxide, Au_2O, is obtained when aurous chloride is decomposed by a cold potassic hydrate solution.

$$2AuCl+2KHO=\underbrace{Au_2O}+2KCl=H_2O.$$

Aurous oxide is obtained as a green powder, partly dissolved by the precipitant, and soon begins to decompose, being resolved into auric oxide and metallic gold, which is deposited on the sides of the vessel as a slim film, appearing green by transmitted light, like gold-leaf. Potassic hydrate produces no precipitate from auric chloride unless some organic matter is present; if *tannic acid* is added, the precipitate (deep-black) is aurous oxide (Au_2O).

Auric oxide, Au_2O_3, may be produced by adding potassic hydrate to auric chloride, then acetic acid, then boiling the mixture; the precipitate, when dried, is auric oxide (Au_2O_3).

$$\left\{\begin{array}{l} AuCl_3+6KHO=K_3O_3Au+3KCl+3H_2O. \\ K_2O_3Au+3C_2H_4O_2=\underbrace{H_3O_3Au}+3KC_2H_3O_2. \\ \underbrace{2H_3O_3Au}+\Delta\delta=Au_2O_3+3H_2O. \end{array}\right.$$

The oxide may also be prepared by digesting zinc oxide in auric chloride, and decomposing the resulting zinc compound with nitric acid.—(Pelletier.)

It is a brown-black powder; when exposed to sun-light it is very quickly reduced.

Intermediate oxide, AuO?—When stannous chloride and organic substances act on solutions of gold, this oxide (AuO) seems to be produced. Auric chloride stains the skin purple, probably in consequence of the formation of this oxide.

METALLIC GOLD.

183. Heated on Charcoal, it fuses with some difficulty, its surface remains bright, and no incrustation is produced.

184. Hydrochloric acid, when pure, does not act on gold.

185. Nitric acid does not act on gold.

186. Nitro-hydrochloric acid dissolves the metal slowly when cold, more rapidly when aided by heat, producing auric chloride, and liberating nitrogen dioxide.

$$2Au+2(HNO_3+3HCl)=2AuCl_3+4H_2O+\overbrace{N_2O_2}.$$

"The gold of commerce, and also that which is found native, contains more or less silver and copper. If the amount of silver present be small, the gold is readily dissolved in aqua-regia, while the silver remains undissolved as chloride.

"If the proportion of silver be more considerable, the gold is protected, and its solution prevented, by the argentic chloride formed.

"If the silver amount to more than three-fourths of the whole, it may be entirely extracted by nitric acid, leaving the gold undissolved."—(Tuttle and Chandler).

187. Sulphuric acid does not attack gold.

GOLD SALTS.

The oxygen salts are few; there is a sodio-aurous hyposulphite (sulpho-sulphate), $Au_2S_2O_3 . 3Na_2S_2O_3 . 4H_2O$, or $\left\{\begin{matrix}(S_2O)_2\\ Na_3Au\end{matrix}\right\}O_4.2H_2O$, or $Na_3Au(S_2O_3)_2.2H_2O$; the solution of this salt is used for fixing daguerreotype pictures. There is a baryto-aurous hyposulphite (sulpho-sulphate) $\left\{\begin{matrix}(S_2O)_2\\ Ba_3Au\end{matrix}\right\}O_4$, or $Ba_3Au(S_2O_3)_2$; sulphuric acid removes all the barium from this last salt, and forms hydrated aurous hyposulphite (sulpho-sulphate). The haloid salts of gold are yellow, and their solutions continue to exhibit this color up to a high degree of dilution. The whole of them are readily decomposed on ignition. Neutral solution of auric chloride reddens litmus-paper.

Solution best fitted for the reactions:

Auric Chloride, $AuCl_3$.

188. Hydrosulphuric acid precipitates from dilute neutral or acid solutions in the cold auric sulphide (Au_2S_3).

$$2AuCl_3 + 3H_2S = \underbrace{Au_2S_3} + 6HCl.$$

From boiling solutions the precipitate is aurous sulphide, Au_2S.

$$2AuCl_3 + 3H_2S = \underbrace{Au_2S} + 6HCl + \underbrace{2S}.$$

Auric sulphide (Au_2S_3) is a black precipitate; dissolves, as also does aurous sulphide, in yellow ammonic sulphide, particularly if heated. Acids reprecipitate *it* from this solution. Auric sulphide and aurous sulphide are insoluble in hydrochloric, nitric, and sulphuric acid, but dissolves in nitrohydrochloric acid.

189. Ammonic sulphide produces a brownish-black precipitate of auric sulphide (Au_2S_3), soluble in excess if precipitant is rich in sulphur.

$$2AuCl_3 + 3NH_4HS = \underbrace{Au_2S_3} + 3NH_4Cl + 3HCl.$$

190. Oxalic acid on boiling produces even in slightly acid solutions a precipitate of finely divided metallic gold, appearing first as a purple or brown powder, which afterwards separates in the form of flakes. If these flakes are rubbed, they assume a metallic appearance.

$$2AuCl_3 + 3H_2C_2O_4 = \underbrace{2Au} + 6HCl + \overbrace{6CO_2}.$$

"If free hydrochloric or nitric acid are present this precipitate does not occur, but quickly makes its appearance if a little ammonic hydrate be added to the boiling solution. If but a small quantity of gold is present, the liquid simply assumes a purple color."—(Tuttle and Chandler.)

191. Ferrous sulphate produces a precipitate of metallic gold from its solutions, as a bluish-black powder, which becomes yellow and lustrous when rubbed. (The solution must not contain an excess of nitric acid.)

$$2AuCl_3 + 6FeSO_4 = \underbrace{2Au}_{} + Fe_2Cl_6 + 2Fe_23SO_4.$$

192. Antimonious chloride precipitates metallic gold from acid solutions of its chloride, by means of acid solution of antimonious chloride.—(Lovel.)

$$3SbCl_3 + 2AuCl_3 = 3SbCl_5 + \underbrace{2Au}_{}.$$

193. Sulphurous acid, or *sulphurous oxide gas*, when added to a solution of gold, precipitates metallic gold completely.

$$2AuCl_3 + 3H_2O + 3H_2SO_2 = 6HCl + 3H_2SO_4 + \underbrace{2Au}_{}.$$

194. Reaction, which takes place during the process of gilding.

$$6AuCl_3 + 3K_2CO_3 + 6Cu = \underbrace{6Au}_{} + 6CuCl_2 + 5KCl + KClO_3 + \overbrace{3CO_2}^{}.$$

195. Stannous chloride and stannic chloride, when mixed together, produce in very dilute solutions of gold a purple precipitate known as "purple of cassius."

An acid solution of tin sesquioxide, Sn_2O_3, produces the same precipitate: this distinguishes stannic sesquioxide from stannic oxide ($SnO + SnO_2 = Sn_2O_3$).

Berzelius found that when "purple of cassius" was ignited there remained a mixture of *stannic oxide* and *metallic gold*; he proposed to represent it as a compound of the purple gold dioxide, AuO, combined with stannic sesquioxide, Sn_2O_3; hence, $AuO.Sn_2O_3$. A glance at its formula shows how readily the "purple of cassius," as thus represented, may pass into gold and stannic oxide:

$$AuO.Sn_2O_3 = Au + 2SnO_2.$$

"Purple of cassius" is considered by *Figuier* to consist of a hydrated double stannate of gold and tin ($Sn^{II}Au_2O_6.4H_2O = Au_2O.SnO_2.SnO.SnO_2.4H_2O$).

"A very delicate method of making this reaction is as follows: Ferric chloride is added to stannous chloride, until a permanent yellow color is produced; the solution is then considerably diluted. The gold solution, having been likewise very much diluted, is poured into a beaker, which is placed on a sheet of white paper; a glass rod is dipped into the tin-iron solution, and afterwards into the gold solution, when, if even a trace of the precious metal is present, a blue or purple streak will be observed in the track of the glass rod."—(ABEL AND BLOXAM.)

The reaction will indicate by a faint coloring 1 pt. of gold in 64,000 pts. of liquid.

196. POTASSIC IODIDE produces, when added to a neutral solution of auric chloride, a dark-green precipitate of AURIC IODIDE, AuI_3.

When first added the liquid acquires a dark-green color, and yields a dark-green precipitate of auric iodide, which redissolves on agitation; but after 1 at. of the auric iodide has been added to 4 at. of potassic iodide, a further addition of the gold solution decolorizes the liquid, and forms a permanent precipitate of auric iodide, because the auric and potassium iodide at first produced are thereby decomposed.

$$AuCl_3 + 4KI = KI.AuI_3.$$

$$3(KI.AuI_3) + AuCl_3 = \underbrace{4AuI_3}_{} + 3KCl.$$

CHARACTERISTIC REACTIONS, **183, 184, 185, 187, 188, 189, 195.**

SCHEME FOR THE SEPARATION AND DETECTION OF THE MEMBERS OF THE SECOND DIVISION OF GROUP II.

The solution to be examined is supposed to contain a salt of ARSENIC, ANTIMONY, TIN, GOLD, AND PLATINUM.

Add HYDROCHLORIC ACID—NO PRECIPITATE.

Add to the acidified solution hydrosulphuric acid; there is produced a precipitate of

$$\underbrace{As_2Sx + Sb_2Sx + SnSx + Au_2S_3 + PtS_2}_{}.$$

Wash the precipitate well, then add hydrochloric acid and potassic chlorate, and heat gently and filter. Residue is sulphur.

SOLUTION.

$AsCl_3 + SbCl_3 + SnCl_4 + AuCl_3 + PtCl_4$.

Divide the solution into two parts.

FIRST PART.

Test this portion for As, Sb, and Sn.

Concentrate the solution; introduce some of it into a flask containing zinc, water, and dilute sulphuric acid. (§ 133, 102.) Then pass the gas thus generated into a solution of argentic nitrate; a precipitate is produced consisting of silver and argentic antimonide. $Ag + Ag_3Sb$. Filter

PRECIPITATE.

Wash precipitate well, introduce filter, and precipitate in a test-tube; add tartaric acid, and boil for a few minutes. The antimony will dissolve; filter. Residue, Ag. Filtrate will contain the antimony; add hydrosulphuric acid, and boil, when a flocculent orange-red precipitate will be produced: antimonic sulphide. (See § 126.) By this process Hoffman readily detected one part of antimony in the presence of 199 parts of arsenic.

FILTRATE.

Add argentic nitrate, neutralize the clear solution with dilute ammonic hydrate; a precipitate of argentic arsenite is produced. Yellow $Ag_4As_2O_5$. (See § 99, 107.)

SECOND PART.

Test this portion for Au and Pt. Divide into halves.

1st Half.

Add hydrochloric acid, then ferrous sulphate; boil the mixture; there is precipitated metallic gold. Filter, wash, dry the precipitate, and fuse on charcoal with borax to a globule, yellow. (See § 191.)

2d Half.

Add a little ammonic chloride, evaporate to dryness over a water-bath, and treat with alcohol. An orange-red residue $(NH_4Cl)_2.PtCl_4$ indicates platinum. (See § 182.)

DETECTION OF TIN.—The tin is precipitated in the flask by the zinc, as a gray metallic powder. It is necessary to detach the tin from the zinc, etc., by agitation; then transfer the tin to another vessel; wash it; then boil in hydrochloric acid; filter if necessary. Add mercuric chloride; there is produced a precipitate of mercurous chloride. (See § 160.)

SCHEME FOR THE SEPARATION AND DETECTION OF THE MEMBERS OF GROUP II.

The solution to be examined is supposed to contain mercuric oxide, copper, cadmium, lead, bismuth, arsenic, antimony, tin, gold, and platinum.

Add hydrochloric acid—NO PRECIPITATE.

Add hydrosulphuric acid, and pass the gas through the solution; there is precipitated

$$\underbrace{Bi_2S_3 + PbS + HgS + CdS + CuS + As_2Sx + Sb_2Sx + Au_2S_3 + PtS_2.}$$

Filter, and wash the precipitate well; then add YELLOW AMMONIC SULPHIDE; warm gently and filter; wash.

<table>
<tr><th colspan="2">RESIDUE.</th><th>SOLUTION.</th></tr>
<tr><td colspan="2">Will contain the PbS, CuS, BiS_2—HgS—CdS. Wash well to remove chlorine. (Test with argentic nitrate.) Boil the precipitate with nitric acid; filter · wash.</td><td rowspan="3">Will contain the As, Sb, Sn, Au, and Pt. Add dilute sulphuric acid; there is precipitated
$\underbrace{As_2S_3 + Sb_2S_3 + SnS_2 + Au_2S_3 + PtS_2 + S.}$
Filter and wash; dissolve in hydrochloric acid and potassic chlorate.
$AsCl_3 + SbCl_3 + SnCl_4 + AuCl_3 + PtCl_4.$
Treat according to scheme.</td></tr>
<tr><td><i>Residue.</i></td><td><i>Solution.</i></td></tr>
<tr><td>HgS + S.</td><td>Contains the Pb, Cu, Bi, and Cd. Treat according to scheme.</td></tr>
</table>

GROUP III.

Metals NOT PRECIPITATED BY HYDROCHLORIC ACID, *nor from their acid solutions* BY HYDROSULPHURIC ACID, but PRECIPITATED BY AMMONIC SULPHIDE:

Aluminum, chromic oxide salts, zinc, iron, cobalt, nickel, manganese.

ALUMINUM.

Symbol, Al. (Latin, *alumen, alum*).—Atomic weight, 27.4—Equivalence $(Al_2)^{VI}$.—Specific gravity, 2.5 to 2.67.—Specific heat, 0.202.—Electric conductivity at 67.2° F., 23.76.—Atomic volume, solid, 10.56.—Malleable white metal.

ALUMINUM OXIDE.

Aluminum unites with oxygen to form one oxide, Al_2O_3.

ALUMINIC OXIDE, Al_2O_3, may be prepared by burning metallic aluminum in a fine state of division, either in the air or in oxygen.

$$2Al + 3O = Al_2O_3.$$

By precipitating a boiling solution of common alum ($Al_3O_3 3SO_4 + K_2SO_4 = Al_2S_3O_{15}.K_2SO_4$), free from iron, with ammonic carbonate, washing the precipitate well with water, and igniting it to expel the combined water.—(WATTS.)

By igniting aluminic sulphate or ammonia alum. In the former case sulphuric oxide is given off; in the latter, that compound, together with ammonic sulphate; an aluminic oxide remains.

$$Al_2 3SO_4 + \Delta\delta = Al_2O_3 + \overbrace{3SO_3}.$$

$$Al_2(NH_4)_2 4SO_4 + \Delta\delta = Al_2O_3 + (NH_4)_2SO_4 + \overbrace{3SO_3}.$$

Artificially prepared aluminic oxide is white, Sp. Gr. 3.87 and 3.90.

Aluminic monohydrate, $Al_2O_3.H_2O = Al_2H_2O_4$.
Aluminic dihydrate, $Al_2O_3.2H_2O = Al_2H_4O_5$.
Aluminic trihydrate, $Al_2O_3.3H_2O = Al_2H_6O_6$.
$Al_2Cl_6 + Na_6O_6Al_2 + 6H_2O = 2Al_2O_3.3H_2O + 6NaCl$.

Aluminic hydrate (trihydrate, $Al_2O_3.3H_2O$ or $Al_2H_6O_6$) forms compounds called aluminates; the hydrogen can be replaced by an equivalent quantity of various metals.

METALLIC ALUMINUM.

197. Heated on charcoal, it fuses, and becomes tarnished on the surface, owing to the formation of aluminic oxide (Al_2O_3).

198. Hydrochloric acid, either dilute or concentrated, dissolves it readily, even at low temperatures, forming aluminic chloride (Al_2Cl_6), with evolution of hydrogen.

$$2Al + 6HCl = Al_2Cl_6 + \overbrace{6H}.$$

199. Nitric acid, either dilute or concentrated, does not attack aluminum, at ordinary temperatures, and very slowly even at the boiling heat.

200. Sulphuric acid, when *hot* and *dilute*, dissolves it slowly, evolving hydrogen. Neither concentrated or dilute acid attacks aluminum in the cold.

201. Potassic hydrate dissolves it readily; caused by the rapid oxidation of the metal, evolving hydrogen, and forming potassic aluminate, which remains in solution.

$$Al_2 + 6KHO = (KO)_6Al_2 + \overbrace{6H}.$$

$$Al_2 + 6NaHO = (NaO)_6Al_2 + \overbrace{6H}.$$

ALUMINUM SALTS.

Some of the aluminum salts are soluble, and some not; most of them are colorless. Aluminic chloride (Al_2Cl_6) is a yellow crystalline volatile solid.

The soluble salts have a sweetish, astringent taste, redden litmus-paper, and lose their acid upon ignition. The insoluble salts are dissolved by hydrochloric acid with the exception of certain native compounds.

Solution best fitted for the reactions:

Alum [$Al_2.3SO_4 + K_2SO_4 + 12H_2O = Al_2K_2(SO_4)_4.12H_2O$].

202. Ammonic sulphide produces a white precipitate of aluminic hydrate ($Al_2O_3.3H_2O$ or $Al_2H_6O_6$), hydrosulphuric gas being evolved. The precipitate is insoluble in excess, but soluble in hydrochloric and other acids.

$$Al_2K_2(SO_4)_4 + 6NH_4HS + 6H_2O = \underbrace{Al_2H_6O_6}_{} + 3(NH_4)_2SO_4 + K_2SO_4 + \overbrace{6H_2S}^{}.$$

203. Ammonic hydrate produces a white, gelatinous precipitate of aluminic hydrate ($Al_2H_6O_6$), but slightly soluble in excess. Insoluble if ammonic chloride be present, but soluble in hydrochloric and other acids.

$$Al_23SO_4.K_2SO_4 + 6NH_4HO = \underbrace{Al_2H_6O_6}_{} + K_2SO_4 + 3(NH_4)_2SO_4.$$

"In very dilute solutions the precipitate can hardly be distinguished by the eye. On boiling, or shaking, however, it becomes visible, being frequently carried to the surface of the liquid by entangled air-bubbles."—(Tuttle and Chandler.)

204. Ammonic carbonate produces a white precipitate of aluminic hydrate and hydroammonic carbonate ($Al_2H_6O_6 + NH_4.H.CO_3$), the ammonic salt not being removed by washing. —(H. Rose.) (Pogg. Ann. xli. 462.)

205. Sodic carbonate produces a white precipitate, which after being washed and dried, then triturated with water, again washed and dried over sulphuric acid, consists of pure aluminic hydrate ($Al_2H_6O_6$).—(James Barret, Chem. News, i. 110.)

206. Potassic hydrate produces the same precipitate as ammonia, soluble in excess, and forming at the same time potassic aluminate.

$$Al_23SO_4.K_2SO_4 + 6KHO = \underbrace{Al_2K_6O_6}_{} + K_2SO_4 + 3H_2SO_4.$$

If the solution now containing POTASSIC ALUMINATE be mixed with aluminic chloride, the aluminum from both compounds will be precipitated as ALUMINIC OXIDE:

$$Al_2K_6O_6+Al_2Cl_6=\underbrace{2Al_2O_3}+6KCl.$$

The aluminum may be precipitated as ALUMINIC HYDRATE, by first acidulating with hydrochloric acid, and then adding ammonic hydrate.

$$Al_2K_6O_6+6HCl+NH_4HO=\underbrace{Al_2H_6O_6}+6KCl+NH_4HO.$$

Sodic silicate, $Na_2O.SiO_2$, precipitates when added to a solution of potassic aluminate, ALUMINIC SILICATE ($Al_2Si_3O_9$ or $Al_2O_3.3SiO_2$?).

207. SODIC PHOSPHATE (ortho), when added to a solution of alum, produces a precipitate which, in the anhydrous state, has the composition ($8Al_2O_3.9P_2O_5$).—(LUDWIG.)

But when the alum solution is carefully added to the sodic phosphate, a precipitate of the neutral salt ($Al_2O_3.P_2O_5.6H_2O$ or $Al^{iii}PO_4.3H_2O$, or with 4 at. or 4½ at. of H_2O) is produced.

$$2Na_2HPO_4+Al_23SO_4.K_2SO_4+6H_2O=\underbrace{Al_2O_3.P_2O_5.6H_2O}$$
$$+2Na_2SO_4+H_2SO_4+K_2SO_4.$$

The precipitate varies in composition, according to the proportions of the acting solution, the temperature at which they are mixed, and the extent to which the precipitate is washed.

The precipitates are soluble in hydrochloric acid and reprecipitated by ammonic hydrate. Precipitates are soluble in excess of potassic hydrate, and reprecipitated by an excess of acetic acid, in which they are nearly insoluble. By this behavior they are distinguished from aluminic hydrate ($Al_2H_6O_6$).

If sodic silicate ($Na_2O.SiO_2$) is added to the solution of aluminic phosphate in potassic hydrate, the aluminum is precipitated as silicate ($Al_2O_3.3SiO_2$?), while the phosphoric acid remains in solution.

208. Blowpipe.—If any of the compounds of aluminum be heated on charcoal, then moistened with a few drops of cobaltic nitrate ($Co2NO_3$) solution, and again strongly ignited, an infused mass of deep sky-blue color is·produced, which consists of a compound of the two oxides.

By candle-light it appears violet. Many *fusible* compounds, *free from aluminic compounds*, assume the same color.

Characteristic Reactions, **203, 206.**

CHROMIUM.

Symbol, Cr. (Greek, *croma,* color).—Atomic weight, 52.12.—Equivalence, II, IV, VI.—Also a pseudo-triad $(Cr_2)^{VI}$.—Specific gravity, 7.01.—Discovered by Vauquelin in 1797.—Atomic volume, 7.00.

CHROMIUM OXIDES.

Chromium unites with oxygen to form several compounds: CrO; Cr_2O_3; CrO_3; Cr_3O_4, which is intermediate between CrO and Cr_2O_3; and several oxides intermediate between Cr_2O_3 and CrO_3.

Chromous oxide, CrO.—This compound exists in some specimens of chromic iron and in pyrope. It is precipitated as hydrate by the action of potassic hydrate on a solution of chromous chloride ($CrCl_2$). Chromous hydrate, $2CrO.H_2O$ or $Cr_2H_2O_3$, is very unstable, decomposing water at ordinary temperatures; unless protected from the air by precipitating from a well-boiled solution of potassic hydrate, it is converted as soon as formed into chromoso-chromic oxide, with evolution of hydrogen. Yellow when precipitated, brown when dry. (Dry in atmosphere of hydrogen.) When ignited it gives off hydrogen forming chromic oxide (Cr_2O_3).

$$2CrO.H_2O + \Delta\delta = Cr_2O_3 + \overset{\frown}{2H}.$$

The anhydrous chromous oxide (CrO) has not as yet been obtained.

Chromoso-chromic oxide, Cr_3O_4 or $CrO.Cr_2O_3$, may be prepared by precipitating chromous chloride ($CrCl_2$) with potassic hydrate, without excluding the air. After washing in water and drying in the air, it has the color of Spanish tobacco. It is but slightly attacked by acids.

Chromic oxide, Cr_2O_3.—This oxide exists in chrome-iron ore and in chrom-ochre. It may be prepared by igniting mercurous chromate (Hg_2CrO_4), or ammonic di-chromate [$(NH_4)_2Cr_2O_7$].

$$4Hg_2CrO_4 + \Delta\delta = 2Cr_2O_3 + 8Hg + \overbrace{10O}.$$

$$(NH_4)_2Cr_2O_7 + \Delta\delta = Cr_2O_3 + 4H_2O + \overbrace{2N}.$$

By passing chlorochromic anhydride (CrO_2Cl_2) through a red-hot porcelain tube:

$$4CrO_2Cl_2 + \Delta\delta = 2Cr_2O_3 + \overbrace{8Cl} + \overbrace{2O}.$$

By passing chlorine gas over ignited potassic di-chromate:

$$K_2Cr_2O_7 + \Delta\delta + 2Cl = Cr_2O_3 + 2KCl + \overbrace{4O}.$$

Chromic oxide obtained by any of these processes has a dark-green color.

Chromic Hydrates.—When chromic chloride (Cr_2Cl_6) is boiled with an excess of potassic hydrate, a precipitate of ($Cr_2O_3.4H_2O$ or $Cr_2H_8O_7$) (Ordway) is produced.

$$Cr_2Cl_6 + 6KHO + 4H_2O = \underbrace{Cr_2O_3.4H_2O} + 6KCl + 3H_2O.$$

By treating the chloride with sufficient potassic hydrate to redissolve the precipitate first formed, and neutralizing the excess of alkali with hydrochloric acid, another hydrate is obtained. A third hydrate is obtained by precipitating a solution of a chromic salt with excess of ammonic hydrate. The dried precipitate thus obtained is, according to Schaffner, $Cr_2O_3.6H_2O$ or $H_{12}Cr_2O_9$.

$$Cr_23SO_4 + 3NH_4HO + 6H_2O = \underbrace{Cr_2O_3.6H_2O} + 3NH_4HSO_4.$$

When chromic salts are treated with an excess of sodic hydrate, and heated, a gelatinous hydrate ($Cr_2O_3.5H_2O$ or $H_{10}Cr_2O_8$) of fine green color is precipitated.

$$Cr_23SO_4 + 6NaHO + 5H_2O + \Delta\delta = \underbrace{Cr_2O_3.5H_2O} + 3Na_2SO_4 + 3H_2O.$$

The same hydrate is obtained by pouring a chromic salt of either modification into excess of the boiling alkali solution.

When a solution of *violet* chrom-alum [$K_2Cr_2(SO_4)_4.12H_2O$] is poured into an excess of ammonic hydrate, and heated not above 50° C., a grayish-green pulverulent precipitate is formed having the composition ($Cr_2O_3.7H_2O$ or $H_{14}Cr_2O_{10}$) (Lefort). Dissolves in acids with violet color.

$$K_2Cr_2(SO_4)_4+7H_2O+3NH_4HO+\Delta\delta=\underbrace{Cr_2H_{14}O_{10}}+3NH_4HSO_4 +K_2SO_4.$$

If the ammoniacal solution is left to evaporate in the air or over oil of vitriol, a hydrate ($Cr_2O_3.9H_2O$ or $H_{18}Cr_2O_{12}$) is obtained. When dry, it forms a grayish-violet, very light powder; when dissolved in acids, it yields red salts.—(Lefort.)

Emerald-green of Panetier is obtained by melting in a crucible a mixture of equivalent quantities of boric-anhydride and hydropotassic chromate, and treating the fused mass with water, when mono-metachromic hydrate ($Cr_2O_3.2H_2O=Cr_2H_4O_5$) is obtained. By washing this hydrate and triturating it, a brilliant green powder is obtained.—(Guignet.)

Chromium peroxide, $Cr_2O_3.CrO_3=Cr_3O_6$ or $2(CrO_2)$. The precipitate formed by ammonic hydrate, when added to chromic sulphate mixed with hydropotassic chromate is ($2CrO_2.H_2O$) (Vogel). The black substance obtained by heating chromic anhydride (trioxide) to 200°C. is, according to Traube, normal chromic chromate, $Cr_2O_3.3CrO_3$ or Cr_5O_{12}. The precipitate formed by mixing the solution of chrom-alum and neutral potassic chromate, when dried at 100° C. is ($3Cr_4O_3.2Cr_2O_3.9H_2O = Cr_{16}O_{15}.9H_2O = Cr_{16}H_{18}O_{24}$). Chromic hydrate digested with excess of chromic acid, yields a dark-brown solution, which dries up to a residue containing according to Maus ($Cr_2O_3.4CrO_3 = 3Cr_2O_5$).

Chromic trioxide (anhydride), CrO_3, may be prepared by pouring 1 vol. of potassic di-chromate in a thin stream into 1½ vol. of sulphuric acid, stirring all the while. As the liquid cools, chromic trioxide crystallizes from it in crimson needles often an inch long.

Chromic trioxide melts at 190° C., and begins to decompose at 250° C.; gives off oxygen, leaving a brown oxide chromic chromate, which, when further heated, is reduced to chromic oxide. Chromic trioxide is a powerful oxidizing agent, being quickly reduced to chromic oxide by sulphydric acid, zinc, arsenious acid, tartaric acid, sugar, alcohol, and various other organic bodies, especially when heated.

$$2CrO_3 + 3H_2S = Cr_2O_3 + 3H_2O + S_3.$$

$$2CrO_3 + 12HCl = Cr_2Cl_6 + 6H_2O + Cl_6.$$

Sulphurous acid added to a solution of a chromate throws down a brown precipitate, consisting of ($Cr_2O_3.CrO_3 = Cr_3O_6 = 3CrO_2$), which is chromium peroxide.

Perchromic acid, $H_2Cr_2O_8$, or ($HCrO_4$).—When hydrogen peroxide dissolved in water is mixed with a solution of chromic acid, the liquid assumes a deep indigo-blue color, but often loses this color very rapidly, giving off oxygen at the same time. The same blue color is obtained by adding a mixture of aqueous hydrogen peroxide and sulphuric or hydrochloric acid to potassic di-chromate, but in a very short time oxygen is evolved, and chrom-alum is left in solution. For each atom of potassic di-chromate 4 at. oxygen are evolved, provided an excess of hydrogen peroxide be present. We may therefore suppose that perchromic acid, $H_2Cr_2O_8$, is first formed by the union of HO (H_2O_2) with CrO_3, and afterwards resolved into oxygen and chromic hydrate.—(Barreswil.)

$$H_2Cr_2O_8 = H_2Cr_2O_4 + \widetilde{O_4}.$$

According to *Storer*, the coloring power of perchromic acid is so great, that when a solution of 1 pt. potassic di-chromate in 30.000 to 40.000 pts. water is shaken up with ether containing hydrogen peroxide, the ether acquires a perceptible blue tint; he therefore recommends this reaction as a very delicate test for chromic acid. *Schönbein* applies it as a test for hydrogen peroxide.

METALLIC CHROMIUM.

209. Heated.—Wöhler's chromium, when heated in the air to redness, acquires yellow and blue tarnish like steel, and gradually becomes covered with a film of *green oxide;* but the oxidation is by no means complete.

Peligot's chromium oxidizes with great facility, taking fire in the air, even at a heat below redness, and being converted into green chromic oxide, Cr_2O_3.

Deville says when chromium is pure it is even less fusible than platinum.

> "The properties of chromium differ considerably, according to the manner in which it is prepared, the peculiarity doubtless depending chiefly on the state of aggregation."

210. Hydrochloric acid dissolves Wöhler's chromium, forming blue chromous chloride ($CrCl_2$) and evolving hydrogen.

$$Cr + 2HCl = CrCl_2 + \overbrace{2H}.$$

Peligot's chromium also dissolves in hydrochloric acid.

Fremy's crystals of chromium are not attacked by any acid, not even by nitromuriatic acid.

211. Nitric acid *does* not attack Wöhler's chromium when either dilute or concentrated.

Peligot's chromium is oxidized by nitric acid.

$$2Cr + 8HNO_3 = Cr_26NO_3 + \overbrace{N_2O_2} + 4H_2O.$$

Fremy's chromium is not attacked.

212. Sulphuric acid when dilute and heated dissolves Wöhler's and Péligot's chromium, forming chromic sulphate (?) (Cr_23SO_4) and evolving sulphurous oxide.

$$2Cr + 6H_2SO_4 = Cr_23SO_4 + \overbrace{3SO_2} + 6H_2O.$$

Fremy's crystals are not attacked.

213. Nitromuriatic acid dissolves Wöhler's and Péligot's chromium, but does not even attack Fremy's crystals of chromium.

CHROMIUM SALTS.

The chromic salts exhibit two principal modifications, the *green* and the *violet.* Most of the salts dissolve in hydrochloric acid retaining their color, but if heated, a green color is produced. Many of the salts are soluble in water, which salts redden litmus-paper. Chromic salts containing a volatile acid are decomposed upon ignition. Chromous salts are but little known, but CHROMOUS CHLORIDE ($CrCl_2$) is one of the most powerful deoxidizing agents known.

Solution best fitted for the reactions:

CHROM-ALUM or POTASSIC CHROMIC SULPHATE [$Cr_2O_3.3SO_3.K_2O.SO_3.12H_2O = Cr_2K_2(SO_4)_4.12H_2O$].

214. AMMONIC SULPHIDE produces a white precipitate of HYDRATED CHROMIC OXIDE ($Cr_2O_3.9H_2O$).

$$Cr_2K_2(SO_4)_4 + 3NH_4HS + 12H_2O = \underbrace{Cr_2O_3.9H_2O} + 3NH_4HSO_4 + K_2SO_4 + \overbrace{3H_2S}.$$

The precipitate is *insoluble* in excess, but soluble in acids.

215. AMMONIC HYDRATE produces in solutions of the *green chromic salts*, a GRAYISH-GREEN PRECIPITATE; in solutions of the *violet chromic salts*, a GRAYISH-BLUE PRECIPITATE, both of which yield green solutions with sulphuric or hydrochloric acid. The liquid above the precipitate has a reddish color, and contains a *small* quantity of *chromic acid*, which may be precipitated by boiling the mixture. The precipitate formed when ammonic hydrate is added in excess is ($Cr_2O_3.6H_2O$), or $H_{12}Cr_2O_9$ when dried.—(SCHAFFNER.)

$$Cr_2K_2(SO_4)_4 + 3NH_4HO + 6H_2O = \underbrace{Cr_2O_3.6H_2O} + 3NH_4HSO_4 + K_2SO_4.$$

LEFORT states that if a violet solution of chrom-alum be poured into *excess of ammonic hydrate*, and *heated* to a temperature not exceeding 50° C., a *grayish-green pulverulent* *precipitate* is produced, having the composition ($Cr_2O_3.7H_2O = H_7CrO_5$), dissolving in acids to a violet color.

Fremy states that when ammonic hydrate is added to a violet chromic salt, there is a precipitate produced, which, when dried in vacuo, has the composition ($Cr_2O_3.9H_2O$).

$$Cr_2K_2(SO_4)_4+3NH_4HO+9H_2O=\underbrace{Cr_2O_3.9H_2O}+3NH_4.HSO_4+K_2SO_4.$$

It dissolves in acetic acid, ammonic hydrate, and dilute potash-ley. Its properties are liable to considerable alterations; thus, by the action of boiling water, or by prolonged contact with cold water, by the action of concentrated saline solutions, by desiccation for several days in the air or in vacuo, and trituration, it is rendered *insoluble* in liquids in which it was previously *soluble*. Frémy is of the opinion that these alterations result from an *allotropic modification* of the chromic oxide, and *not* from *loss* of water. He applies the term CHROMIC OXIDE to the oxide which has been rendered insoluble in acetic acid, potassic hydrate, and ammonia in the manner just mentioned, and METACHROMIC OXIDE to that oxide which is soluble in these reagents, and is precipitated by ammonic hydrate from a violet chromic salt.

216. Potassic hydrate produces a precipitate of HYDRATED CHROMIC OXIDE, which is soluble in excess, but reprecipitated by boiling, as ($Cr_2O_3.5H_2O=CrH_5O_4$, according to Lefort).

$$Cr_2K_2(SO_4)_4+6KHO+5H_2O=\underbrace{Cr_2O_3.5H_2O}+4K_2SO_4+3H_2O.$$

$$Cr_2K_2(SO_4)_4+6NaHO+5H_2O=\underbrace{Cr_2O_3.5H_2O}+3Na_2SO_4+K_2SO_4+3H_2O.$$

According to Frémy, the precipitate is ($Cr_2O_3.9H_2O=2CrH_9O_6$).

$$Cr_2K_2(SO_4)_4+6KHO+9H_2O=\underbrace{Cr_2O_3.9H_2O}+4K_2SO_4+3H_2O.$$

$$Cr_2K_2(SO_4)_4+6NaHO+9H_2O=\underbrace{Cr_2O_3.9H_2O}+3Na_2SO_4+K_2SO_4+3H_2O.$$

If the green solution of chromic oxide in potassic hydrate be boiled with plumbic oxide (or plumbic orthoplumbate), the chromic oxide is *converted* into CHROMIC TRIOXIDE, plumbic oxide at the same time being dissolved. If the liquid be filtered and then acidulated with *acetic acid*, yellow PLUMBIC CHROMATE ($PbCrO_4$) is precipitated.

"When the *chromic oxide* is mixed with much *ferric oxide*, it is not dissolved by excess of potassic hydrate."—(TUTTLE AND CHANDLER.)

217. ZINC, immersed in a solution of chrom-alum or chromic chloride, excluded from the air, *gradually reduces* the *chromic salt* to a *chromous salt*, the liquid after a few hours acquiring a fine blue color, and hydrogen being evolved by decomposition of the water. If the zinc be left in the solution for some time, the whole of the metal is precipitated in the form of a basic chromous salt, and its place taken by the zinc.

TIN likewise, at a boiling heat, reduces the chromic salt to a chromous salt, but only to a limited extent; and on leaving the liquid to cool after the action has ceased, a contrary action takes place, the chromous chloride decomposing the stannous chloride previously formed, *reducing* the *tin* to the metallic state, and being itself *reconverted* into chromic chloride.

Iron does not reduce chromic salts to chromous, but simply precipitates a *basic chromic sulphate* or an *oxychloride* as the case may be.

218. BLOWPIPE.—If any compound of chromium be fused on charcoal or on a platinum-foil with a little potassic nitrate and sodic carbonate, a YELLOW MASS of POTASSIC CHROMATE is obtained. If this be dissolved in a little water, an excess of acetic acid and a few drops of plumbic acetate added, a YELLOW precipitate of PLUMBIC CHROMATE ($PbCrO_4$) is obtained.

219. BORAX.—Compounds of chromium are dissolved in borax, both in the oxidizing and reducing flame, to clear beads of a faint *yellowish-green tint*, which, upon cooling, changes to EMERALD-GREEN.

CHARACTERISTIC REACTIONS, **215, 216, 218, 219.**

ZINC.

Symbol, Zn.—Atomic weight, 65.—Equivalence, II.—Density, 32.5.—Molecular weight, 65.—Molecular volume, 2.—Hard and brittle at ordinary temperatures and at 200° C., but between 100° C. and 150° C. it is malleable and ductile.—Melts at 412° C.—Boils at 1040° C., evolving vapor having half the nominal density.—Atomic volume, 13.76.—Specific heat, 0.0935.—Specific gravity, 7.13.—Electric conductivity at 32° F., is 29.02.

ZINC OXIDES.

Only one well-defined oxide is known—ZINCIC OXIDE, ZnO. *Berzelius* regards the gray film which forms on zinc when exposed to the air as the SUBOXIDE (Zn_2O). *Thénard* also states that a glutinous *peroxide* (ZnO_2) is produced by the action of hydric peroxide on hydrated zinc oxide.

ZINCIC OXIDE, ZnO, occurs native contaminated with manganese oxide as *zincite*, and comprised with ferric and manganic oxides as *Franklinite.* When zinc is burnt in the air, this oxide is produced.

$$Zn + O = ZnO.$$

Ordinary oxide is a white amorphous powder. Specific gravity, 5.6. When heated, assumes a *yellow* color, but becomes *white* again on cooling.

ZINC SALTS.

Zincic salts are colorless; part of them are soluble in water, and the rest in acids. The neutral salts which are soluble in water redden litmus-paper, and are readily decomposed by heat, with the exception of *zincic sulphate*, which can bear a dull red heat, without being decomposed. *Zincic chloride* is *volatile* at a red heat.

METALLIC ZINC.

220. HEATED ON CHARCOAL, it fuses and burns with a white flame, forming ZINCIC OXIDE (ZnO), some of which is deposited as an incrustation, *yellow* while hot, and *white* when cold.

$$Zn + O = ZnO.$$

221. Hydrochloric acid dissolves zinc, forming zincic chloride ($ZnCl_2$), with evolution of hydrogen.

$$Zn+2HCl=ZnCl_2+\overbrace{2H}.$$

If a strip of platinum or copper be put into the solution, a galvanic current is formed, and the zinc dissolves very rapidly.

222. Nitric acid dissolves it readily, forming zincic nitrate ($Zn2NO_3$). If the acid be concentrated, nitrogen dioxide (N_2O_2) is given off; if very dilute, nitrogen monoxide (N_2O) is given off.

$$Zn+4HNO_3=Zn2NO_3+\overbrace{N_2O_2}+2H_2O.$$

$$4Zn+10HNO_3=4Zn(NO_3)_2+\overbrace{N_2O}+5H_2O.$$

223. Sulphuric acid, when diluted, readily dissolves it, forming zincic sulphate ($ZnSO_4$) and liberating hydrogen.

$$Zn+H_2SO_4=ZnSO_4+\overbrace{2H}.$$

Concentrated acid has scarcely any action in the cold.

> "All acids soluble in water, even the organic acids (if not too diluted), dissolve zinc. *Hydrogen* is liberated in every case, except where sulphurous acid is employed. In this case zincic hyposulphite (ZnS_2O_4) and zincic sulphate ($ZnSO_4$) are formed, and *no gas liberated.*"—(Tuttle and Chandler.)

224. Potassic hydrate, sodic hydrate, and even ammonic hydrate, when boiled with zinc, dissolve it, forming potassic zincate (K_2ZnO_2), sodic zincate (Na_2ZnO_2), and ammonic zincate [$(NH_4)_2ZnO_2$], with evolution of hydrogen.

$$Zn+2KHO=K_2O_2Zn+\overbrace{2H}.$$

$$Zn+2NaHO=Na_2ZnO_2+\overbrace{2H}.$$

$$Zn+2NH_4HO=(NH_4)_2O_2Zn+\overbrace{2H}.$$

225. Many metals—silver, copper, tin, for example—are precipitated from their solutions in the metallic state by zinc, soluble salts of zinc being formed at the same time. (See Metallic Silver Precipitate, and § 63–162.)

ZINCIC SALTS.

Solution best fitted for the reactions:

Zincic Sulphate ($ZnSO_4$).

226. Hydrosulphuric acid produces *no precipitate* in a *mineral acid* solution not too dilute; but on neutral solution it precipitates part of the zinc. From acetic acid solutions all of the zinc may be precipitated as $ZnS.H_2O$.

227. Ammonic sulphide produces a white precipitate of hydrated zincic sulphide ($ZnS.H_2O$).—(Wackenroder.)

$$ZnSO_4 + NH_4HS + H_2O = \underbrace{ZnS.H_2O} + NH_4HSO_4.$$

The precipitate is insoluble in excess, but soluble in hydrochloric, sulphuric, and nitric acids, and in *a very large excess of acetic acid.*—(Wackenroder.)

228. Ammonic hydrate, in neutral or but slightly acid solutions, produces a white gelatinous precipitate of zincic hydrate, *soluble in excess*, and reprecipitated by boiling; also soluble in acids and in ammonic salts.

$$ZnSO_4 + 2NH_4HO = \underbrace{ZnH_2O_2} + (NH_4)_2SO_4.$$

229. Potassic hydrate and sodic hydrate produce the same precipitate as ammonic hydrate.

$$ZnSO_4 + 2KHO = \underbrace{ZnH_2O_2} + K_2SO_4.$$

The precipitate is soluble in excess, and from its *sodic or potassic solution it may be precipitated as sulphide* by hydrosulphuric acid.

230. Ammonic carbonate produces a white basic zincic carbonate. If the solutions are *very dilute*, or if concentrated and boiling, the precipitate has the composition ($Zn_2CO_3.ZnHO + xH_2O$ or $Zn_3HCO_4.xH_2O$). Soluble in *excess*, in ammonic salts, and in acids.

231. Sodic carbonate, same precipitate as *ammonic carbonate*, but not soluble in *excess*, but soluble in ammonic salts and in acids.

Fresenius gives the composition of the precipitate formed by ammonic and sodic carbonate as ($3ZnH_2O_2+2Zn+CO_3+4H_2O$ or $Zn_5H_6C_2O_{12}.4H_2O$).

232. Disodic orthophosphate produces a white precipitate of dizincic orthophosphate ($Zn_2H_2P_2O_8.2H_2O$) from hot solutions.

$$2ZnSO_4+2NaHPO_4+2H_2O=\underbrace{Zn_2H_2P_2O_8.2H_2O}+2NaSO_4.$$

233. Potassic ferrocyanide produces a precipitate in the form of a white powder of zincic ferrocyanide ($Zn_4Fe_2Cy_6+3H_2O$). The precipitate is insoluble in hydrochloric acid.

234. Blowpipe.—When compounds of zinc are treated with the reducing flame on charcoal, an incrustation of zinc oxide is formed; yellow while hot, white when cold. If this oxide be moistened with a little cobaltic nitrate, and then heated, an infused mass having a green color is produced.

IRON.

Symbol, Fe.—Atomic weight, 56.—Equivalence, II, IV, VI.—Also a pseudo-triad $(Fe_2)^{VI}$.—White pig-iron, Sp. Gr., 7.5—Gray pig-iron, Sp. Gr., 7.1.—Specific gravity of iron, 7.844.—Atomic volume, 7.10.—Specific heat, 0.112.—Electric conductivity at 32° F., 16.81.

IRON OXIDES.

Iron forms two oxides corresponding to the chlorides: Ferrous oxide, FeO, and ferric oxide, Fe_2O_3, and several oxides of intermediate composition, called ferroso-ferric oxides, which may be regarded as compounds of the two just mentioned; the most important of these is the magnetic oxide, $Fe_3O_4=FeO.Fe_2O_3$. A trioxide may be supposed to exist in the ferrates (FeO_3), as in potassic ferrate ($K_2O.FeO_3$), but it has not as yet been isolated.

Ferrous oxide, FeO. Found in nature in the form of carbonate ($FeCO_3$), in spathic iron ore, and in chalybeate waters. May be obtained, according to *Debray*, by passing a mixture of equal volumes of carbonous oxide (CO) and carbonic oxide

(CO_2) over red-hot ferric oxide. It is not easily prepared in the pure state, on account of the avidity with which it absorbs oxygen.

Ferrous hydrate may be precipitated from a solution of pure ferrous salt, perfectly free from air, with potassic hydrate, also free from air, in a vessel filled with de-aërated water. Precipitate must be washed by decantation with recently boiled water, then dried and preserved in an atmosphere free from oxygen.—(Schmidt.)

Ferric oxide, Fe_2O_3, occurs in nature as specular iron ore, as martite, and as red hematite. May be obtained in small *crystals* by decomposing ferric chloride with lime at a red heat (Daubré). May be obtained as an amorphous powder by igniting ferrous sulphate with $\frac{1}{12}$ pt. of saltpetre and lixiviating the product; by dissolving iron in nitric acid, evaporating, and heating the resulting nitrate to redness.

The amorphous powder is nearly black; has a specific gravity 5.04 to 5.17.—(Rose.)

Ferric oxide is reduced to the metallic state by hydrogen gas at a heat below redness, and at a red heat by charcoal, carbonous oxide, and ammonia gas. Ferric oxide dissolves in acids; best solvent, strong, boiling hydrochloric, much facilitated by presence of zinc or stannous chloride; the oxide then dissolves as ferrous chloride.

$$Fe_2O_3+6HCl+Zn=2FeCl_2+ZnCl_2+\overset{\frown}{6H}.$$

Ferric hydrates are most easily prepared by precipitating a *moderately* dilute solution of ferric chloride with *excess* of ammonic hydrate (with a smaller quantity a basic salt would be thrown down); the precipitate formed in the cold (the ferrum oxidatum fuscum of the pharmacopœias) has the composition $Fe_2O_3.2H_2O$, according to Gmelin (Handbook, v. 198) and Lefort (J. p. Chem., liv. 305); $Fe_2O_3.3H_2O$, according to *Wittstein* (Parm. Centr. 1853, p. 367); or $2Fe_2O_3.3H_2O$, according to Péau de Saint-Gilles (Ann. Ch. Phys. [3], xlvi. 47); the proportion of water doubtless varying according to the degree of dilution, the mode of precipitation, and the temperature at which the hydrate has been exposed in drying. The hydrate precipitated from *hot* solutions is $Fe_2O_3.2H_2O$, according to Lefort.—(SCHAFFNER, Ann. Ch. Pharm., li. 117.)

Native ferric hydrates are also of various composition. Göthite is $Fe_2O_3.H_2O$; and a variety of bog iron (Quellery) from Russia consists, according to Hermann (J. p. Chem., xxvii. 53), mainly of $Fe_2O_3.3H_2O$.

If the ordinary yellow hydrate, $2Fe_2O_3.3H_2O$ (precipitated from chloride by ammonic hydrate), be boiled in water for seven or eight hours, it changes to a brick-red ($Fe_2O_3.H_2O$), and is scarcely acted on by boiling nitric acid, but dissolves slowly in hydrochloric acid. This hydrate is precipitated when ordinary hydrate is boiled in acetic acid (Péau de Saint-Gilles).

FERROSO-FERRIC OXIDES and HYDRATES. Iron oxides intermediate between ferrous and ferric oxide are called ferroso-ferric oxides; they may be regarded as compounds of the two. The principal ones are the *scale oxide* and *magnetic oxide.*

SCALE OXIDE, $Fe_8O_9=6FeO.Fe_2O_3$. If iron is heated to redness in the air, layers of scale oxide are formed, which may be separated. The inner layer is a blackish-gray, porous, brittle substance, attracted by the magnet, and has the composition $6FeO.Fe_2O_3$. The outer layer contains a larger amount of ferric oxide, 32 to 37 per cent, and on the very surface, 52.8 per cent (Mosander). The outer layer is of a reddish iron-black color, dense, brittle, yields a black powder, and is more strongly attracted by the magnet than the inner oxide.

MAGNETIC OXIDE, $Fe_3O_4=FeO.Fe_2O_3$, occurs native; when pure contains nearly 72 per cent of iron (the richest ore). It is produced when iron is heated to redness in aqueous vapor (Regnault, Gay Lussac). When ferrous chloride is heated to redness with excess of sodic carbonate.—(LIEBIG AND WÖHLER).

FERROSO-FERRIC HYDRATE;—there are two hydrates:

Dingy-green hydrate. Made by exposing white ferrous hydrate to the air for a short time; or by precipitating a mixture of ferrous salt with a little ferric salt by ammonic hydrate, a dingy green hydrate of ferroso-ferric hydrate is obtained, which is converted by the air into rusty-brown ferric hydrate.

Black hydrate. This hydrate ($FeO.Fe_2O_3+xH_2O$ nearly) is precipitated from a solution of magnetic oxide in hydrochloric acid by ammonic hydrate. This black precipitate is magnetic in the liquid if a magnet dipped in it, and the precipitate collects around it. It contains about 7 per cent of water, and when heated in a retort, leaves anhydrous ferroso-ferric oxide; when heated in the air, it is converted into ferric oxide.

FERRIC TRIOXIDE, FeO_3, is not known in the free state, but is supposed to exist in the ferrates, viz.: Potassic ferrate, $K_2O.FeO_3=K_2FeO_4$.

METALLIC IRON.

235. HEATED ON CHARCOAL, it is slowly converted into the black magnetic oxide (ferroso-ferric oxide), Fe_3O_4, without fusing.

236. HYDROCHLORIC ACID dissolves iron, forming a pale-green solution of FERROUS CHLORIDE with evolution of hydrogen.

$$Fe+2HCl=FeCl_2+\overbrace{2H}.$$

"A small residue, consisting of carbon and silicon, which are constant ingredients of iron, remain undissolved in the form of a black powder."—(TUTTLE AND CHANDLER.)

237. NITRIC ACID, when concentrated, has very little action on iron; but if diluted, it dissolves the metal very rapidly, forming FERRIC NITRATE (Fe_26NO_3) and liberating nitrogen dioxide (N_2O_2).

$$2Fe+8HNO_3=Fe_26NO_3+\overbrace{N_2O_2}+4H_2O.$$

"Iron, which has been plunged into strong nitric acid, is said to become *passive*, and is unaffected by dilute acid. The same is true of iron-wire, one end of which has been heated to redness."—(TUTTLE AND CHANDLER.)

238. SULPHURIC ACID, when concentrated, dissolves iron, forming FERROUS SULPHATE and generating sulphurous oxide.

$$Fe+2H_2SO_4=FeSO_4+\overbrace{SO_2}+2H_2O.$$

If the acid used be dilute, hydrogen gas is generated.

$$Fe+H_2SO_4=FeSO_4+\overbrace{2H}.$$

239. Nitromuriatic acid dissolves iron, forming ferric chloride (Fe_2Cl_6) and liberating nitrogen dioxide (N_2O_2).

$$2Fe+2(3HCl+HNO_3)=Fe_2Cl_6+\overbrace{N_2O_2}+4H_2O.$$

FERROUS SALTS.

Most of the ferrous salts are soluble and crystallizable; they are white in the anhydrous state, and pale greenish-blue in the hydrated state. The solutions have a sweetish taste, with an inky after-taste; they quickly absorb oxygen, and are converted into basic ferric salts—thus: $2FeSO_4+O=Fe_2O.2SO_4$ ($Fe_2O_3.2SO_3$). Ferrous salts containing a volatile acid give up on ignition, leaving a residue of ferric oxide. The soluble neutral salts redden litmus-paper.

Solution best fitted for the reactions:

Ferrous Sulphate ($FeSO_4$).

240. Hydrosulphuric acid, in *acid* solution, produces *no* precipitate, nor in neutral solutions, provided the iron is in combination with a mineral acid. In neutral solutions, where the iron is combined with acids such as carbonic, oxalic, tartaric, or acetic, part of the iron is precipitated in the form of a black hydrated ferrous sulphide. The precipitation in the last three-mentioned salts going on only until a moderate quantity of acid is set free.

241. Ammonic sulphide produces a black precipitate of ferrous sulphide (FeS) (perhaps containing water):

$$FeSO_4+NH_4HS=\underbrace{FeS}+NH_4HSO_4.$$

Soluble in dilute hydrochloric acid. The precipitate oxidizes rapidly in the air, being first converted into ferrous sulphate, then into yellow-brown *basic* ferric sulphate.

242. Ammonic hydrate precipitates part of the iron as

FERROUS HYDRATE (FeH_2O_2), the rest remains dissolved in the liquid:

$$2FeSO_4+2NH_4HO=\underbrace{FeH_2O_2}+(NH_4)_2SO_4.FeSO_4.$$

The precipitate at first is nearly white; it changes to a dirty green ferroso-ferric hydrate ($Fe_3O_4.O_4H_8$) by absorbing oxygen from the air, then to a reddish-brown ferric hydrate ($FeO_3.3H_2O=Fe_2H_6O_4$).

"If the solution contains free acid, or ammonic salts, ammonic hydrate produces no precipitate, a soluble double ammonic salt and ferrous salt being formed [$FeSO_4+(NH_4)_2SO_4$]. But on exposure to the air, oxygen is absorbed, and ferric hydrate gradually separates."—(TUTTLE AND CHANDLER.)

243. POTASSIC HYDRATE *completely* precipitates the iron as a dirty white FERROUS HYDRATE:

$$FeSO_4+2KHO=\underbrace{Fe(OH)_2}+K_2SO_4.$$

The precipitate changes the same as in the case of ammonic hydrate, absorbing oxygen from the air.

244. POTASSIC FERROCYANIDE produces in solutions perfectly free from ferric salts a *white* precipitate of POTASSIO-FERROUS-FERROCYANIDE ($K_2Fe_2Cy_6$):

$$FeSO_4+K_4FeCy_6=\underbrace{K_2Fe_2Cy_6}+K_2SO_4.$$

This precipitate absorbs oxygen from the air, which acquires a blue color, and prussian blue [ferric ferrocyanide, $Fe_7Cy_{18}=Fe^{III}{}_4Fe^{II}{}_3Cy_{18}$ or $2(Fe_2)^{VI}Cy_6.3Fe^{II}Cy_2$, which, in combination with 18 molecules of water, constitute prussian blue] is formed, probably thus:

$6K_2Fe_2Cy_6+O_3=Fe_7Cy_{18}+3K_4Fe^{II}Cy_6+Fe_2O_3$.—(FOWNES.)

The oxide is dissolved by the free acid present. Nitric acid or chlorine converts potassio-ferrous-ferrocyanide immediately into prussian blue.

245. POTASSIC FERRICYANIDE produces a deep-blue precipitate of FERROUS FERRICYANIDE, $Fe^{II}(Fe_2)^{VI}Cy_{12}+xH_2O$:

$$3FeSO_4+K_6Fe_2Cy_{12}+xH_2O=\underbrace{Fe_3Fe_2Cy_{12}.xH_2O}+3K_2SO_4.$$

The precipitate is insoluble in hydrochloric acid, but is decomposed by potassic hydrate. This precipitate is known under the name of "Turnbull's blue."

"This is an extremely delicate test for ferrous salts. Before adding the ferricyanide, the solution should be acidulated with *acetic acid;* or if it already contains free mineral acid, potassic or sodic acetate should be added, in order to replace the free mineral acid, which might produce a blue color by decomposing the ferricyanide."—(TUTTLE AND CHANDLER.)

246. "NITRIC ACID, in the cold, imparts a brown color to solutions of ferrous salts, due to the formation of a compound of the ferrous salt with nitrogen dioxide (N_2O_2); thus ($4FeSO_4.N_2O_2$). On applying heat this compound is destroyed—the ferrous salt changed to a ferric salt, and the solution assumes a yellow color."

If ferrous sulphate is added very carefully to a solution containing a nitrate (with the same volume of pure sulphuric acid as the nitrate), so that the fluids do not mix, the stratum, where the two fluids are in contact, shows a purple, afterwards a brown, or, in cases where only minute quantities of nitric acid are present, a reddish color. If the fluids are mixed, a clear brownish-purple liquid is obtained.

247. POTASSIC and SODIC CARBONATE and AMMONIC SESQUICARBONATE precipitate white *hydrated* ferrous carbonate in thick white flakes, which, on exposure to the air, absorb oxygen and give off carbonic oxide, first assuming a dirty green color, and ultimately changing to yellowish-brown ferric hydrate. The precipitate may be rendered more permanent by mixing it with a little sugar when moist. Dissolved by aqueous carbonic acid. Exists in chalybeate waters.

248. POTASSIC SULPHOCYANATE neither alters the color of pure ferrous solutions, nor forms any precipitate in them.

249. TINCTURE OF GALLS neither colors nor precipitates ferrous salts, when they are quite free from ferric oxide; but the mixture acquires a violet-black color on exposure to the air.

250. BLOWPIPE.—METALLIC IRON may be obtained by fusing ferrous salts on charcoal with sodic carbonate and potassic cyanide. If the fused mass is washed with water in a mortar, a black powder is obtained, which is readily attracted by the magnet.

251. Borax dissolves ferrous salts in the outer flame, forming a yellow bead; in the inner flame a bottle-green bead, owing to reduction.

FERRIC SALTS.

Most of the ferric salts in solution are yellow or reddish-yellow. The soluble neutral salts redden litmus, and are decomposed by heat. Ferric salts are easily reduced to ferrous salts by various deoxidizing agents; as by sulphydric acid, sulphurous, hyposulphurous, and phosphorous acids; by stannous chloride; by metallic iron, and even by silver at the boiling heat.

Solution best fitted for the reactions:

Ferric Chloride (Fe_2Cl_6).

252. Hydrosulphuric acid reduces the ferric salts to the ferrous and deposits sulphur:

$$Fe_2Cl_6 + H_2S = 2FeCl_2 + 2HCl + \underbrace{S}.$$

It will be seen from the reaction that the hydrogen of the hydrosulphuric acid acts as the reducing agent.

"When in combination with a weak organic acid (as acetic acid), iron is precipitated as sulphide (FeS) by hydrosulphuric acid."—(Tuttle and Chandler.)

253. Ammonic sulphide produces, in strong solutions of ferric salts, a black precipitate of ferrous sulphide mixed with sulphur.

$$\left\{\begin{array}{l} Fe_2Cl_6 + 2NH_4HS = FeCl_2 + \underbrace{2S} + 2NH_4Cl + 2HCl. \\ FeCl_2 + NH_4HS = \underbrace{FeS} + NH_4Cl + HCl. \end{array}\right.$$

The presence of ammonic chloride favors the precipitation. The precipitate is easily soluble in dilute acids, the *sulphur remaining undissolved.*

In very dilute solutions of ferric salts, hydrosulphuric acid only produces a blackish-green coloration, which, if kept for a long time, deposits ferrous sulphide in black flocks.

254. Ammonic hydrate added in excess produces a precipitate of ferric hydrate, $Fe_2O_3.3H_2O$ (Wittstein). (See Ferric Hydrates under Ferric Oxide.)

The precipitate is of a brownish-red color, insoluble in ammonic salts, but soluble in acids.

$$Fe_2Cl_6+6NH_4HO=\underbrace{Fe_2H_6O_6}+6NH_4Cl.$$

255. Potassic hydrate produces the same precipitate as ammonic hydrate.

$$Fe_2Cl_6+6KHO=\underbrace{Fe_2H_6O_6}+6KCl.$$

256. Potassic ferrocyanide produces in very dilute solutions a deep blue precipitate of Ferric ferrocyanide, Fe_7Cy_{18} or $2Fe_2Cy_6.3FeCy_2$:

$$2Fe_2Cl_6+3K_4FeCy_6=\underbrace{Fe_7Cy_{18}}+12KCl.$$

(Fe_7Cy_{18} in combination with 18 molecules of water constitute Prussian blue.) See § 242. The precipitate is insoluble in acid, but decomposed by potassic hydrate, with separation of ferric hydrate:

$$Fe_7Cy_{18}+12KHO=\underbrace{2Fe_2H_6O_6}+3K_4FeCy_6.$$

"This is one of the most delicate tests for iron. Neutral solutions should be acidulated with acetic acid before applying it. As strong acids decompose the potassic ferrocyanide, giving rise to a blue color, it is best to add potassic or sodic acetate to acid solutions, in order to replace the free mineral acid by acetic acid:

$HCl+KC_2H_3O_2=KCl+H.C_2H_3O_2$."—(Tuttle and Chandler.)

257. Potassic ferricyanide produces no precipitate in absolutely pure ferric salts, but changes the color of the solution to a greenish-brown. If there is the least trace of ferrous salt present, a blue precipitate is produced. This test distinguishes the ferric salts from the ferrous salts.

258. Potassic sulphocyanate does not produce a precipitate, but colors the solution a deep blood-red; the color is very distinct in very dilute solutions, and is probably the most sensitive test for ferric salts. The color is due to the formation of a soluble ferric sulphocyanide; it appears in solution not too acid; if much free hydrochloric or nitric acid is present, the hydrochloric acid nearly destroys it, and a certain quantity of nitric acid, after a while, completely destroys it. Ammonic hydrate instantly decolorizes the red solution, and precipitates ferric hydrate [$Fe_2(OH)_6$]. Ammonic sulphide produces a black precipitate of FERRIC SULPHIDE (Fe_2S_3).

"A similar red coloration is produced by potassic sulphocyanate in solution containing molybdic oxide (MoO_2) or hyponitric acid."—(FRESENIUS.)

259. BARIC CARBONATE, when shaken up with a ferric solution, produces a precipitate of FERRIC HYDRATE:

$$Fe_2Cl_6 + 3BaCO_3 + 3H_2O = \underbrace{Fe_2H_6O_6}_{\downarrow} + 3BaCl_2 + \overbrace{3CO_2}^{\uparrow}.$$

In FERROUS SALTS (sulphate excepted), baric carbonate produces *no* precipitate.

260. SODIC ACETATE. "When a solution containing a ferric salt is rendered nearly neutral by sodic carbonate, and then heated to boiling with addition of excess of *sodic acetate*, all the iron is precipitated as a (reddish) brown BASIC sesquiacetate, and may be completely removed from the solution by *filtering hot* and washing with boiling water. If it is allowed to remain in the solution, it *partially redissolves* as the latter becomes *cold*."

261. BLOWPIPE.—See §§ 249, 250.

COBALT.

Symbol, Co.—Atomic weight, 60.—Equivalence, II, IV, and probably VI.—Also a pseudo-triad ($(Co_2)^{VI}$).—Specific gravity, 8.71 (to 8.95).—Malleable at red heat.—Atomic volume, 6.94.—Specific heat, 0.1069.—Electric conductivity at 32° F., 17,22.

COBALT OXIDES.

Cobalt unites with oxygen to form several oxides: CoO, CoO_2, Co_2O_3, Co_3O_4, Co_6O_7, Co_8O_9.

Cobaltous oxide, CoO, or protoxide, may be obtained by igniting cobaltous hydrate, $Co(OH)_2$, or carbonate, $CoCO_3$, in close vessels, by igniting the protochloride (cobaltous chloride) in a stream of aqueous vapor.—(Schwarzenberg.)

$$Co(OH)_2 + \Delta\delta = CoO + \overbrace{H_2O}.$$

$$CoCO_3 + \Delta\delta = CoO + \overbrace{CO_2}.$$

$$CoCl_2 + H_2O + \Delta\delta = CoO + (\overbrace{2H} + \overbrace{2Cl}).$$

The pure cobaltous oxide is a light greenish-gray or olive-green non-magnetic powder. It is reduced to the metallic state at a red heat by hydrogen, charcoal, carbonous oxide (CO), potassium, and sodium.

Cobaltous hydrate, $CoO.H_2O$ or $Co(HO)_2$, is produced when a cobaltous salt is decomposed by potassic hydrate *out of the air.* A blue basic salt is first produced, which changes slowly (quickly on heating) to the *rose-colored hydrate.* If ignited out of the air, cobaltous oxide is formed as above; but if ignited in the air, a higher oxide is formed. Dissolves readily in acids, and forms cobaltous salts.

Cobaltic oxide, Co_2O_3 (sesquioxide).—It may be prepared by passing chlorine through water in which cobaltous hydrate is suspended; it is then precipitated as cobaltic hydrate:

$$2Co(OH)_2 + 3H_2O + 2Cl = \underbrace{Co_2O_3.3H_2O} + 2HCl.$$

The water is decomposed by the chlorine, and hydrochloric acid is produced, while the oxygen of the water preoxidizes the cobalt.

When this black hydrate is cautiously heated to 600° C. or 700° C., the black cobaltic oxide is produced.

Cobaltic oxide acts as a weak base.

Cobaltic acetate is the most permanent cobaltic salt.

Cobaltoso-cobaltic oxides.—The oxide $Co_3O_4 = (CoO.Co_2O_3)$ may be prepared by heating to redness in contact with the air, cobaltous nitrate, oxalate, or cobaltic hydrate (Hess, Rammelsberg), but according to Beetz and Winkelblech, the oxide thus obtained is Co_6O_7 or $Co_{12}O_{14}$.

If the residue obtained by gently igniting the oxalate in contact with air, is digested in strong hydrochloric acid, the oxide Co_3O_4 remains in hard, brittle, grayish-black microscopic octahedrons having a metallic lustre. The same crystalline compound is obtained by igniting dry cobaltous chloride alone, or mixed with ammonic chloride, in dry air or oxygen gas.—(Schwarzemberg.)

Cobaltic anhydride, Co_3O_5 or Co_6O_{10}, is obtained in combination with potassic oxide, by strongly igniting the oxide Co_3O_4, or the pure cobaltous oxide or carbonate, with pure potassic hydrate. A crystalline salt is formed which contains, when dried at 100° C., $K_2O.3Co_3O_5+3H_2O$.

Cobaltic dioxide, CoO_2, has not yet been obtained in a free state, but may be supposed to exist in the oxycobaltic salts. $CoO_2.N_2O_5.5NH_3+H_2O$ = the nitrate.

METALLIC COBALT.

262. Heated on charcoal, it takes fire, and is converted into cobaltoso-cobaltic oxide (Co_3O_4):

$$3Co+O_4+\Delta\delta=CoO.Co_2O_3 \text{ or } Co_3O_4.$$

It decomposes aqueous vapor at a red heat.

263. Hydrochloric acid dissolves the metal slowly in the cold, more rapidly when heated, forming cobaltous chloride ($CoCl_2$) and liberating hydrogen.

$$Co+2HCl=CoCl_2+\overbrace{2H}.$$

264. Nitric acid dissolves the metal easily, forming cobaltous nitrate [$Co(NO_3)_2$] and liberating nitrogen dioxide:

$$3Co+8HNO_3=3Co(NO_3)_2+\overbrace{N_2O_2}+4H_2O.$$

265. Sulphuric acid, when dilute, dissolves the metal, forming cobaltous sulphate ($CoSO_4$), with evolution of hydrogen gas:

$$Co+H_2SO_4=CoSO_4+\overbrace{2H}.$$

If heated the metal dissolves more rapidly.

COBALTOUS SALTS.

Cobaltous salts in solution have a rose-red color, except when they are very concentrated or contain a free acid, in which case they are blue; dilution with water changes the *blue* color to *red.* The neutral solutions faintly redden litmus-paper. Cobaltous sulphate is the most permanent, all others being decomposed at a red heat; the sulphate can stand a moderate red heat. Cobaltic oxide dissolves in hydrochloric acid, forming cobaltous chloride and liberating chlorine.

$$Co_2O_3+6HCl=2CoCl_2+\overbrace{2Cl}+3H_2O.$$

Solution best fitted for the reactions:

Cobaltic Nitrate, $Co(NO_3)_2$.

266. Hydrosulphuric acid produces no precipitate in solution containing an excess of any strong acid; but in solutions of the acetate, or of any cobalt salt mixed with potassic acetate, it forms a black precipitate of cobaltous sulphide (CoS) when cobaltous acetate is used, and cobaltic sulphide (Co_2S_3) when cobaltic acetate is used.

267. Ammonic sulphide precipitates completely the cobalt as cobaltous sulphide, insoluble in excess:

$$Co(NO_3)_2+NH_4HS=\underbrace{CoS}+NH_4NO_3+HNO_3.$$

Ammonic chloride greatly favors the precipitation. The precipitate is with difficulty soluble in hydrochloric acid, but dissolves in nitromuriatic acid very easily, especially when heated.

268. Ammonic hydrate precipitates a portion of the cobalt as a bluish basic salt [$5Co(OH)_2.Co(NO_3)_2$], a portion remaining in solution as a double salt [$Co(NO_3)_2.NH_4NO_3$]

If the solution contains free acid or ammonic salts, no precipitate is produced. The precipitate in contact with the air becomes green. If more ammonic hydrate be added, it dissolves and forms a brownish-red liquid, which, by the action of the air, changes to red-brown, and then consists of the elements of ammonic hydrate united with the higher oxides of cobalt. If the precipitation is performed out of contact with the air, cobaltous hydrate is precipitated. (See Cobaltous Oxide.)

269. Potassic hydrate produces a blue precipitate of a basic salt [$5Co(OH)_2.(CoNO_3)_2$], which is insoluble in excess, assuming a green or dirty bluish-green color when exposed to the air, from formation of cobaltic oxide; but if protected from the air, is converted into cobaltous hydrate of a dingy red color. A solution of cobaltous and cobaltic chloride produces a precipitate with potassic hydrate which does not change to dingy red even on boiling, but merely acquires a darker color.

270. Potassic cyanide produces a red-brown precipitate of cobaltous cyanide [$Co(CN)_2$ or $CoCy_2$], soluble in excess, forming a double cyanide ($4KCy.CoCy_2$), from which acids precipitate cobaltous cyanide:

$$Co(NO_3)_2+2KCN=\underbrace{Co(CN)_2}+2KNO_3.$$

$$\underbrace{Co(CN)_2}+KCN=CoKCy_3 \text{ or } Co(CN)_2.KCN.$$

$$CoK_4Cy_6+4HCl=CoCy_2+4KCl+4HCy.$$

If the solution containing an excess of potassic cyanide be boiled with free hydrocyanic acid (generated by adding a few drops of hydrochloric acid), a compound potassio-cobaltic cyanide is formed ($K_6C_{12}N_{12}Co_2=6KCy.Co_2Cy_6$); in the solution of which acids *produce*, when added, NO PRECIPITATE. (Important distinction from nickel.)

$$4Co(CN)_2+12KCN+4HCN+2O=2K_6C_{12}N_{12}Co_2+2H_2O.$$

271. Potassic ferrocyanide produces a pale-blue precipitate of hydrated cobaltous ferrocyanide, which, when carefully treated, gives off the greater part of its water, and assumes a dark-green color. Dissolves in ammonic hydrate and carbonate; not in chloride. Insoluble in hydrochloric acid.

272. Potassic ferricyanide produces a purplish-brown (brown-red) precipitate of cobaltous ferricyanide, insoluble in hydrochloric acid, and in ammonic hydrate. This precipitate *may be produced* in an ammonic solution of cobalt.

273. Baric carbonate in the cold does not precipitate cobaltous salts (sulphate excepted, which precipitates the greater part of the cobalt after a long time). No precipitate is found when cobaltous chloride is used in the cold, but when heated to boiling, after a long time all the cobalt is precipitated.

274. Potassic nitrite when gradually added to cobaltous nitrate acidified with nitric or acetic acid, precipitates a beautiful orange-yellow compound, which consists, according to A. Stromeyer, of $Co_2O_3.2N_2O_3.6KNO_2.2H_2O$, and contains 13.6 per cent of metallic cobalt:

$$2Co(NO_3)_2+12KNO_2+2C_2H_4O_2+2H_2O=$$
$$\underbrace{Co_2O_3.2N_2O_5.6KNO_2.2H_2O}+4KNO_3+2KC_2H_3O_2+\overbrace{N_2O_2}.$$

By this reaction cobalt may be distinguished from nickel; dilute solutions should be concentrated before adding the potassic nitrite. The precipitate is only slightly soluble in water; insoluble in saline solutions and in alcohol. When boiled with water it dissolves, though not copiously, to a red fluid, from which alkalies precipitate cobaltous hydrate.

275. Potassic carbonate, if added hot to a hot solution of cobaltous nitrate, produces a precipitate of $5CoO.2CO_2.4H_2O$. When added at the ordinary temperature, a precipitate $4CoO.2CO_2.7H_2O$ is formed; if either of these precipitates be boiled, they assume an indigo blue color, and the precipitate is then $4CoO.CO_2.4H_2O$, becoming green during washing by absorption of oxygen.

276. Blowpipe.—When compounds of cobalt are fused on charcoal with a little sodic carbonate and potassic cyanide in the inner flame, and the fused mass pulverized in the cold in a mortar, on treating with water, metallic cobalt is obtained as a gray powder, which is attracted by the magnet.

277. Borax, Any compound of cobalt imparts to a borax bead in either flame a beautiful sapphire blue color.

Characteristic Reactions, **267, 272, 270, 274, 277.**

NICKEL.

Symbol, Ni.—Atomic weight, 58.—Equivalence, II, IV, probably VI.—Also a pseudo-triad $(Ni_2)^{VI}$.—Magnetic; loses this property at 250° C.—Atomic volume, 6.94.—Specific heat, 0.1069.—Specific gravity, 8.82.—Electric conductivity at 32° F., 17.22.

NICKEL OXIDES.

Nickel unites with oxygen to form two oxides, NiO, Ni_2O_3; the first is a salifiable base, the other is not.

NICKELOUS OXIDE, NiO (protoxide), may be obtained by calcining nickelous nitrate, hydrate, or carbonate:

$$Ni(OH)_2 + \Delta\delta = NiO + \overbrace{H_2O}.$$

It may be freed from traces of *peroxide*, which it sometimes contains, by heating it to about 100° C. in hydrogen gas.—(ERDMANN.)

It is a dense green or grayish-green non-magnetic powder, which does not absorb oxygen from the air, either at common or high temperatures. It is reduced to the metallic state by hydrogen at a red heat, and by charcoal at a white heat.

NICKELOUS HYDRATE, $Ni(OH)_2$, is obtained as an apple-green precipitate, by treating the solution of a nickelous salt with excess of potassic or sodic hydrate:

$$Ni(NO_3)_2 + 2KHO = \underbrace{Ni(OH)_2} + 2KNO_3.$$

$$Ni(NO_3)_2 + 2NaOH = \underbrace{Ni(OH)_2} + 2NaNO_3.$$

Dissolves easily in *acids*; also in *ammonic hydrate*, forming a violet solution.

A crystalline hydrate $[Ni(OH)_2.H_2O]$ has been found as an incrustation on chrom-iron in Texas, Pennsylvania.

NICKELIC OXIDE, Ni_2O_3 (*sesquioxide* and *peroxide*). This oxide is produced by calcining the nitrate at a *moderate* heat.

$$2Ni(NO_3)_2 + \Delta\delta = Ni_2O_3 + (\overbrace{2N_2O_2} + \overbrace{5O}).$$

It is a black powder of Sp. Gr. 4.84 (Herapath), which is resolved by ignition into oxygen and nickelous oxide.

$$Ni_2O_3 + \Delta\delta = 2NiO + \overbrace{O}.$$

Nickelic hydrate, $Ni_2O_3.3H_2O$ or $Ni_2(OH)_6$. By passing chlorine gas through an alkaline solution of nickelous hydrate, a precipitate of nickelic hydrate is produced. If a nickelous salt is mixed with an excess of caustic alkali, then with an alkaline hypochlorite, this hydrate is produced. It is dark-brown when suspended in water, but forms a black shining mass when dry. When heated it readily gives off water and oxygen. Dissolves in ammonic hydrate with evolution of *nitrogen*, the solution containing nickelous hydrate.

Another hydrated *nickelic oxide* of a dingy light-green color is obtained by treating the nickelous hydrate with hydrogen peroxide.—(Thenard.)

METALLIC NICKEL.

278. Heated on charcoal by the outer flame, it is rapidly oxidized and converted into **nickelous oxide** (NiO) without fusing or forming an incrustation.

In the inner flame the metal is not changed.

279. Hydrochloric acid, if not too dilute, dissolves the metal slowly with evolution of hydrogen, forming at the same time **nickelous chloride** ($NiCl_2$).

$$Ni + 2HCl = NiCl_2 + \overbrace{2H}.$$

280. Nitric acid rapidly dissolves the metal, forming **nickelous nitrate** [$Ni(NO_3)_2$], and liberating at the same time nitrogen dioxide (N_2O_2).

$$3Ni + 8HNO_3 = 3Ni(NO_3)_2 + \overbrace{N_2O_2} + 4H_2O.$$

281. Sulphuric acid dissolves the metal slowly when dilute and aided by heat, forming nickelous sulphate and liberating at the same time hydrogen.

$$Ni + H_2SO_4 = NiSO_4 + \overbrace{2H}.$$

NICKELOUS SALTS.

The solutions of the nickelous salts have a light-green color. The salts are mostly green in the hydrated state, and yellow in the anhydrous state. The soluble neutral salts *slightly* redden litmus-paper, and are decomposed at a red heat.

Solution best fitted for the reactions:

Nickelous Nitrate [$Ni(NO_3)_2$].

282. Hydrosulphuric acid produces *no precipitate* in *acid* solutions, and only partially precipitates the nickel from neutral solutions (such as sulphate or chloride); but if nickelous acetate or any nickelous salt be mixed with sodic or potassic acetate, the metal is completely precipitated as nickelous sulphide (NiS) on boiling, unless a large excess of acetic acid is present.

283. Ammonic sulphide produces a dark-brown precipitate of nickelous sulphide (NiS), which is slightly soluble in excess, forming a dark-brown solution, from which it may be completely precipitated by boiling:

$$Ni(NO_3)_2 + NH_4HS = \underbrace{NiS} + NH_4NO_3 + HNO_3.$$

Nickelous sulphide is *soluble with difficulty in hydrochloric acid* or acetic acid, but easily soluble in nitric or nitrohydrochloric acids.

284. Ammonic hydrate produces no precipitate if the solution contains ammonic chloride or free acid. If the solution is neutral, a partial precipitate of nickelous hydrate [$Ni(OH)_2$] is produced, a portion remaining in solution as a double salt with the ammonic salt [$Ni(NO_3)_2 + 2NH_4NO_3$]. The precipitate formed is soluble in excess, forming, after standing, a blue solution, from which nickelous hydrate may be precipitated by sufficient potassic hydrate.

285. Potassic hydrate produces an apple-green precipitate of nickelous hydrate, insoluble in excess, soluble in ammonic salts.

$$Ni(NO_3)_2 + 2KHO = Ni(OH)_2 + 2KNO_3.$$

286. Potassic ferrocyanide produces a greenish-white precipitate in flocks, consisting of nickelous ferrocyanide ($Ni_2Fe_2Cy_6$) and some potassic ferrocyanide, soluble in ammonic hydrate, insoluble in ammonic salts and in hydrochloric acid.

287. Potassic ferricyanide produces a yellowish-green precipitate of nickelous ferricyanide ($Ni_2Fe_2Cy_{12}$), insoluble in hydrochloric acid; soluble in *ammonic hydrate.* No precipitate is produced in ammonic solutions of nickel. This distinguishes nickel from cobalt. (See § 276.)

288. Potassic cyanide produces a yellowish-green precipitate of *nickelous cyanide* [$Ni(CN)_2$]:

$$Ni(NO_3)_2 + 2KCN = \underbrace{Ni(CN)_2} + 2KNO_3.$$

Soluble in excess, forming a brownish-yellow solution consisting of a double cyanide of nickel and potassium [$Ni(CN)_2 + 2KCN$]:

$$Ni(CN)_2 + 2KCN = 2KCN.Ni(CN)_2 = K_2NiCy_4.$$

If sulphuric or nitric acid be added to the solution, the potassic cyanide is decomposed, and nickelous cyanide is reprecipitated, which is only soluble with difficulty in these acids, but more so on boiling. (See § 274.)

Mercuric oxide decomposes the solution of the double salt [$2KCN.Ni(CN)_2$], precipitating nickelous hydrate:

$$HgO + 2KCN.Ni(CN)_2 + H_2O = \underbrace{NiH_2O_2} + 2KCN.Hg(CN)_2.$$

Cobaltocyanide is not decomposed by mercuric oxide or alkaline hypochlorites.

289. Potassic Nitrite produces no precipitate, even in concentrated solutions. This distinguishes nickel from cobalt. (See § 278.)

290. Baric carbonate produces no precipitate (sulphate excepted).

291. Blowpipe.—All nickel salts, when fused on charcoal in the inner flame with a mixture of sodic carbonate and potassic cyanide, are reduced to a gray metallic powder, which is attracted by the magnet. The fused mass is best washed with water in a mortar, when the metallic nickel (Ni) may be obtained.

292. Borax.—Compounds of nickel give in the outer flame a clear bead of a reddish-brown color while hot, and a pale or dark yellow when cold. In the inner flame the bead changes to *gray* and opaque, owing to reduction of the metal.

Characteristic Reactions, **283, 287, 288, 292.**

MANGANESE.

Symbol, Mn.—Atomic weight, 55.—Equivalence, II, IV, and VI.—Also a pseudo-triad, $(Mn_2)^{VI}$.—Specific gravity, 8.02.—Specific heat, 0.1217.—Atomic volume, 7.

MANGANESE OXIDES.

Manganese unites with oxygen to form four different definite oxides:

Manganous Oxide	MnO.
Manganoso-manganic Oxide . .	Mn_3O_4.
Manganic Oxide	Mn_2O_3.
Manganese Dioxide	MnO_2.

Manganous oxide, MnO (protoxide), may be obtained by igniting *manganous hydrate*, carbonate, or oxalate, at a moderate heat in a closed vessel, or better, in a stream of hydrogen, and allowing the product to cool in that gas. Liebig and Wöhler recommend mixing equal parts of fused *manganous chloride* and *sodic carbonate* with a small quantity of *sal ammoniac*, heating the mixture until it fuses, and exhausting the fused mass with water when cold. It is a grayish-green powder, which, according to Despretz, melts at the heat of a forge-fire to a fine green-colored mass.

Manganous hydrate is obtained by precipitating a manganous salt with "caustic potash," as a white, milky, flocculent precipitate, which, on exposure to the air, turns brown by oxidation, and is ultimately converted into manganic hydrate.

According to H. Davy, the hydrate contains 24 per cent of water.

Manganic Oxide, Mn_2O_3 (sesquioxide). This oxide occurs native as *braunite* (91–97 per cent Mn_2O_3). May be obtained by heating manganic hydrate to *low redness.* According to Schneider, all the lower oxides are converted into sesquioxide by strong ignition in oxygen gas. Manganic oxide, when strongly ignited in the air or in a closed vessel, gives off oxygen, and leaves manganoso-manganic oxide. Hot strong sulphuric acid *reduces* it to *manganous oxide,* and dissolves it with evolution of oxygen gas.

Manganic hydrate, $Mn_2H_2O_4$. Found native as *manganite* or *gray manganese ore.* It is found when *manganous hydrate* is exposed to the air. Artificially prepared, it is a dark-brown powder, light, and capable of soiling very strongly. When boiled with concentrated nitric acid, it is resolved into manganous oxide, which dissolves, and a hydrated peroxide as a residue (Berthier). Dissolves in cold hydrochloric acid, forming *manganic chloride.*

Manganoso-manganic oxide, $Mn_3O_4 = MnO.Mn_2O_3$ (red oxide of manganese), occurs native as *hausmannite* (98–99.44 per cent Mn_3O_4). When manganous oxide, nitrate or carbonate is strongly ignited in contact wtih air, or when either of the other oxides is subjected to very strong ignition. This oxide is very easily prepared. When heated to whiteness with charcoal, it is reduced to metallic manganese. *Hot* sulphuric acid dissolves it, forming manganous sulphate and liberating oxygen:

$$Mn_3O_4+3H_2SO_4+\Delta\delta=3MnSO_4+3H_2O+\overbrace{O}.$$

Hot hydrochloric acid dissolves it with liberation of chlorine.

$$Mn_3O_4+8HCl+\Delta\delta=3MnCl_2+4H_2O+\overbrace{2Cl}.$$

Manganese dioxide (MnO_2) (peroxide), occurs native as pyrolusite or polianite. When manganoso-manganic oxide or manganic oxide is boiled with strong nitric acid, *manganese dioxide* is produced, or when manganous carbonate is heated in an open vessel to 260° C.; and any portion of carbonate that may then remain undecomposed, may be removed by *cold* and *very dilute* hydrochloric acid; whereupon, according to Forchhammer, pure manganese dioxide remains behind. When heated alone, manganese dioxide is converted into manganoso-manganic oxide. When drenched with strong sulphuric acid, it gives up one-fourth of its oxygen, and yields a dark-red solution of MANGANIC SULPHATE (Mn_23SO_4). With *cold* hydrochloric acid, it forms MANGANIC CHLORIDE (Mn_2Cl_6); on *heating*, *manganous chloride* ($MnCl_2$) is obtained with evolution of chlorine.

HYDRATES OF MANGANESE DIOXIDE. In the spontaneous decomposition of manganates or permanganates dissolved in water or in dilute acid, a black-brown hydrated dioxide is precipitated, which cakes together to a BLACK COHERENT MASS CONTAINING $MnO_2.H_2O$ (Mitscherlich). The same hydrate is formed when manganous carbonate suspended in water is treated with chlorine, and the black-brown residue is well washed with dilute acid (Berthier). A HYDRATE containing $2MnO_2.H_2O$ is obtained when a solution of a manganous salt is precipitated by a mixture of potassic hydrate and potassic hypochlorite.—(WINKELBLECH).

THE HYDRATE $3MnO.H_2O$ is deposited on evaporating a solution of manganous bromate (Rammelsberg). THE HYDRATE $4MnO_2.H_2O$ is obtained by treating manganoso-manganic hydrate with strong nitric acid (Berthier). (See Gmelin's Handbook, iii. 206.)

MANGANESE OXIDES, *intermediate in composition between the sesquioxide and dioxide* are mostly mixtures of different oxides (which cannot be regarded as definite chemical compounds or distinct mineral species), although there are one or two of definite composition. Psilomelane, Varvacite, Wad, Earthy Cobalt, Cupreous Manganese, Wad or Bog Manganese, Groroïlite, Pelokonite.

METALLIC MANGANESE.

293. HEATED ON CHARCOAL, it rapidly oxidizes, but does not melt. Manganese oxidizes very easily when it is exposed to the air at ordinary temperatures, and must therefore be kept under rock-oil, or in sealed tubes. Decomposes water at ordinary temperature, being itself oxidized.

294. Hydrochloric acid dissolves the metal, forming manganous chloride ($MnCl_2$) and liberating at the same time hydrogen.

$$Mn+2HCl=MnCl_2+\overset{\frown}{2H}.$$

295. Nitric acid, when dilute, dissolves the metal.

296. Sulphuric acid, when dilute, dissolves the metal, liberating hydrogen and forming manganous sulphate, $MnSO_4$:

$$Mn+H_2SO_4=MnSO_4+\overset{\frown}{2H}.$$

The metal prepared by Brunner's process, when immersed in *strong* sulphuric acid, liberates but a small quantity of hydrogen at ordinary temperatures, but dissolves on boiling with evolution of sulphurous oxide. In dilute sulphuric acid it dissolves readily; also in nitric acid, in very dilute hydrochloric, and in acetic acid.

MANGANOUS SALTS.

Manganous salts have a pale rose tint, which is not destroyed by sulphurous or hydrochloric acid, and is therefore characteristic. Some of the salts are soluble in water, the rest in acids. The ones soluble in water are decomposed at a red heat (sulphate excepted). The solutions do not alter vegetable colors.

Solution best fitted for the reactions:

Manganous Sulphate ($MnSO_4$).

297. Hydrosulphuric acid produces no precipitate in acid solutions, but from a neutral solution of manganous acetate a flesh-colored precipitate is formed after a while; but not if the solution contains free acetic acid.

298. Ammonic sulphide produces in neutral solutions a flesh-colored precipitate of hydrated MANGANOUS SULPHIDE ($MnS.xH_2O$):

$$MnSO_4+NH_4HS+xH_2O=\underbrace{MnS.xH_2O}+NH_4HSO_4.$$

The precipitate is insoluble in excess, but dissolves in acids, even in acetic acid. The precipitate, on exposure to the air, oxidizes, and its surface turns brown. The separation of the precipitate is much facilitated by the presence of ammonic chloride.

299. AMMONIC HYDRATE produces in neutral solution a white precipitate of MANGANOUS HYDRATE [$Mn(OH)_2$]:

$$MnSO_4+2NH_4HO=\underbrace{Mn(OH)_2}+(NH_4)_2SO_4.$$

In solutions containing free acid or ammonic salts it produces no precipitate; but if sufficient ammonic hydrate is added, and the solution exposed to the air, all the manganese is deposited as brown MANGANIC HYDRATE ($Mn_2O_3.H_2O$). Manganous hydrate, on exposure to the air, oxidizes, and is converted into manganic hydrate.

300. POTASSIC HYDRATE produces a white precipitate of MANGANOUS HYDRATE:

$$MnSO_4+2KHO=\underbrace{Mn(OH)_2}+K_2SO_4.$$

The precipitate soon absorbs oxygen from the air and turns brown; if collected on a filter and washed, it ultimately changes to MANGANIC HYDRATE.

301. POTASSIC or SODIC CARBONATE produces a white precipitate, which, after washing with boiling water and dried in vacuo of sulphuric acid, has the composition $2MnCO_3.H_2O$:

$$2MnSO_4+2K_2CO_3+H_2O=\underbrace{2MnCO_3.H_2O}+2K_2SO_4.$$

If atomic quantities of manganous chloride and sodic carbonate are mixed together, the precipitate will contain $5MnCO_3.2Mn(OH)_2$.

302. POTASSIC FERROCYANIDE produces a white precipitate, *soluble* in *hydrochloric acid.* When the manganous salt is poured into the potassic ferrocyanide, the precipitate contains both manganese and potassium. Both precipitates are tinged with red.

303. Potassic ferricyanide produces a *brown* precipitate which is *insoluble* in *acids.*

304. Plumbic dioxide (or red lead), when saturated with a fluid containing manganous oxide (free from chlorine) and a little nitric acid (free from chlorine), and the mixture boiled and allowed to settle, the fluid is of a purple-red color from the formation of *permanganic acid* (Crum) or *manganic nitrate* (Rose).

The color is very perceptible after the excess of lead-oxide has settled, and is the most delicate test for manganese in the wet way.

305. Baric carbonate produces no precipitate except with the sulphate.

306. Ferrous salt. To determine the amount of ferrous salt in a solution, by adding potassic permanganate and sulphuric (or hydrochloric) acid, the reaction is as follows:

$$10FeSO_4+K_2Mn_2O_8+8H_2SO_4=5Fe_23SO_4+K_2SO_4+2MnSO_4 +8H_2O.$$

$$K_2Mn_2O_8+10FeCl_2+16HCl=2MnCl_2+2KCl+5Fe_2Cl_6+8H_2O.$$

307. Manganese salts of any oxide, when boiled with hydrochloric acid, exhibit the reactions of *manganous salts.*

308. Manganates. *Potassic manganate,* when boiled with water, decomposes and precipitates $MnO_2.H_2O$:

$$3K_2MnO_4+3H_2O=MnO_2.H_2O+K_2Mn_2O_8+4KHO.$$

This change is retarded by excess of alkali. Nitric, sulphuric, or hydrochloric acid, effects the change at once; with hydrochloric acid the red solution gradually becomes brown, and when heated, colorless, owing to the formation of *mangánous chloride.* The solution is also decolorized by sulphurous and sulphydric acid and other reducing agents.

$$K_2MnO_4+2H_2SO_4=MnSO_4+K_2SO_4+2H_2O.$$

309. PERMANGANATES form a deep purple-red colored solution. They are very easily reduced by organic compounds, and by all reducing reagents, such as hydrochloric, sulphurous, arsenious, nitrous, and sulphydric acids, and ferrous salts (see § 310), stannous salts, etc.; the solution first becoming green and ultimately colorless.

310. MANGANIC SALTS in solution are red, and yield with potassic hydrate, in the *absence of ammonic chloride*, a black precipitate of manganous hydrate. They are easily reduced to manganous salts by merely heating, also by hydrochloric, sulphurous, or nitrous acid or any organic compound; the liquor then becomes colorless. Ammonic sulphide first reduces them to manganous salts, then precipitates the flesh-colored sulphide.

311. BLOWPIPE.—If a manganese compound be fused on charcoal or on a piece of platinum-foil in the outer flame of the blowpipe with sodic carbonate, there is produced sodic manganate (Na_2MnO_4), which is green while hot, and bluish-green when cold.

Potassic nitrate may be added with advantage. The mixture should be heated on the under-side of the platinum-foil in the hottest part of the flame.

312. BORAX. Any compound of manganese, when heated with borax or phosphorous salt, in the outer blowpipe flame, forms an amethyst-colored bead containing manganoso-manganic oxide, which becomes colorless in the inner flame, by reduction of that compound to manganous oxide. This test is very sensitive, and serves to distinguish manganese from other metals, when not disguised by other metals forming colored beads.

CHARACTERISTIC REACTIONS, **297, 298, 304, 307, 311, 312.**

SCHEME FOR THE SEPARATION AND DETECTION OF THE MEMBERS OF GROUP III.

The solution to be examined is supposed to contain a CHROMIC SALT, a salt of ALUMINUM, ZINC, IRON, COBALT, NICKEL and MANGANESE.

Add AMMONIC CHLORIDE, then AMMONIC HYDRATE (*until alkaline*), and then AMMONIC SULPHIDE. There will be precipitated:

$$\underbrace{Al_2(OH)_6 + Cr_2O_3.9H_2O + ZnS.H_2O + FeS.(xH_2O\ ?) + CoS + NiS + MnS.xH_2O.}$$

Filter off the precipitate, and wash it; dissolve it in the funnel with hydrochloric acid; then wash. There will be a

<table>
<tr><th colspan="2">RESIDUE.</th><th colspan="6">SOLUTION.</th></tr>
<tr><td colspan="2" rowspan="4">The residue will contain
$CoS + NiS + S$.
Test the residue with borax bead (after washing well).
Blue bead signifies—Cobalt.
Brown bead signifies—Nickel.
See §§ 277, 292.
Place precipitate in a porcelain crucible, paper and all; burn it; dissolve residue in hot nitric acid; dilute, filter, and concentrate filtrate to a few drops. Add acetic acid, then potassic nitrite, filter off the precipitate and wash.</td><td colspan="6">The solution will contain the Zn, Mn, Fe, Al, Cr, and H_2S. Add a few crystals of potassic chlorate, and boil to destroy H_2S, and to change FeO to Fe_2O_3. Add an excess of potassic hydrate, filter off the precipitate and wash.</td></tr>
<tr><th colspan="2">SOLUTION.</th><th colspan="4">PRECIPITATE.
Divide precipitate into three parts.</th></tr>
<tr><td colspan="2">Solution will contain some of the Zn, Al, Cr. Boil the solution; a precipitate will be $Cr_2O_3.5H_2O$. See § 216. Filter, wash, and test the precipitate with borax bead. See § 219. Divide filtrate into two parts.</td><th>1ST PART.</th><th colspan="2">2D PART.</th><th>3D PART.</th></tr>
<tr><th>1ST PART.</th><th>2D PART.</th><td rowspan="3">Dissolve in hydrochloric acid. Then add potassic sulphocyanate, which colors the solution a deep blood-red, showing the presence of IRON. See § 258. Test also with potassic ferrocyanide, § 256.</td><td colspan="2">Fuse on platinum-foil with sodic nitrate and sodic carbonate. If green, manganese is present. See § 310. Dissolve residue in water and filter.</td><td rowspan="3">Dissolve in warm hydrochloric acid. Add sodic carbonate, ammonic hydrate and baric carbonate: shake well; a precipitate is a greenish chromic hydrate and baric salt. Filter, add ammonic hydrate to filtrate; then ammonic sulphide, which will show the presence of manganese by a precipitate
$MnS.xH_2O$.
See § 298.</td></tr>
<tr><th>FILTRATE.</th><th>PRECIPITATE.</th><td rowspan="2">Add hydrosulphuric acid or ammonic sulphide; a precipitate is
$ZnS.H_2O$.
See §§ 226, 227. Test according to § 233.</td><td rowspan="2">Add hydrochloric acid, then ammonic hydrate; a precipitate is
$Al_2(OH)_6$.
See § 203. Test according to § 208.</td><th>SOLUTION.</th><th>RESIDUE.</th></tr>
<tr><td>Add potassic hydrate: a precipitate equal nickelous hydrate
$Ni(OH)_2$.
See § 285. Filter off precipitate and wash it; then test with borax bead, to be sure. See § 292.</td><td>A yellow precipitate
$CO_2O_3.2N_2O_3.6KNO_2.2H_2O$.
See § 274.
Test precipitate with borax bead, to be sure. See § 277.</td><td>Contains Cr, Mn, Zn. Add acetic acid and divide in halves.
1st Half.
Add plumbic acetate; a yellow precipitate is
$PbCrO_4$.
See last part of § 216.
2d Half.
Add alcohol. Boil; filter, if necessary; then add hydrosulphuric acid; a precipitate is
$ZnS.H_2O$.
See § 226.</td><td>Contains Mn, Fe, Zn. Dissolve in hydrochloric acid. Add potassic hydrate in excess, filter, add to filtrate hydrosulphuric acid; a precipitate is
$ZnS.H_2O$.
See § 226.</td></tr>
</table>

GROUP IV.

Metals NOT PRECIPITATED by HYDROCHLORIC ACID, HYDROSULPHURIC ACID, or AMMONIC SULPHIDE.

FIRST DIVISION

Will contain the metals which are precipitated by AMMONIC CARBONIC in presence of AMMONIC CHLORIDE, viz.: BARIUM, STRONTIUM, and CALCIUM.

SECOND DIVISION

Will contain the metal which is *not* precipitated by AMMONIC CARBONATE in presence of AMMONIC CHLORIDE, but is precipitated by sodic phosphate, viz., Magnesium.

FIRST DIVISION.

BARIUM.

Symbol, Ba.—Atomic weight, 137. Equivalence, II and IV.—Recognized first by Scheele in 1774.—Isolated by Davy in 1808.—Sp. Gr., 4.00.

BARIUM OXIDES.

Barium unites with oxygen to form two oxides: BaO and BaO_2.

BARIC OXIDE, BaO. When baric iodate is ignited, all the iodine is given off and $\frac{5}{6}$ of its oxygen, there then remaining baric oxide.

$$Ba(IO_3)_2 + \Delta\delta + BaO + \overbrace{I_2O_5}.$$

When baric carbonate is exposed to the strongest heat of a forge-fire, baric oxide and carbonic oxide are produced.

$$BaCO_3 + \Delta\delta = BaO + \overbrace{CO_2}.$$

Baric oxide is a grayish-white, friable mass, having a specific gravity of 4.7 (Karsten). 5.54 (Filhol). Heated in vapor of carbon disulphide, it forms baric carbonate and sulphide·

$$3BaO + CS_2 + \Delta\delta = BaCO_3 + 2BaS.$$

Baric hydrate, $BaO.H_2O$ or $Ba(OH)_2$. When baric oxide is moistened with water, it combines into hydrate with great evolution of temperature. May be prepared by boiling the sulphide with water and cupric oxide:

$$6BaS + 6H_2O + 8CuO + \Delta\delta = 5Ba(OH)_2 + BaS_2H_2O_4 + 4Cu_2S.$$

As the last two compounds are insoluble if the liquid is filtered and the filtrate allowed to cool, crystals of hydrate are deposited as the liquid cools $[Ba(OH)_2.8H_2O]$.

Baric dioxide, BaO_2, may be obtained by heating baric oxide or hydrate to low redness in a current of pure oxygen or of air free from carbonic oxide. It is a gray powder. When thrown into water it diffuses itself, forming a hydrate which probably contains $BaO_2.3H_2O$.

Argentic oxide, chloride, sulphate or carbonate introduced into an acid solution of baric dioxide, is partly reduced to metallic silver. Silver compounds in small quantities or other similar compounds are capable of reducing large quantities of baric dioxide. Iodine, on the other hand, decomposes it in exactly atomic proportions:

$$BaO_2 + I_2 = BaI_2 + \overset{\frown}{2O}.$$

METALLIC BARIUM.

313. Water. Barium decomposes water at ordinary temperatures, forming baric oxide and evolving hydrogen:

$$Ba + H_2O = BaO + \overset{\frown}{2H}.$$

314. Heated in the air, it burns with a dark-red light (Davy), but heated before the oxyhydrogen blowpipe, it burns with a greenish flame (Clarke).

315. Sulphuric acid converts the metal very rapidly into baric sulphate, with evolution of hydrogen.

$$Ba + H_2SO_4 = BaSO_4 + \overbrace{2H}.$$

BARIC SALTS.

All baric salts are colorless, except those which have a colored acid. Most of the salts are insoluble in water, but dissolve in hydrochloric acid, with the exception of baric sulphate and silicofluoride, which are insoluble in any acid. The soluble salts do not affect litmus-paper. Baric nitrate and chloride are insoluble in alcohol. All but baric chloride are decomposed upon ignition.

Solution best fitted for the reactions:

Baric Chloride, $BaCl_2$.

316. Ammonic hydrate (pure) forms no precipitate even in the most concentrated solutions.

317. Potassic hydrate (free from carbonate) produces in concentrated solutions a precipitate of baric hydrate:

$$BaCl_2 + 2KHO + 8H_2O = \underbrace{Ba(OH)_2.8H_2O} + 2KCl.$$

Water dissolves the bulky precipitate $[Ba(OH)_2.8H_2O]$.

318. Sodic or ammonic carbonate produces a white precipitate of baric carbonate:

$$BaCl_2 + Na_2CO_3 = \underbrace{BaCO_3} + 2NaCl.$$

$$BaCl_2 + (NH_4)_2CO_3 = \underbrace{BaCO_3} + 2NH_4Cl.$$

Baric carbonate is slightly soluble in ammonic chloride, so that if the solution is very dilute no precipitate is produced. With ammonic carbonate, in acid solution, a precipitate is only produced upon heating the fluid when the last reagent is used.

319. Sulphuric acid and all soluble sulphates throw down from all baric salts, whether neutral or acid, a white pulverulent precipitate of baric sulphate, which is insoluble in nitric or hydrochloric acid even at a boiling heat:

$$\mathrm{BaCl_2 + H_2SO_4 = \underbrace{BaSO_4} + 2HCl.}$$

$$\mathrm{BaCl_2 + Na_2SO_4 = \underbrace{BaSO_4} + 2NaCl.}$$

According to Harting, a solution of baric chloride containing 1 pt. of barium in 71,000 pts. of water becomes turbid with sodic sulphate after the lapse of half an hour. A solution of nitrate in 200,000 to 400,000 pts. of water, after some minutes gives a cloudiness, but in 800,000 pts. of water the reaction is no longer visible.—(Lassaigne.)

320. Sodic phosphate produces, in neutral or alkaline solutions, a white precipitate of baric phosphate ($\mathrm{BaPO_4}$), which is soluble in free acid. If ammonic hydrate is added, a portion of the precipitate is converted into basic baric phosphate ($\mathrm{3BaO.P_2O_5}$ or $\mathrm{Ba_3P_2O_8}$).

321. Potassic chromate produces a yellow precipitate of baric chromate ($\mathrm{BaCrO_4}$):

$$\mathrm{BaCl_2 + K_2CrO_4 = \underbrace{BaCrO_4} + 2KCl.}$$

The precipitate dissolves in nitric, hydrochloric, or excess of chromic acid, forming a reddish-yellow colored solution, from which it may be precipitated by ammonic hydrate.

Potassic bichromate may be used.

322. Potassic oxalate produces a white precipitate of baric oxalate ($\mathrm{Ba_2C_4O_8.2H_2O}$), soluble in hydrochloric and nitric acid:

$$\mathrm{BaCl_2 + 2KC_2O_4 + H_2O = \underbrace{Ba_2C_4O_8.2H_2O} + 2KCl.}$$

This precipitate dissolves in oxalic acid and acetic acid; but the solution rapidly deposits in the form of a crystalline powder of an hydrobaric oxalate ($\mathrm{Ba_2O_4C_4H_2.4H_2O}$).

323. Hydrofluosilicic acid, when added, produces a precipitate of microscopic crystals, insoluble in excess of the acid, composed of baric silicofluoride ($\mathrm{BaSiF_6}$).

$$\mathrm{BaCl_2 + SiH_2F_6 = BaSiF_6 + 2HCl.}$$

$$\mathrm{2HF.SiF_4 = SiH_2F_6.}$$

The precipitate is nearly insoluble in nitric and hydrochloric acid. This reaction will detect one part of baric chloride in 3800 pts. of water. Alcohol favors the precipitation. Strontium compounds *not being precipitated* by silicofluoric acid, are therefore easily detected from barium compounds and *vice versa.*

324. HEATED. Baric salts, when heated with dilute alcohol, impart to the flame a GREENISH-YELLOW color (not very characteristic). When heated in the inner blowpipe flame, the outer flame is colored yellowish-green. This flame, when viewed through green glass, appears BLUE-GREEN.

CHARACTERISTIC REACTIONS, **316, 319, 320, 324, 323.**

STRONTIUM.

Symbol, Sr.—Atomic weight, 88.—Equivalence, II and IV.—Distinguished by Hope in 1792.—Prepared pure by Matthiessen in 1855.—Atomic volume, 34.56.—Specific gravity, 2.54.—Electric conductivity, 6.71 (at 68–62° F.).

STRONTIUM OXIDES.

Strontium unites with oxygen to form two oxides: STRONTIC OXIDE and STRONTIC PEROXIDE.

STRONTIC OXIDE, SrO, may be prepared by heating strontic nitrate to redness, or by exposing the carbonate, either alone or mixed with charcoal, to the strongest heat of a forge-fire. It is a grayish-white porous mass of specific gravity, 3.0 to 4.0 (Davy), 3.932 (Karsten), infusible, not volatile, and glows in the blowpipe flame with a dazzling white light.

STRONTIC HYDRATE, $SrO.H_2O=Sr(OH)_2$, may be produced by adding atomic quantities of water to strontic oxide, when the mass becomes hot, and the strontia hardens to a crystalline hydrate. On dissolving the hydrate with five or six pts. of boiling water, filtering hot, and leaving the solution to cool, needle-shaped transparent crystals of $[Sr(OH)_2.8H_2O]$ are deposited, which deliquesce when exposed to the air. When heated to 100° C., or above, they give off fifty per cent. of water and leave strontic hydrate $[Sr(OH)_2]$.

STRONTIC PEROXIDE is obtained as hydrate in shining scales by mixing "strontia water" with hydrogen peroxide.—(THENARD.)

METALLIC STRONTIUM.

325. Heated in the air, it burns with a beautiful red light, strontic oxide being formed.

326. Acids. Hydrochloric, sulphuric, and dilute nitric act upon strontium, nitric acid often causing it to ignite. Concentrated nitric acid does not act upon it below the boiling heat.

327. Water is readily decomposed by metallic strontium, strontic oxide and hydrogen gas being formed.

$$H_2O+Sr=SrO+\overbrace{2H}.$$

STRONTIC SALTS.

Strontic chloride deliquesces in moist air, and dissolves in absolute alcohol; but strontic nitrate does not dissolve in absolute alcohol, nor does it deliquesce when exposed to the air.

Solution best fitted for the reactions:

Strontic Nitrate $[Sr(NO_3)_2]$.

328. Ammonic hydrate does not produce a precipitate when added to strontic nitrate.

329. Potassic hydrate produces a precipitate of strontic hydrate $[Sr(OH)_2.8H_2O]$:

$$Sr(NO_3)_2+2KHO+8H_2O=\underbrace{Sr(OH)_2.8H_2O}+2KNO_3.$$

This precipitate of crystals dissolves more easily in water than the corresponding baric salt.

330. Sodic or ammonic carbonate produces a white precipitate of strontic carbonate:

$$Sr(NO_3)_2+Na_2CO_3=\underbrace{SrCO_3}+2NaNO_3.$$

$$Sr(NO_3)_2+(NH_4)_2CO_3=\underbrace{SrCO_3}+2NH_4NO_3.$$

Strontic carbonate dissolves in ammonic chloride with more difficulty than baric carbonate.

331. Sulphuric acid and sulphates produces a precipitate of strontic sulphate in the form of a white powder:

$$\mathrm{Sr(NO_3)_2 + H_2SO_4 = \underbrace{SrSO_4} + 2HNO_3.}$$

$$\mathrm{Sr(NO_3)_2 + Na_2SO_4 = \underbrace{SrSO_4} + 2NaNO_3.}$$

If the solution is heated, the precipitation is greatly promoted.

Strontic sulphate is far more soluble in water than baric sulphate, therefore from dilute solution it takes a longer time for it to separate; even in concentrated solutions, if a calcic sulphate solution is used, the precipitate takes some time in forming. As strontic sulphate is insoluble in alcohol, if it be added the precipitate will form far more rapidly. If the solution is acid with nitric or hydrochloric acid, the reaction is not so delicate, as strontic sulphate is perceptibly soluble in those acids.

If baric chloride is added to a solution of baric sulphate in hydrochloric acid, then water, the mixture becomes turbid. Strontic sulphate decomposes by long digestion in solutions of ammonic carbonate or dicarbonate; also, and far more rapidly, in a boiling solution of one part of potassic carbonate and three parts of potassic sulphate. (This is an important distinction from baric sulphate.)

332. Hydrofluosilicic acid fails to produce a precipitate in dilute or concentrated solutions. (See § 326.)

333. Ammonic oxalate produces a white precipitate from even dilute solution of strontic oxalate ($\mathrm{SrC_2O_4.H_2O}$).

$$\mathrm{Sr(NO_3)_2 + (NH_4)_2C_2O_4 + H_2O = \underbrace{SrC_2O_4.H_2O} + 2NH_4NO_3.}$$

Strontic oxalate dissolves readily in nitric and hydrochloric acid, and slightly in ammonic salts, but very slightly in oxalic or acetic acids.

334. Sodic phosphate produces a white precipitate of strontic phosphate ($\mathrm{Sr_2H_2P_2O_8}$ or $\mathrm{SrHPO_4}$):

$$\mathrm{Sr(NO_3)_2 + Na_2HPO_4 = \underbrace{SrHPO_4} + 2NaNO_3.}$$

Strontic orthophosphate is a white powder, insoluble in water, but soluble in water containing acids or ammonic salts.

335. Heated with alcohol, and the mixture ignited and stirred, the flame will be a beautiful carmine color. If strontic salts be exposed on platinum-wire to the inner flame of the blowpipe, the outer flame is colored red, which, when viewed through a blue glass, appears purple to rose-colored, which distinguishes it from calcic salts, which, under the same circumstances, has a faint green-gray tint.

Characteristic Reactions, **331, 332, 335.**

CALCIUM.

Symbol, Ca.—Atomic weight, 40.—Equivalence, II and IV.—Specific gravity, 1.5778.—Atomic volume, 25.28.—Discovered by Davy in 1808, and in 1855 by Matthiessen in a pure state.

CALCIUM OXIDES.

Calcium unites with oxygen to form two oxides: CaO and CaO_2.

Calcic oxide, CaO (Lime), may be prepared by heating any calcic salt containing an easily expelled acid, such as calcic nitrate or carbonate, etc.:

$$CaCO_3 + \Delta\delta = CaO + \overbrace{CO_2}.$$

Lime or calcic oxide, when pure, forms a white porous mass of specific gravity 2.3 to 3.08. Lime takes up water very rapidly, generating steam, then falling to a powder (known as slaked lime), which is calcic hydrate (or hydrate of lime) [$Ca(OH)_2 = CaO.H_2O$]. This powder is soft, and at a red heat gives off its water and is converted again into *quick*-lime.

Calcic dioxide, CaO_2 (peroxide), is known only in the state of hydrate, which falls down in fine crystalline scales when lime-water is mixed with an aqueous solution of hydrogen peroxide.—(Thenard.)

METALLIC CALCIUM.

336. Water is decomposed by calcium; calcic oxide (CaO) being formed and hydrogen being liberated.

$$H_2O + Ca = CaO + \overbrace{2H}.$$

337. Acids, such as dilute nitric, hydrochloric, and sulphuric, rapidly act upon the metal. Nitric acid acts so rapidly sometimes that the metal ignites. Concentrated nitric acid will not act upon the metal unless heated to boiling.

338. Heated in the air on platinum, it burns with a bright flash, oxidizing and forming calcic oxide.

CALCIC SALTS.

All calcic salts dissolve in nitric or hydrochloric acid (calcic sulphate excepted). Calcic bromide, iodide, nitrate, acetate, and many other organic salts dissolve in water. Calcic carbonate, borate, phosphate, arsenate, and oxalate are insoluble in water; the sulphate is sparingly soluble. Calcic chloride and nitrate are soluble in absolute alcohol, and deliquesce in the air.

Solution best fitted for the reactions:

Calcic Chloride ($CaCl_2$). (Hydrated Calcic Chloride, $CaCl_2.3H_2O$.)

339. Ammonic hydrate produces no precipitate.

340. Potassic hydrate produces a white gelatinous precipitate of calcic hydrate [$Ca(OH)_2$], unless the solution is very dilute.

$$CaCl_2 + 2KOH = Ca(OH)_2 + 2KCl.$$

341. Sodic carbonate produces a white precipitate of calcic carbonate ($CaCO_3$):

$$CaCl_2 + Na_2CO_3 = \underbrace{CaCO_3} + 2NaCl.$$

Calcic carbonate is soluble with effervescence in nitric, hydrochloric, and acetic acids.

Hydrosodic carbonate produces no precipitate in the cold; but on boiling, a pulverulent precipitate is produced with escape of carbonic oxide.

342. Sulphuric acid and soluble sulphates produce immediately a white precipitate of hydrated calcic sulphate, unless the solution is too dilute, in which case if alcohol be added, the precipitate is soon deposited, as calcic sulphate is insoluble in alcohol.

$$CaCl_2 + H_2SO_4 + 2H_2O = \underbrace{CaSO_4.2H_2O} + 2HCl.$$

$$CaCl_2 + Na_2SO_4 + 2H_2O = \underbrace{CaSO_4.2H_2O} + 2NaCl.$$

Hydrated calcic sulphate is slightly soluble in water, the anhydrous salt nearly insoluble. 1 pt. of hydrate dissolves in 332 pts. of water at any temperature (Lassaigne). The solubility is increased by the presence of acids and sodic chloride.

343. Hydrofluosilicic acid produces no precipitate. (See § 326.)

344. Ammonic oxalate "precipitates hydrated calcic oxalate ($CaC_2O_4.H_2O$) as a white pulverulent powder, at the boiling heat or in the cold from concentrated solutions. From very dilute solutions (provided there is no free mineral acid present), in the cold the precipitate is always a mixture of ($CaC_2O_4.H_2O$ and $CaC_2O_4.3H_2O$)."—(Souchay and Lessen.)

$$CaCl_2 + (NH_4)_2C_2O_4 + H_2O = \underbrace{CaC_2O_4.H_2O} + 2NH_4Cl.$$

345. Sodic phosphate precipitates hydrated dicalcic orthophosphate ($Ca_2H_2P_2O_8.xH_2O$ or $CaHPO_4.xH_2O$):

$$CaCl_2 + Na_2HPO_4 + xH_2O = \underbrace{CaHPO_4.xH_2O} + 2NaCl.$$

If the solution is *very slightly* acid, the precipitate forms more rapidly. The precipitate is more or less soluble in acids according to the manner of precipitations.

346. Heated. When alcohol is burnt on soluble calcic salts, the flame is red tinged with yellow; viewed through a green glass, the flame appears siskin-green; through a blue glass, a faint green-gray tint. The hydrated chloride and a few other calcic compounds, when heated in the blowpipe-flame on platinum-wire, impart a red color to the flame, similar to that of strontium, but less intense; the color disappears as soon as the salts are dehydrated, and does not appear at all if baric salts are present.

CHARACTERISTIC REACTIONS, **341, 342, 343, 344, 345, 346.**

[The separation and detection of the members of the first division of Group IV will be given combined with the members of the second division.]

SECOND DIVISION.

MAGNESIUM.

Symbol, Mg.—Atomic weight, 24.—Equivalence, II.—A wire 0.297 mm. in thickness gives a light equal to 74 stearine candles, five of which weigh a pound.—Atomic volume, 13.76.—Specific heat, 0.245.—Specific gravity, 1.74. —Electric conductivity at 62.6° F. is 25.47.

MAGNESIUM OXIDE.

MAGNESIC OXIDE, MgO (Magnesia), may be produced by burning the metal in the air or in oxygen gas, or when carbonate or nitrate is ignited in the air. It is a white powder, having a specific gravity of 3.07 to 3.200, increased by ignition in a pottery-furnace to 3.61 (H. Rose). It melts under oxyhydrogen blowpipe, and is converted into an enamel which scratches glass like a diamond (Clark).

MAGNESIC HYDRATE, $Mg(OH)_2$, occurs native as brucite, and is precipitated as a white powder on adding potassic or sodic hydrate or baryta water in excess to the solution of a magnesic salt.

MAGNESIUM.

347. HEATED to redness in the air or in oxygen gas, it burns with a bluish-white light, forming magnesic oxide.

$$Mg+O=MgO.$$

348. WATER is decomposed by the metal very slowly, but if the water be acidulated the decomposition is very rapid.

349. Hydrochloric acid. When the metal is thrown on this acid, it takes fire momentarily.

350. Sulphuric acid, when concentrated, dissolves it slowly, forming magnesic sulphate ($MgSO_4$):

$$Mg + H_2SO_4 = MgSO_4 + \overbrace{2H}.$$

A mixture of sulphuric acid and fuming nitric acid does not act upon it at ordinary temperatures.

MAGNESIC SALTS.

Magnesium salts are colorless unless they contain a colored acid. They all dissolve in hydrochloric acid, with the exception of magnesic metaphosphate. Magnesic carbonate, borate, phosphate, arsenate, arsenite, and many organic salts are insoluble in water, but most of these salts are soluble in ammonic chloride; most of the others are soluble in water. They have a bitter taste. They are decomposed on ignition (magnesic sulphate excepted).

Solution best fitted for the reactions:

Magnesic Sulphate ($MgSO_4$).

351. Hydrosulphuric acid or ammonic sulphide produce no precipitate.

352. Ammonic hydrate, when added to an aqueous pure solution of a magnesic salt, produces a precipitate of magnesic hydrate [$Mg(OH)_2$], which is insoluble in excess:

$$MgSO_4 + 2NH_4OH = \underbrace{Mg(OH)_2} + (NH_4)_2SO_4.$$

If the solution were made previously acid (no excess), no precipitate would be produced, owing to the formation of an ammonic salt. Even if the solution is neutral, only part of the magnesia is precipitated, owing to the formation of a double ammonic salt.

353. Potassic hydrate produces a white precipitate of magnesic hydrate [$Mg(OH)_2$]:

$$MgSO_4 + 2KOH = Mg(OH)_2 + K_2SO_4.$$

The precipitate is insoluble in ammonic salts, especially in ammonic chloride.

354. Sodic carbonate produces a white precipitate of basic magnesic carbonate $[4MgCO_3 + Mg(OH)_2 + 10H_2O]$. "One-fifth of the carbonic oxide liberated in the process combines with a portion of the magnesic carbonate and forms a dicarbonate, which remains in solution. But if the solution be boiled, further precipitation takes place ($MgCO_3+3H_2O$ is produced)." Ammonic chloride and other ammonic salts prevent the precipitation and dissolve the precipitate formed.

355. Ammonic carbonate produces, after a time, a white precipitate of ammonio-magnesic carbonate $[(NH_4)_2CO_3+MgCO_3+4H_2O=(NH_4)_2Mg(CO_3)_2.4H_2O]$ in concentrated solution, but not in very dilute solutions. Ammonic chloride only hinders the precipitation, but does not prevent it in concentrated solutions.

356. Baric hydrate and calcic hydrate both precipitate magnesic hydrate:

$$MgSO_4+Ba(OH)_2=\underbrace{Mg(OH)_2}+BaSO_4.$$

$$MgSO_4+Ca(OH)_2=\underbrace{Mg(OH)_2}+CaSO_4.$$

This reaction affords an easy means of separating magnesia from the alkalies.

357. Sodic phosphate, when added to neutral solutions, produce a white precipitate of magnesic phosphate ($MgHPO_4.7H_2O$). If this precipitate be boiled, trimagnesic phosphate $[Mg_3(PO_4)_2.7H_2O]$ is produced:

$$MgSO_4+Na_2HPO_4+7H_2O=\underbrace{MgHPO_4.7H_2O}+Na_2SO_4.$$

If ammonic hydrate and ammonic chloride be added before precipitating, the precipitate will be ammonic dimagnesic orthophosphate $[(NH_4)_2Mg_2(PO_4)_2.12H_2O]$, which is a crystalline precipitate. This is a very delicate test for magnesic salts.

If the solution is very dilute, the crystals attach themselves to the glass, on the sides. According to Harting (J. pr. Chem., xxii. 50), a solution containing only $\frac{1}{200000}$ of magnesia gives a precipitate after twenty-four hours with ammonic phosphate mixed with free ammonic hydrate, provided the latter solution is highly concentrated and added in equal quantity.

358. Ammonic oxalate, in concentrated solutions, produces a white precipitate of magnesic oxalate ($MgC_2O_4.2H_2O$), mixed with various ammonic-magnesic oxalates.

359. Sulphuric acid produces no precipitate.

360. Hydrofluosilicic acid produces no precipitate.

361. Heated on charcoal, when moistened with water to redness, then moistened with one drop of cobaltic nitrate; heated again, first gently, then intensely, in the oxidation flame, a *pinkish* mass is obtained which becomes apparent on cooling. The salt must be free from alkalies, alkaline earths, and heavy metallic oxides to manifest this reaction.

362. Flame. Magnesic salts impart *no color* to the flame.

Characteristic Reactions, **357, 356, 359, 360, 362.**

SCHEME FOR THE SEPARATION AND DETECTION OF THE MEMBERS OF GROUP IV.

The solution to be examined is supposed to contain a salt of barium, calcium, strontium, and magnesium.

Add ammonic chloride, then ammonic hydrate, and then ammonic carbonate, there will be precipitated baric, strontic, and calcic carbonate; filter and wash the precipitate.

Precipitate.	Filtrate.
$BaCO_3 + SrCO_3 + CaCO_3$. Dissolve in hydrochloric acid; add sodic acetate, and then potassic dichromate; a *yellow* precipitate ($BaCrO_3$) is produced; filter and wash.	Test for magnesic salt by adding sodic phosphate; there will be precipitated magnesic phosphate [$Mg_2(PO_4).7H_2O$]. (See § 357.)

Precipitate.	Filtrate.
$BaCrO_3$. (See § 321.)	Add to a *portion* of the filtrate calcic sulphate, and wait *ten minutes*, if a precipitate forms. Add to the remaining portion potassic sulphate; a precipitate is produced; filter and wash thoroughly.

Precipitate.	Filtrate.
Strontic sulphate, $SrSO_4$. (See §§ 331, 335.)	Add ammonic hydrate and oxalic acid; a white precipitate is CaC_2O_4. (See §§ 344, 346, 342.)

GROUP V.

To this Group belong **Potassium**, **Sodium**, and **Ammonia**, neither of which are precipitated by **Hydrochloric Acid**, **Hydrosulphuric Acid**, **Ammonic Sulphide**, **Ammonic Carbonate**, or **Sodic Phosphate**.

POTASSIUM.

Symbol, K.—Atomic weight, 39.1.—Equivalence, I, III and V.—Atomic volume, 44.96.—Specific heat, 0.16956.—Fusing point, 144.5° F.—Specific gravity, 0.860. Electric conductivity between 68°–71° F., 20.85.

POTASSIUM OXIDES.

Potassium unites with oxygen to form three oxides, K_2O, K_2O_2, K_2O_4. "A gray suboxide is said also to be found during the gradual oxidation of the metal in the air, but it is probably a mixture of the protoxide with potassium."—(Watt.)

Potassic protoxide, (K_2O), or anhydrous potash. When potassium is exposed to air free from moisture in thin slices, potassic protoxide is produced, or when 1 at. of potassium is heated with 1 at. of potassic hydrate.

$$2KHO+K_2=2K_2O+\overbrace{2H}.$$

It is white, very deliquescent and caustic, volatilizes at a high temperature, melts at a low heat. Combines with water very rapidly.

Potassic peroxide, (K_2O_4), or tetroxide, may be prepared by heating pure potassium in a current of dry air moderately, and then in dry oxygen gas. It is a chrom-yellow powder which cakes together about 280° C. It absorbs moisture from the air, and is decomposed by water forming potassic dioxide, K_2O_2.

Potassic dioxide, K_2O_2, is formed at a certain stage in the preparation of the peroxide, but it is difficult to obtain it free from the yellow peroxide. It is a white powder; its aqueous solution is prepared by dissolving potassic peroxide in water as stated above.

POTASSIUM.

363. Heated in the air to its point of volatilization, it bursts into flame and burns rapidly with a *violet* light, forming potassic oxide (K_2O).

$$K_2+O=K_2O.$$

364. Water is decomposed with great violence by potassium, displacing half the hydrogen and forming potassic hydrate.

$$2H_2O+K_2=2KHO+\overbrace{H_2}.$$

> "The escaping hydrogen carries with it a small portion of the volatilized metal, and takes fire from the heat evolved, burning with a beautiful rose-red flame, while the metal floats on the water, and finally disappears with an explosive burst of steam as the globule of melted potash becomes cool enough to come into contact with the water."

POTASSIC SALTS.

Most of the salts are readily soluble in water. They are colorless, unless colored by their constituent acid. Potassic sulphate, carbonate, phosphate, arsenate, and borate are not decomposed by heat. Potassic chloride, bromide, iodide, and hydrate volatilize without decomposition at a very high temperature. Most other potassic salts are decomposed by heat.

Solution best fitted for the reactions:

Potassic Chloride, KCl.

365. Platinic dichloride produces a yellow crystalline precipitate of potassic chloro-platinate ($2KCl.PtCl_4=K_2PtCl_6$) in neutral and acid solutions:

$$2KCl+PtCl_4=\underbrace{2KCl,PtCl_4}.$$

$$2KNO_3+2HCl+PtCl_4=\underbrace{K_2PtCl_6}+2HNO_3.$$

$$2KClO_3+2HCl+PtCl_4=\underbrace{K_2PtCl_6}+2HClO_3.$$

In concentrated solution the precipitate forms immediately, in dilute solution only after standing for some time, and in very dilute solution the precipitate is only discernible under the microscope.

The dilute solution is best to be evaporated to a small bulk, then add alcohol and a little ether (as potassic chloroplatinite is not soluble in alcohol or ether, but is to some extent in water). As AMMONIC CHLOROPLATINITE greatly resembles POTASSIC CHLOROPLATINITE, care must be taken not to confound the two.

366. SODIC HYDROTARTRATE, $NaC_4H_5O_6$, produces a white crystalline precipitate of ACID POTASSIC TARTRATE ($KC_4H_5O_6$):

$$KCl + NaC_4H_5O_6 = \underbrace{KC_4H_5O_6} + KCl.$$

The precipitate is soluble in 180 pts. of cold water, readily soluble in acids or in alkaline solutions, *insoluble* in *alcohol.* In dilute solution the precipitation is facilitated by addition of alcohol, also by agitating the solution or scratching the side of the vessel with a glass rod. Better evaporate to small bulk, add alcohol, then the acid sodic tartrate.

367. TARTARIC ACID produces the same precipitate as sodic hydrotartrate in neutral or alkaline solutions. If the solution is acid, the acid must first be neutralized. The precipitate forms very rapidly in concentrated solutions, but not in very dilute solutions; they must first be evaporated to a small volume.

$$KCl + H.C_4H_5O_6 = \underbrace{KC_4H_5O_6} + HCl.$$

368. FLAME. Any potassic salt that is volatile at a red heat when brought in contact with the outer blowpipe flame, colors the flame violet.

Alcoholic solutions of potassic salts burn with a violet flame. The color is not visible in the presence of sodium or (lithium); but if viewed through a plate of dark-blue glass, the sodium flame is cut off, and and the potassium flame becomes distinctly visible as a rich reddish-violet color.

CHARACTERISTIC REACTIONS, **365, 366, 368.**

SODIUM.

Symbol, Na.—Atomic weight, 23.—Specific gravity, 0.972. Atomic volume, 23.60.—Specific heat, 0.29340.—Fusing point, 207.7° F.—Electric conductivity between 68°–71° F., 37.43.

SODIUM OXIDES.

Sodium unites with oxygen to form two oxides: Na_2O and Na_2O_2.

SODIC OXIDE, Na_2O (protoxide or anhydrous soda). When metallic sodium is burnt in the air, sodic protoxide and dioxide are produced. If the dioxide be exposed to a very high temperature, the protoxide is produced, or if sodic hydrate be heated with atomic quantities of metallic sodium.

$$NaOH + Na = Na_2O + \overset{\frown}{H}.$$

The specific gravity of the protoxide is 2.805.—(KARSTEN.)

SODIC DIOXIDE, Na_2O_2 (peroxide). This oxide may be prepared by igniting the metal in oxygen gas until constant weight. It is a pure white powder, which becomes yellow on heating, and on cooling, white again. When thrown into water little by little, a solution of dioxide is obtained. If this solution be evaporated over oil of vitriol, crystals of SODIC DIOXIDE HYDRATE are obtained ($Na_2O_2.8H_2O$). These crystals left to effervesce for nine days over oil of vitriol, form another hydrate, $Na_2O_2.2H_2O$.

SODIUM.

369. HEATED in the air, it burns with a yellowish flame, forming SODIC PROTOXIDE and DIOXIDE.

$$Na_4 + O_3 = Na_2O + Na_2O_2.$$

When simply exposed to the air, it oxidizes like potassium, but not so rapidly.

370. WATER is decomposed when sodium is dropped on it; hydrogen is evolved while the metal runs around on the surface of the water; the hydrogen does not take fire unless the water is previously heated.

SODIC SALTS.

Sodic salts are more generally soluble than potassic salts. They are colorless unless colored by some colored acid.

Sodic carbonate crystallizes readily whilst potassic carbonate crystallizes with difficulty. The tabular crystals of sodic carbonate effervesce rapidly when exposed to the air. The same applies to sodic sulphate, but not to potassic sulphate.

Solution best fitted for the reactions:

Sodic Chloride ($NaCl$).

371. Tartaric acid or sodic ditartrate produce no precipitate even in concentrated solutions.

372. Silicofluoric acid produces in concentrated solutions a gelatinous precipitate of sodic silicofluoride ($4NaF.SiF_4$):

$$4NaCl + 4HF.SiF_4 = \underbrace{4NaF.SiF_4}_{} + 4HCl.$$

The potassic salt ($4KF.SiF_4$) is prepared in the same way.

373. Potassic acid metantimoniate ($K_2O.Sb_2O_5.7H_2O$) (sometimes called granular antimonate of potassium). This salt may be prepared by treating antimonic trichloride with an excess of potassic hydrate sufficient to redissolve the precipitate first formed, and adding potassic permanganate till the solution acquires a faint rose color. The liquid filtered and evaporated, yields crystals of granular metantiomonate (Reynoso). This salt dissolves readily in water between 45° and 50° C., but sparingly in cold water. It must be preserved in a solid state, and only dissolved as required. When this solution is added to a sodic solution (if not too dilute), the precipitate of sodic acid metantimoniate ($Na_2O.Sb_2O_5 + 7H_2O$ or $2NaOH.SbO_5 + 6H_2O$) is flocculent at first, but finally becomes crystalline.

$$2NaCl + K_2O.Sb_2O_5.7H_2O = \underbrace{Na_2O.Sb_2O_5.7H_2O}_{} + 2KCl.$$

If the solution to be examined contain 1 pt. of sodic salt in 300 pts. of water, the precipitate is produced immediately. In dilute solutions the precipitate is gradual, and is deposited as crystal on the sides of the glass; in solutions containing $\frac{1}{1000}$ pt. of sodic salt the effect is apparent after twelve hours. The presence of alcohol helps the precipitation. Alkali in a free state retards it, and the presence of lithium and ammonia in diluted solution spoils the test; as they themselves form similar precipitates, they should first be removed, and also earth metals if present.

The solution to be tested should be neutral, or slightly alkaline, for free acid would separate antimonic acid from the potassic salt.

374. PLATINIC DICHLORIDE produces no precipitate with sodic solutions.

SODIC CHLOROPLATINATE is very soluble in water and alcohol. It may be prepared by slowly evaporating a drop of sodic chloride with an excess of platinic dichloride on a piece of glass, when crystals of sodic chloroplatinate appear, which may be seen sometimes with the eye, and readily by the help of a magnifier.

375. FLAME. Any sodic salts colors the outer blowpipe flame with a *rich yellow color*, which entirely destroys the color produced by any other metal. Alcoholic solutions of sodic salts burn with a yellow flame. The sodic flame is characterized by its rendering a crystal of potassic dichromate, which is illuminated by its light colorless. Paper covered with mercuric iodide when seen by the sodic flame appears yellowish-white (Bunsen). Viewed through *green glass*, its color is orange-yellow.—(MERZ.)

CHARACTERISTIC REACTIONS, **373, 374, 375.**

AMMONIA.

Symbol, NH_3.—Molecular weight, 17.—Molecular volume, 2.—Density, 8.5.—One litre weighs 0.762 grams (8.5 criths).—Specific heat (H_2O=1) is 0.508 (Regnault).—Specific gravity, 0.5893 (calculated by H. Davy).—Refractive power (air=1) is 1.309 (Dulong).—Faraday obtained solid ammonia by exposing the dry gas to a pressure of 20 atmospheres and to a cold of −75° C.—It is a white, transparent, crystalline body, which melts at 75° C. and has a higher specific gravity than ammonia in the liquid state, which

has a specific gravity, 0.76; boiling point at 749 mur., barometric pressure, −33.7° C. (Bunsen).—Its tension at −17.78° C. = 2.48 atmospheres; at 0° C. = 4.44 atm.; at 10.8° C. = 6 atm.; at 19.44° C. = 7.60 atm.; at 28.81° C. = 10. atm.

AMMONIC HYDRATE.

When ammonia gas is passed into water it is rapidly absorbed, with considerable evolution of heat and with great expansion.

"Davy found that 1 vol. water at 10° C. and 29.8 inches barometric pressure absorbs 670 vols. ammonia, or nearly half its weight; the specific gravity of this solution is 0.875. According to Dalton, water at even a lower temperature absorbs even more ammonia, and the specific gravity of the solution is 0.85. According to Osaun, 100 pts. water at 24° C. absorbs 8.41 pts., at 55° C., 5.96 pts. ammonia. 1 vol. water, by absorbing 505 vols. ammonia, forms a solution occupying 1.5 vols., and having a specific gravity 0.9; this, when mixed with an equal bulk of water, yields a liquid of specific gravity 0.9455, whence it appears that aqueous ammonia expands on dilution."—(URE.)

AMMONIC HYDRATE or aqueous ammonia ($NH_3 + H_2O = NH_4.OH$) is a colorless transparent liquid, smelling of ammonia, and having a sharp, burning taste.

Its specific gravity varies from 1.000 to 0.85, according to amount of ammonia it contains; its boiling point varies similarly. A perfect saturated solution freezes between −38° C. and −41° C., forming shining, flexible needles; at −49° C. it solidifies to a gray gelatinous mass without smell (Fourceroy and Vauquelin). It lost almost all its ammonia at or below 100° C. The following table, on next page, shows the amount of real ammonia contained in ammonic hydrate of different densities.

AMMONIC SALTS.

When ammonia or ammonic carbonate is brought in contact with an acid, the salt corresponding to the acid is directly produced. Ammonic salts have a pungent, saline, bitter taste. They are soluble in water generally with facility; less soluble in alcohol and ether. They are colorless if their acids are colorless. They are volatile at a high temperature with or without decomposition.

DALTON.			H. DAVY.		URE.			
Specific Gravity.	Percentage Ammonia.	Boiling Point.	Specific Gravity.	Percentage Ammonia.	Specific Gravity.	Percentage Ammonia.	Specific Gravity.	Percentage Ammonia.
0.85	35.3	−4° C.	0.8750	32.3*	0.8914	27.940	0.9363	15.900
0.86	32.6	+3.5°	0.8857	29.25	0.8937	27.633	0.9410	14.575
0.87	29.9	10°	0.9000	26.00	0.8967	27.038	0.9455	13.250
0.88	27.3	17°	0.9054	25.37*	0.8983	26.751	0.9510	11.925
0.89	24.7	23°	0.9166	22.07	0.9000	26.500	0.9564	10.600
0.90	22.2	30°	0.9255	19.54	0.9045	25.175	0.9614	9.275
0.91	19.8	37°	0.9326	17.52	0.9090	23.850	0.9662	7.950
0.92	17.4	44°	0.9385	15.88	0.9133	22.525	0.9716	6.625
0.93	15.1	50°	0.9435	14.53	0.9227	19.875	0.9768	5.500
0.94	12.8	57°	0.9476	13.46	0.9275	18.550	0.9828	3.975
0.95	10.5	63°	0.9513	12.40	0.9320	17.225	0.9887	2.650
0.96	8.3	70°	0.9545	11.56			0.9945	1.325
0.97	6.2	79°	0.9573	10.82				
0.98	4.1	87°	0.9597	10.17				
0.99	2.0	92°	0.9616	9.60				
			0.9692	9.50*				

Solution best fitted for the reactions:

AMMONIC SULPHATE $(NH_4)_2SO_4$.

376. POTASSIC HYDRATE. If a solution containing an ammonic salt be treated with potassic hydrate, ammonia is liberated:

$$(NH_4)_2SO_4+2KHO=\overbrace{2NH_3}^{\uparrow}+K_2SO_4+2H_2O.$$

The ammonia thus liberated may be detected by the smell, or by the fumes generated when a volatile acid is brought in contact with it. As, for example, HYDROCHLORIC ACID produces WHITE FUMES of AMMONIC CHLORIDE:

$$NH_3+HCl=NH_4Cl.$$

The gas generated may be detected by moistened test-paper. Calcic or sodic hydrate may be used in place of potassic hydrate.

377. PLATINIC DICHLORIDE, when added to a solution con-

---

* These numbers were determined by experiment; the rest is Davy table by calculation.

taining an ammonic salt, produces a yellow precipitate of AMMONIC CHLOROPLATINATE $[(NH_4Cl)_2PtCl_4=(NH_4)_2PtCl_6]$:

$$NH_4Cl+PtCl_4=\underbrace{(NH_4Cl)_2.PtCl_4}.$$

$$(NH_4)_2SO_4+2HCl+PtCl_4=\underbrace{(NH_4Cl)_2+PtCl_4}+H_2SO_4.$$

This precipitate is somewhat lighter in color than the corresponding potassic precipitate. Where the precipitate is ignited it is converted into pure metallic platinum perfectly free from chloride.

378. NESSLER'S TEST. If to a solution containing an ammonic salt, POTASSIC HYDRATE be added, and a solution of MERCURIC IODIDE in POTASSIC IODIDE, a brown PRECIPITATE or COLORATION is immediately produced:

$$NH_3+2HgI_2=\underbrace{NHg_2I}+3HI.$$

$$(NH_4)_2SO_4+4HgI_2=\underbrace{2NHg_2I}+6HI+H_2SO_4.$$

This reaction is by far the most delicate test for ammonia.

379. SODIC ACID TARTRATE or TARTARIC ACID produces a white precipitate of ammonic acid tartrate $(NH_4C_4H_5O_6)$:

$$(NH_4)_2SO_4+2NaC_4H_5O_6=\underbrace{2NH_4C_4H_6O_6}+Na_2SO_4.$$

This precipitate is slightly soluble in cold water, readily soluble in alkaline solutions and mineral acids. If this precipitate be ignited the carbonaceous residue obtained will have no alkaline reactions.

380. SODIC PHOSPHO-MOLYBDATE produces a YELLOW PRECIPITATE, soluble in alkalies and non-volatile organic acids, but insoluble in mineral acids.

381. FLAME. Alcoholic solutions of ammonic salts burn with a blue or violet flame.

382. HEATED. Any ammonic salt, if heated, either alone or with a fixed alkali, baryta, lime, plumbic oxide, etc., evolve ammonia. Magnesia expels only half the ammonia, forming a double salt.

CHARACTERISTIC REACTIONS, **376, 378, 382.**

SCHEME FOR THE SEPARATION AND DETECTION OF MEMBERS OF GROUP V.

The solution to be examined is supposed to contain a salt of potassium, sodium, and ammonia.

Divide the solution into two parts:

<table>
<tr><th>First Part.</th><th colspan="2">Second Part.</th></tr>
<tr><td rowspan="3">Add potassic hydrate and boil, and test for ammonia with hydrochloric acid; also by smell and test-paper. (See § 376.) Test also with Nessler's solution. (§ 378.)</td><td colspan="2">If ammonia has been found in "First Part," evaporate to dryness the "Second Part" to expel all ammonia. Dissolve residue in water; add hydrochloric acid, then platinic dichloride; there will be precipitated potassic chloroplatinate; filter and wash.</td></tr>
<tr><th>Precipitate.</th><th>Filtrate.</th></tr>
<tr><td>K_2PtCl_6. (See § 365.) Test as in § 368.</td><td>Evaporate filtrate to dryness; the presence of red circular crystals indicate the presence of a sodic salt. Add alcohol, and test by flame. (See § 375.)</td></tr>
</table>

SCHEME FOR

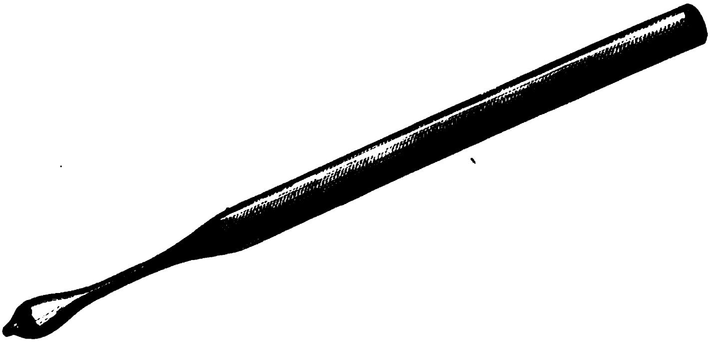
QUALITATIVE ANALYSIS.

THE SUBSTANCE FOR EXAMINATION IS A SOLID.

PRELIMINARY EXAMINATION.*

This consists in an accurate observation of the physical properties of the substance, its form, color, hardness, gravity, and odor, and of its deportment at a high temperature, either alone or in contact with some chemical compound which produces decomposition.

1. The substance is heated in a dry narrow tube.



(*a*). Organic compounds *carbonize* and *blacken*, evolving empyreumatic, inflammable gases.

---

* The majority of the preliminary tests are taken from Manual of Chem. Anal., by Fred. Hoffman, Ph.D.

(*b*). The *substance remains unaltered;* indicating absence of organic matter, of salts containing water of crystallization, and of volatile compounds.

(*c*). The *substance fuses, expelling aqueous vapors*, which condense in the cooler parts of the tube; indicating salts with water of crystallization (these will generally re-solidify after the expulsion of the water) or decomposable hydrates, which often give off their water without fusing.

(*d*). *Gases or fumes are evolved;* smell of iodine from iodine compounds; smell of sulphurous oxide from decomposition of sulphates; smell of nitrogen oxides from the nitrates; smell of ammonia from ammonic salts, from cyanides, or from nitrogenous organic compounds, in which latter case carbonization takes place, and either cyanogen or empyreumatic fumes escape with the ammonia.

(*e*). *Sublimates are formed* by volatile substances, as sulphur and compounds of ammonium, mercury, arsenic, and antimony. In this case the sublimate is removed to the bottom of the test-tube, and, together with the substance, is covered with a few small pieces of charcoal, and again heated; mercury and arsenic form metallic sublimates, the latter with the characteristic garlic odor, the former without. In another tube part of the substance is heated, and the sublimate is moistened with solution of potassic hydrate; mercurous chloride turns black; mercuric chloride red; and ammonic salts evolve the odor of ammonia.

2. THE SUBSTANCE IS MIXED WITH DRIED SODIC CARBONATE, AND HEATED ON CHARCOAL IN THE REDUCING-FLAME OF THE BLOWPIPE.

(*a*). *Fusion and absorption* into the coal indicates alkalies.

(*b*). An *infusible white residue*, either at once or after previous fusion in the water of crystallization, indicates compounds of calcium, barium, strontium, magnesium, aluminium, zinc, or tin.

(*c*). A *reduction to the metallic state* takes place, without formation of a *peripheric incrustation* upon the charcoal. Compounds of tin, silver, and copper give malleable shining scales. Compounds of iron, manganese, cobalt, and nickel are reduced to a gray infusible powder; all visible upon cutting the fuse from the coal, and triturating and levigating it in an agate mortar.

(*d*). *Reduction with incrustation:* Antimony compounds give a brittle metallic globule and a white incrustation; bismuth, a brittle globule and a brown-yellow incrustation; lead, a malleable globule and a yellow incrustation; zinc and cadmium are reduced, but give, the former a white incrustation, not volatile in the oxidizing flame, the latter a brown-red incrustation.

(*e*). Arsenic compounds give the smell of garlic.

(*f*). Borates and aluminates swell up.

(*g*). Sulphur compounds give an alkaline sulphide, which, when moistened, leaves a black stain upon a clean piece of silver.

3.* FUSE A SMALL PORTION TOGETHER WITH A BEAD OF MICROCOSMIC SALT, AND EXPOSE FOR SOME TIME TO THE OUTER FLAME OF THE BLOWPIPE.

(*A*). THE SUBSTANCE DISSOLVES READILY, AND RATHER LARGELY, TO A CLEAR BEAD (WHILE HOT).

(*a*). *The hot bead is colored:*

BLUE, by candle-light inclining to violet—COBALT.

GREEN, upon cooling, blue; in the reducing-flame, after cooling, red—COPPER.

GREEN, particularly fine on cooling, unaltered in the reducing-flame—CHROMIUM.

BROWNISH-RED, on cooling, light-yellow or colorless; in the reducing-flame, red whilst hot, yellow whilst cooling, then greenish—IRON.

DARK-YELLOW to REDDISH, turning lighter or altogether colorless on cooling; in the reducing-flame unaltered—NICKEL.

YELLOWISH-BROWN, on cooling, changing to light-yellow or losing its color altogether; in the reducing-flame almost col-

---

* From "Qualitative Analysis," Fresenius, 1870, p. 252.

orless (especially after addition of a very little tin-foil), blackish-gray on cooling—BISMUTH.

BRIGHT-YELLOWISH TO OPAL, when cold, somewhat turbid; in the reducing-flame, whitish-gray—SILVER.

AMETHYST-RED, especially on cooling; colorless in the reducing-flame, not quite clear—MANGANESE.

(*B*). *The hot bead is colorless:*

IT REMAINS CLEAR ON COOLING: ANTIMONY, ALUMINA, ZINC, CADMIUM, LEAD, LIME, MAGNESIA; the latter five metals, when added in somewhat large proportion to the microcosmic salt, give enamel white beads; the bead of oxide of lead is yellowish when saturated.

IT BECOMES ENAMEL-WHITE ON COOLING, even when only a small portion of the powder has been added to the microcosmic salt—BARYTA, STRONTIA.

(*b*). THE SUBSTANCE DISSOLVES SLOWLY AND ONLY IN SMALL QUANTITY:

(*a*). The bead is colorless, and remains so even after cooling; the undissolved portion looks semi-transparent; upon addition of a little ferric oxide, it acquires the characteristic color of an iron bead—SILICIC ACID.

(*b*). The bead is colorless, and remains so after the addition of a little ferric oxide—TIN.

(*c*). THE SUBSTANCE DOES NOT DISSOLVE, BUT FLOATS (IN THE METALLIC STATE) IN THE BEAD—GOLD, PLATINUM.

"As the body under examination may consist of a mixture of the most dissimilar elements, it is impossible to give well-defined cases that shall offer at the same time the advantage of general applicability. If, therefore, reactions are observed in an experiment which proceed from a combination of two of several cases, the conclusions drawn from these reactions must of course be modified accordingly."—(FRESENIUS.)

4. DISSOLVE A PORTION OF THE FINELY POWDERED SUBSTANCE IN H_2O, AND FILTER:

If not soluble in . . . . . H_2O, dissolve in . . . . . . HCl.
" " " " . . . . . HCl, " " . . . . . HNO_3.
" " " " . . . . HNO_3, " " $(3HCl+HNO_3)$.
" " " "$(3HCl+HNO_3)$, it must be rendered soluble

by other means. This is generally accompanied by fusion with three to four parts by weight of alkaline carbonates, in the case of baric, strontic, calcic, and plumbic sulphate, and also of silicic oxide and silicates, or by fusion with hydropotassic sulphate in the case of aluminic oxide or aluminates.*

H_2O SOLUTION.

Test with red and blue litmus-paper. Add HCl. If solution was acid, the precipitate may be either $PbCl_2$, AgCl, or Hg_2Cl_2. If solution was alkaline, it may be either $2SbCl_3.5Sb_2O_3$, $SnO_2.H_2O$, H_4SiO_4, etc. Filter if precipitate forms. Add to filtrate H_2S; if precipitate is produced, saturate the liquid with H_2S gas and precipitate PbS, CuS, HgS, CdS, Bi_2S_3, As_2S_x, Sb_2S_x, SnS_x, Au_2S_3, PtS_2. Filter and wash; test according to Group II.

ACTUAL ANALYSIS.

Substance to be examined is soluble in water; also such as are insoluble in water, but soluble in HCl, HNO_3, $(3HCl.HNO_3)$.

GROUP I.

SCHEME FOR DETECTING.

Ag. salts.—Hg_2 salts.—Pb salts.

Add HCl. Prec. = $AgCl + Hg_2Cl_2 + PbCl_2$. None

Filter and wash; *lay filtrate one side* to be further treated (as in Group II). No precipitate; pass on to Group II.

Boil precipitate in H_2O and filter.

<table>
<tr><th>Filtrate.</th><th colspan="2">Residue.</th></tr>
<tr><td rowspan="3">$PbCl_2$ in H_2O.
Add dilute H_2SO_4, which will precipitate $PbSO_4$. (See §§ 18, 27.)</td><td colspan="2">$AgCl + Hg_2Cl_2$.
Add NH_4OH and filter.</td></tr>
<tr><th>Solution.</th><th>Residue.</th></tr>
<tr><td>Add HNO_3 which will precipitate AgCl. (See § 5.)</td><td>If black (see § 32). Dissolve in $(3HCl.HNO_3)$. Add $SnCl_2$ and boil; Hg precipitated. (See § 33.)</td></tr>
</table>

---

* See Scheme for Analysis of Insoluble Substances.

GROUP II.

SCHEME FOR DETECTING.

Pb, Cu, Bi, Hg, Cd, As, Sb, Sn, Au, Pt.

Add to filtrate from Group I (after testing with HCl), H_2S until filtrate smells distinctly of the reagent; filter off the precipitate (after passing H_2S gas through solution); wash it. Lay filtrate aside (test according to Group III). If no precipitate forms, pass on to Group III. The precipitate may be:

PbS, CuS, Bi_2S_3, HgS, CdS, As_2S_x, Sb_2S_x, SnS_x, Au_2S_3, PtS_2.

Add yellow NH_4HS, warm gently and filter.

RESIDUE.

PbS, CuS, Bi_2S_3, HgS, CdS.

Wash well to remove Cl. (Test with $AgNO_3$.)

Boil prec. with HNO_3; filter; wash.

RESIDUE. $HgS + S$ (black). Dissolve in $3HCl.HNO_3$ and boil with $SnCl_2$. Prec. = Hg. (See § 43.)

SOLUTION. Pb, Cu, Bi, Cd. Add dilute H_2SO_4; conc. sol. to expel HNO_3. Add H_2O and filter.

RESIDUE. $PbSO_4$. (See § 21.)

SOLUTION. Cu, Bi, Cd. Add NH_4OH and filter.

PRECIPITATE. $Bi_2O_3.H_2O$. Wash. Dissolve in HCl test. (§ 90.)

FILTRATE. Cu, Cd. Divide in two parts.

1ST PART. Acidulate with acetic acid. Add K_4Cfy; a precipitate is Cu_2Cfy. (See § 60.)

2D PART. Add KCN to destroy blue color; then add H_2S, which will precipitate CdS. (See § 70.)

SOLUTION.

As_2S_x, Sb_2S_x, SnS_x, Au_2S_3, PtS_2.

Add dilute H_2SO_4; there is precipitated [illegible]$S_3 + Sb_2S_3 + SnS_2 + Au_2S_3 + PtS_2 + S$.

Filter and wash; dissolve in HCl and $KClO_3$ by gentle heat $AsCl_3 + SbCl_3 + SnCl_4 + Au$[illegible]$ + PtCl_4$. Divide in two parts.

1ST PART. Test this portion for As, Sb, Sn. Concentrate; introduce some into flask containing $Zn + H_2O + H_2SO_4$. See §§ 132, 102. Pass gas generated into $AgNO_3$. Prec. = $Ag + Ag_3Sb$. Filter; wash.

PRECIPITATE. Wash well; introduce filter and precipitate in a test-tube. Add tartaric acid and boil for a few minutes, filter (residue Ag). Add H_2S and boil; an orange-red prec. = Sb_2S_3. (See § 126.)

FILTRATE. Add $AgNO_3$. Neutralize with dilute NH_4OH; a yellow prec. = $Ag_4As_2O_5$. (See §§ 99, 107.)

2D PART. Test this portion for Au, Pt. Divide in halves.

1st Half. Add HCl then $FeSO_4$ and boil. Prec. equal Au. (See § 191.)

2d Half. Add NH_4Cl. Evaporate to dryness over water bath; treat with alcohol. Orange-red residue is $(NH_4Cl)_2.PtCl_4$ indicates Pt. (See § 182.)

DETECTION OF TIN. Detach tin f[illegible]n flask by agitation, then transfer the tin [illegible]r vessel; wash it; boil with HCl; filter, if necessary. Add $HgCl_2$. There is p[illegible]d Hg_2Cl_2; boil. Hg is precipitated, which indicates Sn. (See § 160.)

GROUP III.

SCHEME FOR DETECTING.

Al_2O_3, Cr_2O_3, ZnO, CoO, NiO, MnO, FeO, Fe_2O_3, Appendix.

Add to filtrate from [illegible] II (after testing wi[illegible]$_2$S) $NH_4Cl + NH_4OH$ (until alkaline) $+ NH_4HS$. Filter off [illegible] precipitate. Lay filtrate to one side to be tested according to Group IV. If no precipitate forms, pass on to Group IV.

The precipitate may be:

$$Al_2(OH)_6 + Cr_2O_3.9H_2O + ZnS.H_2O + FeS(xH_2O\ ?) + CoS + NiS + MnS.xH_2O.$$

Wash, and dissolve in the funnel with HCl, then wash again. There will be a

RESIDUE.

$CoS + NiS + S$.

Wash well and treat with borax bead (note color). (See §§ 277, 292.) Burn precipitate, paper and all, in porcelain crucible, dissolve residue in hot HNO_3 dilute, filter, concentrate to a few drops. Add acetic acid to the KNO_2. Filter off the precipitate and wash.

FILTRATE.

Add KOH; a precipitate is $Ni(OH)_2$. (See § 285.) Filter off precipitate; wash it, then test with borax bead to be sure. (See § 292.)

PRECIPITATE.

A yellow precipitate, $Co_2O_3.2N_2O_5.6KNO_3.2H_2O$. (See § 274.) Test prec. with borax bead to be sure. (See § 277.)

SOLUTION.

$Zn + Mn + Fe + Al + Cr + H_2S$.

Add a few crystals of $KClO_3$ and boil to destroy H_2S and to change FeO to Fe_2O_3. Add an excess of KOH. Filter off precipitate and wash.

FILTRATE.

Some Zn, Al, Cr.

Boil; a precipitate is $Cr_2O_3 5H_2O$. Filter; wash; test with bead. (See §§ 216, 219.)

Divide filtrate in two parts.

1ST PART.

Add H_2S or NH_4HS; a precipitate is $ZnS.H_2O$. (See §§ 226, 227.) Test according to § 233.

2D PART.

Add HCl, then NH_4OH; a precipitate is $Al_2(OH)_6$. (See § 203.) Test according to § 208.

PRECIPITATE.

Fe, Mn, Appendix (Zn, Cr ?).

Divide in two parts.

1ST PART.

Dissolve in HCl and divide in halves.

1st Half.

Test a portion with KCNS; color deep blood-red, indicates iron. (See § 258.) Test another portion with potassic ferrocyanide. (See § 256.)

2d Half.

Add Tartaric acid, then an excess of NH_4HO; a precipitate will be the APPENDIX. Filter and wash, and *save filtrate.** The Appendix will consist of phosphates and oxalates of Ca, Ba, Sr, Mg. Dissolve precipitate in acetic acid and filter.

FILTRATE.

Divide in two parts.

1ST PART.

A[illegible] part dr[illegible] to a so[illegible] am[illegible]bdate [([illegible])O_4] in HNO_3: a pulverulent pale yellow precipitate indicates presence of phosphoric acid.

2D PART.

Add Fe_2Cl_6 and sodic acetate. Warm gently and filter.

PRECIPITATE.

$Fe_2O_3.P_2O_5 = FePO_4$.

White powder. Indicates the presence of phosphoric acid.

FILTRATE

Will contain Ba, Sr, Ca, Mg. Test according to Group IV.

RESIDUE

Consists of oxalates. Wash dry and ignite. Dissolve in dilute HCl. Effervescence of CO_2 indicates the presence of phosphoric acid.

2D PART.

Divide in two parts: *a* and *β*.

1st *a*. Dissolve in warm HCl. Add Na_2CO_3, NH_4OH and $BaCO_3$; shake well; a precipitate is a greenish chromic hydrate mixed with basic salt. Filter, add NH_4OH to filtrate, then NH_4HS, which will show the presence of Mn by a precipitate $MnS.xH_2O$. (See § 298.)

2d. *β*. Fuse on Pt foil with $NaNO_3$ and Na_2CO_3. If green, Mn is present. (See § 311.) Dissolve residue in H_2O and filter.

SOLUTION.

Cr, Mn, Zn.

Add acetic acid and divide.

1st Half.

Add [illegible] acetate; [illegible] precipitate is [illegible]O_4. (See last [illegible] § 216.)

2d Half.

Add alcohol; boil: filter if necessary; then add H_2S; a precipitate is $ZnS.H_2O$. (See § 226.)

RESIDUE.

Mn, Fe, Zn.

Dissolve in HCl. Add KOH in excess. [illegible], add to filtrate H_2S; a precipitate is [illegible]O. (See § 226.)

[illegible] This filtrate may be tested for any of the metals of this Group.

GROUP IV.

SCHEME FOR DETECTING

Ba, Sr, Ca, Mg.

Add to filtrate from Group III (after testing with NH_4HS), $NH_4Cl + NH_4OH + (NH_4)_2CO_3$; a precipitate is produced; filter and wash.

[illegible] no precipitate is produced, pass on to Group V.

Precipitate.	**Filtrate.**
$BaCO_3 + SrCO_3 + CaCO_3$. Dissolve in HCl; add sodic acetate, then $K_2Cr_2O_7$; a yellow precipitate is produced; filter.	Mg. Add $NaHPO_4$; a precipitate is $Mg_3(PO_4)_2.7H_2O$. (See § 357.)

Precipitate.	**Filtrate.**
$BaCrO_4$. (See § 321.) $BaCrO_4$	Add to a portion of filtrate $CaSO_4$, and wait ten minutes, if a precipitate forms. Add to the remaining portion K_2SO_4; a precipitate is produced; filter and wash thoroughly.

Precipitate.	**Filtrate.**
$SrSO_4$. (See §§ 331, 335.)	Add NH_4OH and oxalic acid; a white precipitate is CaC_2O_4. (See §§ 344, 346, 342.)

GROUP V.

SCHEME FOR DETECTING

NH_3, K, Na.

Divide a portion of the *original solution* in two parts:

First Part.	**Second Part.**
Add KOH and boil: test gas with HCl; smell, and try test-paper. (See § 376.) Test also with Nessler's solution. (See § 378.)	If ammonia has been found in "First Part," evaporate to dryness the "Second Part" to expel all amm[illegible] (present as salts). Disso[illegible] in H_2O; add HCl, then [illegible] precipitate forms; filter and [illegible]

PRECIPITATE.	FILTRATE.
K_2PtCl_6. (See § 365.) Test as in § 368.	Evaporate filtrate to dryness; the presence of red circular crystals indicates the presence of Na. Add alcohol, and test by flame. (See § 375.) May also test with $K_2O.Sb_2O_5.7H_2O$. (See § 373.)

INSOLUBLE SUBSTANCES.

SCHEME FOR THEIR DETECTION.

SiO_2, Silicates, $BaSO_4$, $PbSO_4$, $SrSO_4$, SnO_2, CrO_3.

Make borax bead—green$=Cr_2O_3$. Fuse part of insoluble substance with Na_2CO_3 on charcoal with reducing flame, then put it on a bright silver coin when cold, and moisten with water; a small black spot on silver, after standing, indicates sulphur. Wash the fused mass a little, then grind to a powder, and carefully look for metallic scales$=Pb(SO_4)$. Boil original substance with $NH_4C_2H_3O_2$, and filter and wash.

SOLUTION.	RESIDUE.
Contains the $Pb(SO_4$?).	Fuse some with Na_2Co_3 on charcoal; metallic globule$=Sn$. Black spot on silver coin$=BaSO_4+SrSO_4$. Fuse some of residue on Pt foil with Na_2CO_3; boil with water and filter.

SOLUTION.	RESIDUE.
Acidulate with HCl; evaporate to dryness; moisten with HCl; dissolve in H_2O and filter.	Dissolve in HCl; evaporate to dryness; moisten with HCl; dissolve in H_2O and filter.

SOLUTION.	RESIDUE.	SOLUTION.	RESIDUE.
Test for H_2SO_4 with $BaCl_2$.	Test for SnO_2 with phosphorous bead.	Ba, Sr. Test according to Group IV.	Test for SiO_2 with phosphorous bead.

DETECTION OF THE INORGANIC AND ORGANIC ACIDS IN SUBSTANCES SOLUBLE IN WATER.

SULPHURIC ACID (H_2SO_4).

Add baric chloride to a portion of the original solution [if Pb.Ag. or Hg_2 salt have been found, add $Ba(NO_3)_2$], which, if acid, first make neutral or slightly alkaline with NH_4OH. If a precipitate forms, add HCl; if it does not dissolve, sulphuric acid (H_2SO_4) is present.

$$H_2SO_4 + BaCl_2 = \underbrace{BaSO_4} + 2HCl.$$

To detect free H_2SO_4 in presence of a sulphate, mix the fluid under examination with a very little cane-sug[illegible]nd evaporate to dryness at 212° F. If free H_2SO_4 was present, a black residue remains, or in the case of most minute quantities, a blackish-green residue. Other free acids do not decompose cane-sugar in this way.—(Runge.)

Hydrochloric (HCl); **Hydrobromic** (HBr); **Hydriodic** (HI); **Hydrocyanic** (HCN); **Hydroferrocyanic** ($H_4Fe^{II}Cy_6$); **Hydroferricyanic** [$H_6(Fe_2)^{VI}Cy_{12}$]; and **Sulphur.**

Add to a portion of the original solution argentic nitrate ($AgNO_3$); there will be precipitated:

$$AgCl + AgBr + AgI + AgCy + Ag_4FeCy_6 + Ag_6Fe_2Cy_{12}.$$

Observe the color of the precipitate:

AgCl, AgBr, AgCy, Ag_4FeCy_6 are *white precipi[illegible]*
AgI is a *yellow precipitate.*
$Ag_6Fe_2Cy_{12}$ is a *brownish-red precipitate.*

Add HNO_3 to the precipitate and shake it; if it does not dissolve, one or all of the above acids may be present. If the precipitate is blackish, this points to hydrosulphuric acid or a soluble metallic sulphide. Sulphur may easily be detected by testing a fresh solution w[illegible]SO_4.

If hydrosulphuric acid [illegible]ent in the solution to [illegible]ted, it must first be removed by boiling. Alkaline sulphides must be removed by a metallic salt, such as will not precipitate any of the other acids, or at least will not precipitate them from acid solutions.

HYDRIODIC ACID (HI) and HYDROCYANIC ACID (HCN), in the presence of hydrochloric or hydrobromic acid, may be detected, viz.: The HYDRIODIC ACID solution is mixed with some thin clear starch-paste, then made distinctly acid with dilute H_2SO_4 or HCl, and a drop or two of a concentrated solution of potassic nitrate (KNO_2) is then added, when the *starch iodide*, blue color, makes its appearance; if the hydriodic acid present is v[illegible] dilute, the fluid turns reddish instead of blue. This reaction is more delicate when the solution is quite cold.

[illegible] HYDROCYANIC ACID solution (or the solution containing it) is mixed with ferrous sulphate, which has been exposed to the air for a while; then potassic hydrate is added, when a bluish-green precipitate forms, which consists of prussian blue and ferric hydrate. Heat, then add HCl, when the hydrate will dissolve and leave prussian blue undissolved. If hydrocyanic acid is present in only minute quantities, the fluid sim[illegible]ppears green after adding HCl, and it is only after long standing that a small precipitate falls.

For the detection of HYDROCHLORIC and HYDROBROMIC ACID, hydrocyanic and hydriodic acid must be removed. All the radicals present in the solution to be tested must be converted into silver salts and ignited. The argentic cyanide wi[illegible]by be decomposed, leaving the argentic chloride, b[illegible]nd iodide unaltered. The residue is then fused wi[illegible]O_3+K_2O, then boiled with H_2O; sodic and potassic chloride, bromide, and iodide are then in solution; or the fused silver salts may be easily decomposed by means of zinc and H_2SO_4, and the whole allowed to stand for some time. The solution, containing the soluble zincic chloride, b[illegible]nide, or iodide, is filtered o[illegible]n the metallic silver. If to t[illegible]ixed sodic or zincic [illegible] solution of one part of cupr[illegible]phate and two and a [illegible] parts of ferrous sulphate be added, the sodic or zincic iodide will be decomposed and cuprous iodide (Cu_2I_2) will be precipitated as a dirty-white precipitate. The addition of a little ammonic hydrate helps the complete precipitation.

From HYDROBROMIC ACID, hydriodic acid is separated most accurately by palladious chloride, which only precipitates the hydriodic acid as palladious iodide. From hydrochloric it is separated by palladious nitrate.

HYDROBROMIC ACID, in presence of hydriodic acid and hydrochloric acid, may be detected, viz.: "Mix the fluid with a few drops of dilute H_2SO_4, then with some starch-paste, and add a little red fuming nitric acid or, better still, a solution of hyponitric acid in sulphuric acid, whereupon the iodine reaction will show itself immediately. Add now chlorine water, drop by drop, until that reaction has disappeared; and then add some more chlorine water to set the bromine also free, which may then be separated and identified," viz.: The substance to be examined is placed in a test-tube, and a little carbonic disulphide or chloroform is added, which gathers as a globule at the bottom; dilute chlorine water is then added drop by drop, the whole being agitated. When bromine is present in considerable quantities (*e.g.*, 1 of bromine to 1000 of water), the globule acquires a reddish-yellow color; with very minute quantities (*e.g.*, 1 of bromine to 30,000 of water), it still has a perceptible pale-yellow tint.

HYDROCHLORIC ACID.

Hydrochloric acid may be said to be present wh[illegible]ere traces of iodine and bromine have been found; if the precipitate by argentic nitrate is quite large, and is not soluble in nitric acid.

METALLIC CHLORIDE.

Metallic chlorides are detected in the presence of metallic bromides, viz.: The metallic chlorides and bromides are triturated with potassic chromate, the mixture treated with sulphuric acid in a tubulated retort, and a gentle heat applied;

a deep brownish-red gas is evolved, which condenses into a fluid, and passes over into the receiver. If this distillate is mixed with ammonic hydrate in excess, if a metallic chloride is present, a yellow tint is imparted to the liquid by the ammonic chromate which forms; upon the addition of an acid, the color of the solution changes to a reddish-yellow, owing to the formation of ammonic dichromate. In the case of a metallic bromide, the distillate does not turn yellow, but becomes colorless upon supersaturation with ammonic hydrate.

NITRIC ACID (HNO_3).

If ferrous sulphate is added very carefully to a solution containing a nitrate (with the same volume of pure sulphuric acid as the nitrate), so that the fluids do not mix, the stratum, where the two fluids are in contact, shows a purple, afterward a brown, or in cases where only minute quantities of nitric acid are present, a reddish color. If the fluids are mixed, a clear brownish-purple liquid is obtained.

CHLORIC ACID ($HClO_3$).

When sulphuric acid is poured into a solution containing a chlorate (as, for example, potassic chlorate), there will be produced potassic perchlorate ($KClO_4$), potassic hydrosulphate ($KHSO_4$); and a bright yellow gas, perchloric oxide (Cl_2O_4), is evolved:

[illegible] $$KClO_3 + 2H_2SO_4 = KClO_4 + 2KHSO_4 + H_2O + \overbrace{Cl_2O_4}.$$

The gas has an aromatic odor, and colors the solution yellow. If the solution be heated (which should be done with only a small quantity, and with a great deal of care), a *cracking* sound occurs.

PHOSPHORIC ACID (H_3PO_4).

Add to the solution supposed to contain phosphoric acid, ammonic hydrate in excess, then ammonic chloride, and then magnesic sulphate; there will be precipitated ammonio-magnesian phosphate $(NH_4)_2Mg_2P_2O_8$. The precipitate is white, and if kept in a warm place (not too hot) it subsides quickly.

If a solution containing phosphoric acid be added drop by drop to a solution of ammonic molybdate in nitric acid, there is formed in the cold, either immediately or after the lapse of some time, a *pulverulent pale-yellow precipitate*, which gathers on the sides and bottom of the tube. If the phosphoric acid is only present in quantity (0.0002 grm.), it is necessary to heat gently (not above 100° F.), and to wait a few hours.

OXALIC ACID ($C_2H_2O_4$).—HYDROFLUORIC ACID (HF).

Add ammonic hydrate, then calcic chloride; if a precipitate is produced, add acetic acid; if not dissolved, test a portion of the original solution by adding some finely-pulverized manganese dioxide and a few drops of sulphuric acid for OXALIC ACID. If present, a lively effervescence ensues, caused by escaping carbonic oxide:

$$MnO_2+C_2H_2O_4+H_2SO_4=MnSO_4+\overbrace{2CO_2}^{\uparrow}+2H_2O.$$

Test another portion of the original substance for HYDROFLUORIC ACID. Mix together the substance to be tested with sulphuric acid (so that a thin paste is made) in a platinum crucible, and cover with a watch-glass which has been coated on the convex side with bees-wax, and a few marks made with a pin through the wax to the glass; fill the concave side with water, and heat the crucible gently for an hour or so, when the marks made by the pin will be etched into the glass by the action of the hydrofluoric acid evolved, and the marks will not be removed by washing.

BORACIC ACID (H_3BO_3).

Add to a portion of the original solution, hydrochloric acid until distinct acid reaction; then dip a slip of turmeric paper in the solution; then dry the paper at 112° F., when, if boracic acid was present, the paper will show a peculiar *red* tint

(H. Rose). If this peculiar red-tinted paper be moistened with an alkali or alkaline carbonate, its color passes into bluish or greenish-black. Hydrochloric acid restores the red tint (A. Vogel; H. Ludwig). Malvern W. Iles, Ph.B., has discovered what may be called the most reliable test for boracic acid and borates known. It consists in simply dipping a platinum-wire in glycerine, then into the finely-powdered substance, and then holding the same in a gas flame, when the flame will be colored green. By this method boracic acid has been detected in substances when, by all other tests, its presence could not be demonstrated.

SILICIC ACID (H_4SiO_4).

This acid has probably been found already. Evaporate some of original substance with hydrochloric acid to dryness; moisten with hydrochloric acid, and dissolve in water. If SiO_2 remains, silicic acid is present. (Phosphorous bead.)

CHROMIC ACID (H_2CrO_4).

The yellow or red color of the original solution, or the purple-red color of the precipitate produced by argentic nitrate, points to the presence of chromic acid. If there remains any doubt, add plumbic acetate to a portion of the original solution acidified with acetic acid, when basic plumbic chromate will be precipitated ($Pb_2CrO_5=2PbO.CrO_3$).

ORGANIC ACIDS.

Before testing for organic acid, remove, first, Group I, II, III, according to Scheme, as their presence might disturb the reactions.

Make a portion of the fluid from which Group I, II, III have been removed slightly alkaline by adding NH_4OH; add some NH_4Cl, then CaCl, and shake vigorously, and let the mixture stand at rest for some minutes (ten to twenty).

A precipitate forms; filter.

Precipitate.

Digest and shake the precipitate with NaHO; dilute with water; filter, and boil filtrate for some time. If a precipitate separates, TARTARIC ACID ($C_4H_6O_6$) may be assumed to be present. Pour over the precipitated calcic tartrate NH_4OH in a test-tube, then add $AgNO_3$, and heat, when pulverulent metallic silver will separate.

Filtrate.

Add some more calcic chloride, then add alcohol. A precipitate forms; filter.

Precipitate.

Wash with some alcohol, dissolve on filter with HCl; add NH_4OH to feeble alkaline reaction, and boil for some time. A heavy white precipitate forms; filter.

Precipitate.

Calcic citrate dissolve in HCl; add NH_4OH, and boil; if calcic citrate is precipitated again, CITRIC ACID ($C_6H_8O_7$) is present.

Filtrate.

Add alcohol again, which will precipitate calcic malate; dissolve in acetic acid; add alcohol, and filter if necessary. The filtrate is precipitated with plumbic acetate, and neutralized with ammonic hydrate; wash precipitate; stir in water decomposed by H_2S, and evaporate filtrate to dryness.

The malic acid thus obtained, if heated in a glass tube, is converted into *maleic acid* ($C_4H_4O_4$), which will condense to crystals in the colder part of the tube. This indicates the presence of MALIC ACID ($C_4H_6O_5$).

Filtrate.

Heat to expel alcohol, neutralize exactly with HCl, and add Fe_2Cl_6. If a light-brown flocculent precipitate is produced, filter, digest, and heat the washed precipitate with NH_4OH in excess; filter, evaporate filtrate nearly to dryness, and divide in halves.

1st half.

Add alcohol and baric chloride; a white precipitate will consist of baric succinate, $BaC_4H_4O_4$, which indicates the presence of SUCCITRIC ACID ($C_4H_6O_4$).

2d half.

Add hydrochloric acid, when BENZOIC ACID ($C_7H_6O_2$) will be precipitated as a dazzling white sparkling powder.

"Benzoic acid may generally be detected by pouring a little hydrochloric acid over the original solution, when the benzoic acid will remain undissolved; if this be heated on a platinum-foil, it will fuse, and afterward volatilize completely. The fumes of benzoic acid cause a peculiar irritating sensation in the throat and provoke coughing; when cautiously cooled, they condense to brilliant needles; when kindled, they burn with a luminous sooty flame."

ACETIC ACID ($C_2H_4O_2$).

Introduce a portion of the original solution in a small tube, pour some alcohol over it, add about an equal volume of sulphuric acid, and heat to boiling. Evolution of the odor of acetic acid demonstrates its presence, increased by shaking.

FORMIC ACID (CH_2O_2).

When neither chromic or tartaric acid have been found, add to solution argentic nitrate in excess the sodic hydrate until the fluid is exactly neutralized, and boil.

If formic acid is present, the argentic formiate which was produced is decomposed and metallic silver precipitated

If chromic and tartaric acid *have* been found, mix the original solution with some nitric acid; add plumbic oxide in excess; shake the mixture; filter; add to the filtrate dilute sulphuric acid in excess, and distil. Add to the distillate ferric oxide (Fe_2O_3), when the fluid will become a blood-red color, owing to the formation of a soluble neutral salt.

A COMPLETE TABLE OF

BY JAMES

(OLD SYSTEM OF

NAME.	AMMONIA.	POTASH.	CARBONATE OF POTASH.	BICARBONATE OF POTASH.
Salts of Potash,	No precipitate.	— — —	— — —	— — —
Soda,	No precipitate.	— — —	— — —	— — —
Lithia,	No precipitate.	— — —	No immediate precipitate. but after a time a granular one.	The same.
Baryta,	A voluminous precipitate, soluble in a large quantity of water.	The same.	A white precipitate, soluble with, effervesces in free acids.	The same.
Strontia,	No precipitate unless left for some days.	Same as Baryta; not quite so soluble.	Same as Baryta.	Same as Baryta.
Lime,	Same as Strontia.	The same, not quite so soluble.	The same as Baryta & Strontia.	The same.
Magnesia,	A bulky precipitate completely soluble in Muriate of Ammonia.	A white precipitate, insoluble in excess; soluble in Muriate of Ammonia.	A white precipitate, soluble in Muriate of Ammonia.	No precipitate unless solution is boiled, then a strong one.
Alumina,	A white precipitate, insoluble in Muriate of Ammonia in excess, but soluble in Potash.	A precipitate soluble in excess, insoluble in Muriate of Ammonia.	A white precipitate, soluble in caustic potash.	The same; Carbonic Acid gas is disengaged.
Glucina,	A white precipitate, insoluble in excess and in Muriate of Ammonia.	A precipitate completely soluble in excess.	A precipitate, soluble in a great excess of precipitant.	The same.
Thoria,	A gelatinous precipitate, insoluble in excess.	The same.	A white precipitate, soluble in excess.	The same.
Yttria,	A white, voluminous precipitate, insoluble in excess.	The same.	A white precipitate, slightly soluble in a great excess.	The same, completely soluble in a great excess.
Zirconia,	A white precipitate, insoluble in excess.	The same, perfectly insoluble in excess.	A white precipitate, slightly soluble in a great excess.	The same.
Cerium, (Protoxide, Peroxide)	A white precipitate, turning brown. insoluble in excess.	The same.	A white precipitate, slightly soluble in excess.	The same.

HAYWOOD.

NOMENCLATURE.)

CARBONATE OF AMMONIA.	SULPHURETTED HYDROGEN.	HYDROSULPHATE OF AMMONIA.	YELLOW PRUSSIATE OF POTASH.	RED PRUSSIATE OF POTASH.
— — —	— — —	— — —	— — —	— — —
— — —	— — —	— — —	— — —	— — —
No precipitate.	No precipitate.	— — —	— — —	— — —
The same.	No precipitate.	— — —	— — —	— — —
The same.	No precipitate.	— — —	— — —	— — —
The same.	No precipitate.	— — —	— — —	— — —
Same as the Bicarbonate of Potash, soluble in Muriate of Ammonia.	No precipitate.	No precipitate if the test is pure.	— — —	— — —
The same.	No precipitate in any solution.	A white precipitate of Alumina, soluble in Potash.	No precipitate.	No precipitate.
A white precipitate, soluble in excess.	No precipitate.	A white precipitate, soluble in Potash.	No precipitate.	— — —
The same.	No precipitate.	A white precipitate of Thoria.	A white, heavy precipitate, soluble in acids.	No precipitate.
The same.	No precipitate.	A precipitate of Yttria.	A white precipitate.	No precipitate.
The same, more easily soluble in excess.	No precipitate.	A voluminous precipitate.	A white precipitate.	No precipitate.
The same.	No precipitate.	A white precipitate of Protoxide.	A white precipitate.	No precipitate.

A COMPLETE TABLE OF

BY JAMES

(OLD SYSTEM OF

NAME.	OXALIC ACID.	IODIDE OF POTASSIUM.	SULPHATE OF POTASH.	PHOSPHATE OF SODA.
Salts of Potash,	— — —	— — —	— — —	— — —
Soda,	— — —	— — —	— — —	— — —
Lithia,	No precipitate	— — —	A white precipitate, if Ammonia be added.	No precipitate; but if Ammonia be added, a strong one.
Baryta,	No precipitate unless left for some days.	— — —	A voluminous, white precipitate, insoluble in strong acids.	A white precipitate, soluble in free acids.
Strontia,	A troubling in strong solutions; if Ammonia be added, a precipitate.	No precipitate.	The same as Baryta; rather more soluble in water.	Same as Baryta.
Lime,	An immediate precipitate, soluble in Nitric or Muriatic Acid.	— — —	No precipitate in dilute solutions, but a white one if strong.	Same as Baryta.
Magnesia,	No precipitate unless Ammonia be added.	— — —	No precipitate.	A white precipitate, particularly if Ammonia be added.
Alumina,	No precipitate.	— — —	After a time crystals of Alum are formed.	A white precipitate, soluble in Acids or Potash.
Glucina,	No precipitate.	— — —	No crystals are formed.	A voluminous precipitate.
Thoria,	A white precipitate, insoluble in excess.	— — —	Thrown down as a double salt, insoluble in excess.	A white, flaky precipitate.
Yttria,	A white precipitate, soluble in Muriatic Acid.	— — —	After a time a precipitate is formed, but is easy soluble in an excess.	A white precipitate, soluble in acids, but is again precipitated by boiling.
Zirconia,	A white precipitate, soluble in a great excess or in Muriatic Acid.	— — —	A white precipitate, almost insoluble in water and acids.	A voluminous precipitate.
Cerium, (Protoxide, Peroxide)	A white precipitate, even in acid solutions; sparingly soluble in Muriatic Acid.	— — —	After a time a precipitate, insoluble in excess.	A white precipitate.

HAYWOOD.

NOMENCLATURE)

METALLIC ZINC.	BEFORE THE BLOWPIPE.	OBSERVATIONS.
— — —	On Platinum wire tinges outer flame violet; with Borax and Oxide of Nickel, a blue bead.	Give a white precipitate with Tartaric Acid, a yellow one with Chloride of Platinum, and a gelatinous one with Hydrofluosilicic Acid, which distinguishes it from other substances.
— — —	The bead of Nickel and Borax is not changed by Soda; heated on Platinum wire tinges outer flame yellow.	Gives no precipitate with Tartaric Acid, or Chloride of Platinum, by which it may be distinguished.
— — —	Tinges outer flame of a carmine color; the double phosphate is fusible.	No precipitate with Chloride of Platinum; can easily be distinguished from the former.
— — —	Cannot easily be distinguished: the Chloride tinges outer flame greenish; infusible alone; fusible with fluxes.	Easily distinguished by forming a white precipitate with Sulphates and Carbonates. The Chloride is insoluble in Alcohol.
— — —	Tinges outer flame carmine red when heated on Platinum wire.	Distinguished from Baryta by giving a precipitate with Hydrofluosilicic Acid, and by the filtered liquid of the still Alkaline Sulphate giving a precipitate with Baryta water.
— — —	Same as Strontia, only not so bright; gives a powerful white light when strongly heated.	Distinguished from Baryta and Strontia by giving no precipitate with Sulphates when diluted; separated in the state of Nitrates and Chlorides by Alcohol.
— — —	When a salt of Magnesia, that has been heated, is moistened with Nitrate of Cobalt, it acquires a pale red color.	Easily distinguished and separated by Sulphates from the above, or by the precipitates being all soluble in Muriate of Ammonia.
— — —	Treated as the above on Charcoal, a fine blue color is communicated to the assay.	Distinguished from the Alkalies by giving a white precipitate with Ammonia, and may be separated from most other substances by Caustic Potash.
— — —	When moistened with Nitrate of Cobalt, becomes dark gray, or nearly black.	May be distinguished from Alumina by the Carbonates, from Magnesia by being insoluble in Muriate of Ammonia, and from Lime and the Alkalies by Ammonia.
— — —	Not easily distinguished; produces a colorless bead with Borax.	Thoria may be distinguished and separated from the above substances, as it is perfectly insoluble after ignition in all acids except the Sulphuric.
— — —	Yttria behaves in the same manner as Glucina.	Distinguished from Thoria by Sulphate of Potash, and from the other substances described by the same means as Thoria.
— — —	Cannot easily be distinguished from similar substances.	Distinguished from Thoria by Sulphate of Potash and Oxalic Acid, and from Yttria by its Oxide, after ignition, being insoluble in all Acids except the Sulphuric.
— — —	Converted to Peroxide, soluble in Borax, producing a red bead; color flies on cooling.	Distinguished from other substances previously described by turning into a red Peroxide when heated in contact with the atmosphere.

NAME.	AMMONIA.	POTASH.	CARBONATE OF POTASH.	BICARBONATE OF POTASH.
Manganese, - - - (Protoxide)	A white precipitate, soluble in Muriate of Ammonia, turning brown at the surface.	A precipitate, turning brown, insoluble in Muriate of Ammonia.	A permanent, white precipitate, slightly soluble in Muriate of Ammonia.	The same, unless very dilute.
Manganese, - - - (Sesquioxide and Peroxide)	A dark-brown precipitate, insoluble in Muriate of Ammonia.	The same.	A brown, voluminous precipitate.	The same.
Zinc, - - - - -	A white, gelatinous precipitate, soluble in excess.	The same as Ammonia.	A white precipitate, insoluble in excess, but soluble in Muriate of Ammonia or Caustic Alkalies.	A white precipitate, which behaves in the same manner.
Cobalt, - - - - (Protoxide or Peroxide)	A blue precipitate, soluble in excess, forming a greenish solution, turning brown.	A blue precipitate, insoluble, turning green and pale, red when boiled.	A red precipitate, which boiling renders blue.	A red precipitate.
Nickel, - - - - - (Protoxide and Peroxide)	A slight green troubling, then a clear, blue solution, precipitate green by Potash.	An apple-green precipitate, insoluble in excess.	A light-green precipitate.	The same; Carbonic Acid gas is given off.
Iron, - - - - - (Protoxide)	A green precipitate, soluble in Muriate of Ammonia, turning brown in contact with the air.	A green precipitate, insoluble in excess, turning brown at the surface.	A white precipitate, soluble in Muriate of Ammonia.	The same.
Iron, - - - - - (Sesquioxide and Peroxide)	A reddish-brown precipitate, insoluble in Muriate of Ammonia.	The same.	A light-brown precipitate.	The same; Carbonic Acid is disengaged.
Cadmium, - - -	A white precipitate, soluble in a slight excess.	A white precipitate, insoluble in excess.	A white precipitate, insoluble in excess.	A white precipitate; Carbonic Acid is disengaged.
Lead, - - - - - (Protoxide Peroxide)	A white precipitate, insoluble in an excess, except with Acetates.	A white precipitate, soluble in a great excess.	A white precipitate, insoluble in excess, but soluble in Potash.	A similar precipitate with an evolution of gas.
Bismuth, - - - -	A white precipitate, insoluble in excess.	The same.	The same.	The same.
Copper, - - - - (Deutoxide)	A green precipitate and deep purple solution; again precipitated by Potash if boiled.	A green precipitate, which boiling renders black.	A green precipitate, which boiling renders black.	A light-green precipitate, soluble in excess.

CARBONATE OF AMMONIA.	SULPHURETTED HYDROGEN.	HYDROSULPHATE OF AMMONIA.	YELLOW PRUSSIATE OF POTASH.	RED PRUSSIATE OF POTASH.
The same.	No precipitate unless Ammonia be added.	A flesh-red precipitate, turning brownish in contact with the air.	A pale-red precipitate, soluble in free acids.	A brown precipitate, insoluble in free acids.
The same.	A milk-white precipitate of Sulphur; solution then contains a Protosalt.	The flesh-red precipitate; the precipitate by Ammonia is turned flesh-red by it.	A grayish-green precipitate.	The same as the Protoxide.
A white precipitate, soluble in excess.	A white precipitate if neutral, but none if acid.	A white precipitate, insoluble in excess.	A gelatinous, white precipitate, insoluble in Muriatic Acid.	A yellowish-red precipitate, soluble in Muriatic Acid.
A red precipitate, soluble in Muriate of Ammonia.	No precipitate; solution turns darker.	A black precipitate, insoluble in excess.	A green precipitate turning gray, insoluble in Muriatic Acid.	A reddish-brown precipitate, insoluble in Muriatic Acid.
A green precipitate, soluble in excess, forming a bluish solution.	No precipitate; solution turns darker.	A black precipitate, slightly soluble in excess.	A white precipitate, slightly tending to green, insoluble in Muriatic Acid.	A yellowish-green precipitate, insoluble in Muriatic Acid.
The same.	No precipitate..	A black precipitate, turning brown at the surface.	A light-blue precipitate, turning darker, insoluble in Muriatic Acid.	An immediate dark-blue precipitate, insoluble in Acids.
A light-brown precipitate.	A milky-white precipitate of Sulphur; solution then contains Protoxide.	A black precipitate, same as Protoxide.	An immediate dark-blue precipitate, insoluble in Muriatic Acid.	No precipitate.
A white precipitate, insoluble in excess.	A yellow precipitate.	A yellowish precipitate, insoluble in excess.	A slightly yellow precipitate, soluble in Muriatic Acid.	A yellow precipitate, soluble in Muriatic Acid.
The same.	A black precipitate, in both neutral and acid solutions.	A black precipitate, insoluble in excess.	A white precipitate.	No precipitate.
The same.	A black precipitate, in both neutral and acid solutions.	A black precipitate, insoluble in excess.	A white precipitate, soluble in Muriatic Acid.	A pale-yellow precipitate, soluble in Muriatic Acid.
A green precipitate, soluble in excess, same as Ammonia.	A black or dark-brown precipitate, in both neutral and acid solutions.	The same; insoluble in excess.	A reddish-brown precipitate, insoluble in Muriatic Acid.	A yellowish-green precipitate, insoluble in Muriatic Acid.

NAME.	OXALIC ACID.	IODIDE OF POTASSIUM.	SULPHATE OF POTASH.	PHOSPHATE OF SODA.
Manganese, (Protoxide)	A white crystalline deposit, unless very dilute.	— — —	No precipitate.	A permanent, white precipitate.
Manganese, (Sesquioxide and Peroxide)	No precipitate, but the solution is soon rendered colorless.	— — —	— — —	A brown precipitate in neutral solutions.
Zinc,	A white precipitate, soluble in free Acids and Alkalies.	— — —	No precipitate.	A white precipitate, soluble in free Acids and Alkalies.
Cobalt, (Protoxide or Peroxide)	A slight troubling and shortly a pale-red precipitate.	— — —	No precipitate.	A blue precipitate.
Nickel, (Protoxide and Peroxide)	No immediate precipitate, but a slow deposit.	— — —	No precipitate.	A white precipitate, slightly tending to green.
Iron, (Protoxide)	A yellow color, and shortly a precipitate.	No precipitate.	No precipitate.	A white precipitate, turning green.
Iron, (Sesquioxide and Peroxide)	No precipitate; solution turns yellowish.	No precipitate.	— — —	A white precipitate, which Ammonia turns brown, and at length dissolves.
Cadmium,	An immediate precipitate, soluble in Ammonia.	— — —	— — —	A white precipitate.
Lead, (Protoxide, Peroxide)	An immediate, white precipitate.	A yellow precipitate, soluble in a great excess.	A white precipitate, very insoluble.	A white precipitate, soluble in Potash.
Bismuth,	No immediate precipitate, but after a time a granular one.	A brown precipitate, soluble in excess.	No precipitate except from the water of solution.	A white precipitate.
Copper, (Deutoxide)	A greenish precipitate.	A white precipitate, soluble in a great excess.	No precipitate.	A greenish-white precipitate, soluble in Ammonia.

METALLIC ZINC.	BEFORE THE BLOWPIPE.	OBSERVATIONS.
No precipitate.	Produces a bead of an amethyst color in the outer flame with Borax, which disappears in the inner flame.	The reaction of these salts with Hydrosulphate of Ammonia is so well characterized that they cannot be mistaken.
— — —	Same as Protoxide.	The Peroxide is always converted into the Deutoxide by solution in an Acid. Muriatic Acid converts it into Protoxide by boiling.
— — —	On Charcoal with Soda a coat of white Oxide is formed; with Nitrate of Cobalt they assume a green color.	The solution in Potash is precipitated by Hyd. Sul. Am., which distinguishes it from earthy salts, and may easily be separated from other metals by Ammonia.
— — —	The smallest portion colors Borax strongly blue; reduced to a metallic state with Soda; magnetic.	Easily distinguished from all other salts by their behavior with Hydrosulphate of Ammonia.
— — —	With Borax in the outer flame, a reddish color, which disappears when cold; with Soda, a white magnetic powder.	Distinguished from Cobalt by Ammonia and Potash, and from other substances in the same way as Cobalt.
— — —	With Borax in the outer flame, a red bead, turning lighter as it cools; interior flame a green bead, turning lighter on cooling.	The Salts of Iron are easily distinguished by their behavior with the Prussiates; may be separated from Manganese by Succinate of Soda.
— — —	Peroxide behaves in the same manner; with Soda, a magnetic powder is obtained.	Peroxide is distinguished and separated from Protoxide by red Prussiate of Potash and Ammonia.
Is precipitated as small metallic spangles.	Heated on Charcoal, in the inner flame a brownish-red powder sublimes.	Distinguished by Sulphuretted Hydrogen, and may be separated from all the above by a bar of Zinc.
Precipitates in a crystalline metallic state.	Heated on Charcoal with Soda, is reduced to metallic globules, which are malleable; a yellow powder sublimes; produces clear glass with Borax.	Solutions of Lead give a precipitate with Sulphuric Acid and sulphates, and therefore may be distinguished from most other metals. Muriatic Acid also precipitates Lead, but water dissolves the precipitate.
Precipitates it from the milky solution, even as a spongy mass.	On Charcoal are easily reduced to brittle metallic globules; a yellow oxide sublimes; with Borax, a clear glass.	May be detected by giving a precipitate with water alone.
Zinc and Iron both precipitate metallic Copper from all its solutions.	Outer flame with Borax, a fine green bead; inner flame dirty red; with Soda is reduced.	Salts of Copper can be easily distinguished from other salts by their behavior with Ammonia and Potash.

NAME.	AMMONIA.	POTASH.	CARBONATE OF POTASH.	BICARBONATE OF POTASH.
Silver, - - - -	A brown precipitate, very soluble in excess, but is reprecipitated by Potash.	A brown precipitate, insoluble in excess, but soluble in Ammonia.	A white precipitate, soluble in Ammonia.	The same.
Mercury, - - - - (Protoxide)	A black precipitate, soluble in excess.	A black precipitate, soluble in excess.	A dirty yellow precipitate, which boiling renders black.	A white precipitate, rendered black by boiling.
Mercury, - - - - (Peroxide)	A white precipitate, insoluble in excess.	A yellow or white precipitate, soluble in excess.	A reddish-brown precipitate; if it contains Muriate of Ammonia, a white one.	A reddish-brown precipitate, either immediate or after a time.
Platina, - - - -	A yellow precipitate, soluble in excess, insoluble in free acids.	A yellow precipitate, soluble in excess when boiled, and again precipitated by acids.	A yellow precipitate, insoluble in excess.	The same; Muriatic Acid must be added in all cases.
Gold, - - - - -	A yellow precipitate.	At first no precipitate, but shortly a black one.	No precipitate.	No precipitate
Tin, - - - - - - (Protoxide)	A white precipitate, insoluble in excess.	A white precipitate, soluble in excess; decomposed by boiling.	A white precipitate, insoluble in excess.	The same.
Tin, - - - - - - (Peroxide)	A white precipitate, soluble in acids and in excess.	The same, soluble in excess.	The same; deposits slowly again after solution.	A white precipitate, insoluble in excess.
Antimony, - - -	A white precipitate, insoluble in excess and in Muriatic Acid.	The same, soluble in Muriatic Acids.	The same.	The same.
Chromium, - - -	A greenish-blue precipitate, insoluble in excess.	A green precipitate, soluble in excess; again thrown down by boiling.	A green precipitate, slightly soluble in excess.	The same; rather lighter.
Vanadium, - - -	A grayish-white precipitate, turning red and dissolving.	The same.	A grayish-white precipitate, soluble in excess.	The same.
Columbium, - - -	Is readily dissolved, and may be again precipitated by acids.	The same, insoluble in strong acids.	The same, and may be dissolved by Acetic Acid.	The same.
Iridium, - - - -	A brown precipitate, partly soluble, forming a purple solution.	A dark-brown precipitate.	No precipitate; color destroyed.	The same.

CARBONATE OF AMMONIA.	SULPHURETTED HYDROGEN.	HYDROSULPHATE OF AMMONIA.	YELLOW PRUSSIATE OF POTASH.	RED PRUSSIATE OF POTASH.
A white precipitate, soluble in excess.	A black precipitate, in both neutral and acid solutions.	A black precipitate, insoluble in excess.	A white precipitate.	A reddish-brown precipitate.
A gray or black precipitate.	A black precipitate, in acid and neutral solutions.	A black precipitate, insoluble in excess, partly soluble in Potash.	A white, gelatinous precipitate.	A reddish-brown precipitate, turning white.
A white precipitate.	A black precipitate, turning white, and again black by an excess, soluble in Potash.	The same; solution must be neutral.	A white precipitate, turning blue.	A yellow in most solutions, but none with the Perchloride.
A yellow precipitate.	A brown color and shortly a precipitate.	A brown precipitate, soluble in a large excess.	A yellow precipitate, solution turns darker.	The same.
A yellow precipitate, if neutral.	A black precipitate, in both acid and neutral solutions.	A brown precipitate, soluble in excess.	An emerald-green color.	No precipitate.
The same.	A dark-brown precipitate, in both acid and neutral solutions.	A brown precipitate, soluble in excess, reprecipitated by Muriatic Acid.	A white, gelatinous precipitate.	A white precipitate, soluble in Muriatic Acid.
The same.	No immediate precipitate, but shortly a yellow one.	A yellow precipitate, soluble in excess.	No precipitate at first, but shortly the whole forms a thick jelly.	No precipitate.
The same.	A red precipitate in acid solutions.	A red precipitate, soluble in an excess.	A white precipitate, insoluble in Muriatic Acid.	No precipitate, but shortly a slight opacity.
The same; approaching to violet.	No precipitate in any solutions.	A greenish precipitate.	No precipitate.	No precipitate.
The same, insoluble in excess.	Generally a brown precipitate, in ether, acid, or neutral solutions.	A grayish-white precipitate.	— — —	— — —
The same.	— — —	No action with the Acid, but a brown precipitate with the Oxide.	A yellowish-green precipitate.	— — —
The same.	A dark-brown precipitate.	The same; soluble in excess.	No precipitate.	— — —

NAME.	OXALIC ACID.	IODIDE OF POTASSIUM.	SULPHATE OF POTASH.	PHOSPHATE OF SODA.
Silver, - - - - -	A white precipitate, soluble in Ammonia.	A yellowish precipitate, soluble in excess.	A white precipitate, unless the solution be diluted; soluble in water.	A yellow precipitate, soluble in Ammonia.
Mercury, - - - - (Protoxide)	A white precipitate.	A greenish-yellow precipitate, rendered black by an excess and at length dissolves.	A white precipitate.	A white precipitate.
Mercury, - - - - (Peroxide)	A white precipitate, but none in the Perchloride.	A fine scarlet precipitate, soluble in excess and in Muriatic Acid.	A white precipitate.	A white precipitate in most, but not in the Perchloride.
Platina, - - - -	No precipitate.	A deep-brown color and precipitate, which boiling reduces.	No precipitate.	No precipitate.
Gold, - - - - -	A dark color, and shortly the Gold is precipitated.	A dark color and a yellowish precipitate.	No precipitate.	No precipitate.
Tin, - - - - - - (Protoxide)	A white precipitate.	A yellowish precipitate, turning red, soluble in excess.	A white precipitate, partial.	A white precipitate.
Tin, - - - - - - (Peroxide)	No precipitate.	No precipitate.	No precipitate.	A white precipitate.
Antimony, - - -	A white precipitate, caused by water.	The same.	The same.	The same.
Chromium, - - -	No precipitate.	A greenish precipitate, soluble in Muriatic Acid.	No precipitate.	A light-green precipitate.
Vanadium, - - -	— — —	— — —	No precipitate.	No precipitate.
Columbium, - -	Dissolves the Oxides.	— — —	Fused with it, the Oxide remains after boiling.	— — —
Iridium, - - - -	— — —	— — —	No precipitate or action.	— — —

METALLIC ZINC.	BEFORE THE BLOWPIPE.	OBSERVATIONS.
Is precipitated in a metallic state.	With Borax in the outer flame, a milky glass; with Soda is easily reduced.	Muriatic Acid throws down a white precipitate, insoluble in acids, but soluble in Ammonia, which distinguishes it from all other substances.
Forms a gray coating, which is an amalgam.	Heated in a glass tube with a little Soda, Mercury sublimes and condenses in small globules.	Muriatic Acid gives a white precipitate, insoluble in acids, which Ammonia renders black, but does not dissolve; by this it may be distinguished.
Same as Protoxide.	Same as Protoxide.	Persalts of Mercury are easily recognized by Sulphuretted Hydrogen and Iodide of Potassium.
A black, metallic powder.	Completely reduced, but gives no color to fluxes or flame.	Easily recognized by its behavior with Potash and Ammonia; may be separated by Muriate of Potash.
A brown, bulky coating.	Same as Platina, insoluble in all acids except Nitro-Muriatic.	Protochloride of Tin gives a deep purple color and precipitate; Sulphate of Iron throws down the gold, which distinguishes it from most other metals.
Small grayish-white spangles of Tin.	Easily reduced with Soda; deprives a bead of Copper and microcosmic salt of its green color.	The behavior of these salts with Gold, as above, is sufficient to distinguish them.
A white jelly; Hydrogen gas is disengaged.	Reduced on Charcoal, forms a white enamel with glass; does not dissolve easily in Borax.	The Peroxide is insoluble in all Acids after ignition; Nitric Acid oxidizes Tin, but does not dissolve the Oxide.
Precipitated in the form of a black powder.	Reduced with Soda, rapidly oxidizes and sublimes in the outer flame as a thick, white smoke.	The Oxide is volatile and insoluble in Nitric Acid; may be distinguished from Tin by Sulphuretted Hydrogen; water only precipitates part of the Oxide.
— — —	A fine emerald-green bead, both in the inner and outer flame, with fluxes.	Its solutions are usually green, and may be distinguished from most other solutions by Sulphuretted Hydrogen.
No precipitate.	In the inner flame, with Borax, a green glass, outer becomes yellow.	All its salts have a blue color; distinguished from Iron by Hydrosulphate of Ammonia.
— — —	Effervesces with Soda; a clear glass with Borax, or the Phosphoric Salt.	When fused with Caustic or Carbonated Alkalies, the whole is soluble in water.
Precipitated as a dark powder.	No action with fluxes; no odor; may be coupled with lead.	Fused with Carbonate of Potash, the result is not soluble in water, but dissolves in Muriatic Acid, producing various colors.

NAME.	AMMONIA.	POTASH.	CARBONATE OF POTASH.	BICARBONATE OF POTASH.
Rhodium, - - -	Shortly a lemon-yellow color.	A yellow precipitate, soluble in acids.	A gelatinous precipitate when boiled with the double Chloride.	No precipitate
Palladium, - - -	A yellowish precipitate, slightly soluble in excess.	An orange-colored precipitate from the Nitrate.	A deep-brown precipitate, insoluble in excess.	The same.
Osmium, - - - -	No precipitate; solution turns yellow.	Fused with the whole, is soluble in water.	No precipitate; solution turns yellowish.	The same.
Tellurium, - - -	A white precipitate, soluble in excess.	A white precipitate, soluble in excess; reprecipitated by acids.	The same.	The same.
Titanium, - - -	A white precipitate, insoluble in excess.	The same.	The same.	The same.
Tungsten, - - -	The Acid dissolves, but is again precipitated by stronger acids.	The same.	Is insoluble in water when fused in it.	— — —
Uranium, - - -	A brown, flaky precipitate, insoluble in excess.	A yellowish precipitate, insoluble in excess.	The same, slightly soluble.	The same.
Molybdenum, - -	The Acid is dissolved, and the Protoxide forms a brown precipitate.	The same; precipitate insoluble in excess.	A brown precipitate, soluble in excess.	The same.

CARBONATE OF AMMONIA.	SULPHURETTED HYDROGEN.	HYDROSULPHATE OF AMMONIA.	YELLOW PRUSSIATE OF POTASH.	RED PRUSSIATE OF POTASH.
No precipitate.	— — —	No precipitate.	No precipitate.	— — —
The same.	A dark-brown precipitate.	The same.	An orange or olive yellow precipitate.	— — —
The same.	A brown precipitate.	The same; soluble in excess.	No precipitate.	No precipitate.
The same.	A black precipitate, soluble in Potash.	The same, or in excess.	No precipitate.	No precipitate.
The same.	No precipitate.	A dirty-green precipitate, unless Tartaric Acid be present, then no precipitate.	A deep orange precipitate.	The same.
— — —	No precipitate.	A precipitate, soluble in excess.	— — —	— — —
A yellowish precipitate, soluble in excess.	No precipitate.	A black precipitate, slightly soluble in excess.	A brownish-red precipitate.	— — —
The same.	A brown precipitate, in Alkaline solutions.	The same, if Muriatic Acid be added.	A brown precipitate.	The same.

NAME.	OXALIC ACID.	IODIDE OF POTASSIUM.	SULPHATE OF POTASH.	PHOSPHATE OF SODA.
Rhodium, - - -	— — —	— — —	Fused with the Bisulphate, the whole dissolves in water.	— — —
Palladium, - - -	No action.	— — —	An orange-yellow precipitate.	— — —
Osmium, - - - -	Turns darker, but is not precipitated.	— — —	No precipitate or action.	— — —
Tellurium, - - -	— — —	— — —	— — —	— — —
Titanium, - - -	A white flocculent precipitate.	— — —	— — —	— — —
Tungsten, - - -	— — —	— — —	Does not form a double salt.	— — —
Uranium, - - -	— — —	— — —	No double salt.	— — —
Molybdenum, - -	— — —	— — —	— — —	— — —

METALLIC ZINC.	BEFORE THE BLOWPIPE.	OBSERVATIONS.
Precipitated from double Chloride of Rhodium and Soda.	No action with fluxes.	Insoluble in acids after ignition; distinguished and separated by Bisulphate of Potash; the double Chloride is soluble in Alcohol.
Precipitated in a metallic state.	Same as Rhodium.	The Cyanide of Mercury will easily separate Palladium as a yellow precipitate; the Chloride is soluble in Alcohol.
Precipitated as a dark powder.	Gives a strong odor of Chlorine; has no action with fluxes; may be cupelled with Lead.	Tincture of Galls gives a purple precipitate; separated by distillation.
Is precipitated as a black powder.	A white glass, when cold; with fluxes; fumes when heated alone.	May be separated from most other metals, combined with Chlorine or Hydrogen, both compounds being volatile.
A deep-blue color is produced.	With Soda, a yellow glass, opaque when cold; with Borax and inner flame, a blue glass.	Is precipitated by boiling; distinguished from other metals by its behavior with Tartaric Acid and Hydrosulphate of Ammonia.
In Muriatic Acid a blue Oxide is formed.	With Borax, a clear glass in the outer flame, yellow in the inner; blood-red with Iron and Phosphorous salt.	Sulphuric, Nitric, and Muriatic Acid precipitate its Alkaline solutions white, turning yellow when boiled with Nitro-Muriatic Acid.
— — —	On Platinum with Borax, a clear, yellow glass, outer flame, dirty green, not volatile.	Separated from most metals by dissolving in Carbonate of Ammonia or Soda; its solutions are green.
In a Muriatic solution of the Acid a blue and red powder.	Sublimes as a white powder; a clear glass with Borax.	Distinguished by Carbonates. but separated by Hydrosulphate of Ammonia.

ZETTNOW'S SCHEME FOR QUALITATIVE ANALY

ARRANGED BY

FOR THE STUDENTS OF THE SCHOOL

Add hydrochloric acid to the solution, wash, and filter.

<table>
<tr><td colspan="3"><i>Precipitate.</i>
Boil with water and filter.</td><td colspan="6">Add excess of dilute</td></tr>
<tr><td><i>Solution.</i>
Add H_2SO_4</td><td colspan="2"><i>Residue.</i>
Treat with $(NH_4)HO$</td><td colspan="3"><i>Precipitate.</i>
Agitate with considerable cold water and filter.</td><td colspan="3"></td></tr>
<tr><td rowspan="2"><i>Precipitate</i>
Pb.</td><td><i>Solution.</i>
Add HNO_3.</td><td rowspan="2"><i>Residue</i> turns gray or black, Hg.</td><td><i>Filtrate.</i>
Add excess of $(NH_4)_2C_2O_4$</td><td colspan="2" rowspan="2"><i>Residue.</i>
Add $(NH_4)HO$ and $(NH_4)_2C_4H_4O_6$, digest and filter.</td><td colspan="2">To ½ add BaH_2O_2 and boil.</td><td>Place ½ when wash</td></tr>
<tr><td><i>Precipitate</i>
Ag.</td><td><i>Precipitate</i>
Ca.</td><td><i>Volatilized.</i>
$(NH_4)_2O$. Test gas with HCl and litmus.</td><td rowspan="5"><i>Solution.</i>
Add excess of $(NH_4)_2CO_3$ and $(NH_4)_2C_2O_4$, warm, filter, evaporate to dryness, and ignite residue. Test on platinum wire in colorless flame; intense yellow color indicates
Na.
Violet color seen through blue glass indicates
K.</td><td rowspan="5"><i>Volatilized.</i>
Collect spots on cold porcelain, and treat with NaClO. Spots dissolve;
As.
Spots do not dissolve;
Sb.
Test also with $AgNO_3$.</td></tr>
<tr><td colspan="3" rowspan="4"></td><td colspan="2" rowspan="2"><i>Residue.</i>
Boil with Na_2CO_3, filter, wash, dissolve on filter with HCl, neutralize filtrate with $(NH_4)HO$, and divide into two parts.</td><td><i>Filtrate.</i>
Add $H(C_2H_3O_2)$ and K_2CrO_4</td><td rowspan="4"></td></tr>
<tr><td><i>Precipitate</i>
Pb.</td></tr>
<tr><td><i>1st Half.</i>
Add excess of solution of $SrSO_4$.</td><td colspan="2" rowspan="2"><i>Second Half.</i>
Add excess of H_2SiFl_6 and alcohol. Shake, filter, dilute with water, expel alcohol by evaporation, add solution of $CaSO_4$, and after one or two minutes a precipitate
Sr.</td></tr>
<tr><td><i>Precipitate</i>
Ba.</td></tr>
</table>

In this scheme regard is had to the following substances in aqueous solution:

I. PbO, Ag_2O, HgO.
II. CaO, BaO, SrO.
III. $(NH_4)_2O$, Na_2O, K_2O.
IV. As_2O_3, As_2O_5, Sb_2O_3, Sb_2O_5, SnO, SnO_2, Hg_2O, CuO, CdO, Bi_2O_3.
V. FeO, Fe_2O_3, Cr_2O_3, Al_2O_3.
VI. MnO, MgO, CoO, NiO.
VII. ZnO.

N. B.—To test for zinc, mix
HCl, H_2SO_4, filter, add NaHO in
and NH_4Cl to filtrate, boil until
ter. Add $K_4Fe_2Cy_6$ to solution,

SIS WITHOUT THE USE OF H_2S OR (NH_4) HS.

H. C. BOLTON, Ph. D.,

OF MINES, COLUMBIA COLLEGE.

Filtrate.

H_2SO_4 and wash on filter.

Filtrate.

Divide the solution tnto two unequal parts, ¼ and ¾.

---

of the solution in a Marsh's apparatus, add pieces of zinc and a strip of platinum foil, but little zinc remains heat 15 or 20 minutes, and throw contents of flask on a filter; thoroughly.

Residue.

Treat with strong HNO_3, and filter.

Residue. Wash, boil with HCl, and filter.

Solution. Put in a platinum dish with a piece of zinc. A dark spot on the platinum indicates **Sb.**

Residue. Add to solution in platinum dish, boil with HCl, filter and add $HgCl_2$, *Precipitate* **Sn.**

Filtrate. Divide into two parts.

1st Half. Add $SnCl_2$.

Precipitate **Hg.**

Second Half. Add HCl, boil, then add excess of NaHO, wash the precipitate on filter with water, then with $(NH_4)HO$ containing NH_4Cl.

Residue. Dissolve on filter in very little HCl and add large quantity of H_2O to the filtrate. A cloudy precipitate indicates **Bi.**

Filtrate. Divide into two parts.

1st Half. Acidify with HCl and add $K_4Fe_2Cy_6$. *Precipitate* **Cu.**

2d Half. Add excess of NaHO, a white gelatinous *Precipitate* **Cd.**

Filtrate.

Boil with a little HNO_3 and divide in two unequal parts.

1st Portion. Add KCyS. *Red Color*, **Fe.***

Second Portion. Neutralize with $(NH_4)HO$, add excess of $BaCo_3$, agitate 10 minutes, filter and wash thoroughly.

Precipitate. Boil in a porcelain dish with dilute H_2SO_4 and filter. Add excess of NaHO to filtrate, a few drops of $K_2Mn_2O_8$, and a little NH_4Cl, boil, filter, and divide the solution.

1st Half. Add some $H(C_2H_3O_2)$ and $Pb(C_2H_3O_2)_2$ *Precipitate* **Cr.**

2d Half. Add excess of NH_4Cl. *Precipitate* **Al.**

* To determine degree of oxidation of Fe, examine the original solution with $K_4Fe_2Cy_6$ and KCyS.

Filtrate. Add excess of dilute H_2SO_4, filter, and saturate filtrate with $(NH_4)_2CO_3$, warm, filter, and wash.

Precipitate Mix a portion with Na_2CO_3 and $NaNO_3$, fuse on platinum foil. *Green color*, **Mn.**

Dissolve another portion in HCl, neutralize with $(NH_4)HO$, add considerable NH_4Cl and $(NH_4)_2C_2O_4$ *Precipitate* **Ca.**

Solution. Add Na_2HPO_4.

Precipitate **Mg.**

Solution. Evaporate to dryness, dissolve in HCl, add KNO_2 and $H(C_2H_3O_2)$, filter.

Precipitate **Co.**

Solution. Add NaHO.

Precipitate **Ni.**

---

a portion of the original solution with excess, and boil. Add a little $(NH_4)_2CO_3$ all odor of $(NH_4)HO$ is expelled, and fil- a cloud or precipitate indicates **Zn.**

STAS-OTTO'S SCHEME FOR THE

TRANSLATED FROM THE GERMAN

Taken up by ether in acid solutions.*			Taken up by ether			
With tannic acid.			Solid			
Precipitated.		No action.	With concentrated sulphuric acid.			
			In the cold.		On heating.	
			Rose-red.	Brown-red.	Yellow, then orange, and cherry-red.	Yellow, then violet-blue, and dark-red.
Colchicin.	**Digitalin.**	**Picrotoxin.**	**Brucin.**	**Delphinin**	**Veratrin**	**Narcotin**
The *yellow* solution is colored *violet* by concentrated HNO_3.	Mixed with a solution of galls concentrated H_2SO_4, a *bright-red* stratum is formed and finally a red liquid.	The dilute alkaline (NaHO) solution is *colorless* and reduces Fehling's copper solution.	Soluble in concentrated HNO_3, with a *bright-red* color, which becomes *yellow* on heating. On adding stannic choride to this solution, a *violet* color is formed.	forms with concentrated H_2SO_4 and bromine water a *reddish-violet* color. The same coloration appears on evaporating with phosphoric acid.	forms with concentrated HCl a *colorless* solution, which becomes a fine *dark-red* on heating.	on dissolving in H_2SO_4 with a little HNO_3, forms a *red* color. Concentrated H_2SO_4 with a trace of sodic molybdate forms a *green* color. Dissolves in HCl, forming a *pale-green* solution which turns *yellowish-red* on adding NH_4HO.
On diluting the nitric acid solution and making it alkaline with NaHO, an *orange-red* coloration is obtained.	On dissolving in concentrated H_2SO_4 and mixing with a drop of bromine water, a *violet-red* coloration is produced.			**Aconitin** dissolves in H_2SO_4 with a *red-brown* color.		

---

* Also a small quantity of atropin.

† Also partially

* Pharmaceutische Post,

DETECTION OF ALKALOIDS, ETC.

BY H. CARRINGTON BOLTON, PH.D.*

in alkaline solutions.†					Insoluble in ether.
(odorless).			Liquid (strongly odorous).		**Morphin.**
With concentrated H_2SO_4 and $K_2Cr_2O_7$.		With concentrated phosphoric acid and application of heat.	With chlorine water.		The ammoniacal solution gives a *grass-green* solution on heating with cuprammonium (Nadler). Concentrated HNO_3 colors it *blood red*, neutral Fe_2Cl_6 colors it *dark-blue*. On dissolving in concentrated H_2SO_4, heating, allowing to cool, and then adding a little HNO_3, an intense *red* color is produced. Reduces an acid solution of iodic acid, the iodine dissolving out in CS_2 with a *violet* color.
In the cold.	On heating.				
Violet-blue.	Characteristic odor.		Precipitated.	No action.	
Strychnin forms a *yellow* solution with HNO_3. The *violet* coloration also obtains when either potassic ferricyanide, plumbic and manganic dioxides, or potassic iodate is used in place of $K_2Cr_2O_7$.	**Atropin.** The odor is better formed by placing the alkaloid on a few crystals of chromic acid and gently heating until the green oxide of chromium begins to form.	**Aconitin** produces a *violet* color. Dissolves in concentrated H_2SO_4 with a *hair-brown* color.	**Conin.** Aqueous solutions become colored on heating.	**Nicotin.** Aqueous solutions do not become colored on heating.	
Note. **Curarin** gives similar reactions to strychnin, but forms a *red* color with H_2SO_4 alone, and is moreover insoluble in ether in the presence of acids and alkalies.		**Delphinin** and **Digitalin** behave in the same manner with H_3PO_4.	Dry HCl gas colors it *red* and then *deep-blue*.	On gently heating with HCl, becomes *violet*, and on adding HNO_3 the color changes to *orange*.	
colchicin and digitalin.					

DETECTION AND SEPARATION OF ALKALOIDS.

According to J. Trapp (Jahresb., 1863, p. 702).

The yellow pulverulent or flocculent precipitates produced in the acid solution of many organic bases by phosphomolybdic acid are insoluble in dilute nitric acid, but easily soluble in ammonic hydrate and the fixed alkalies. The solutions of the several precipitates in ammonic hydrate exhibit the following color-reactions:

	Precipitate.	*Solution in Ammonic Hydrate.*	*On Boiling.*
Aconitin	Yellow	Blue	Colorless.
Atropin			
Bebeerin			
Berberin			
Brucin	Orange	Yellow-green	Brown.
Codein	Yellow	Green	Orange-red.
Quinin	Yellow	Insoluble	Colorless.
Quinidin			
Caffein	Yellow	Colorless	——
Conin	Yellowish-white	Light-blue	Colorless.

With digitalin ($\frac{1}{100}$ of a grain) and phosphomolybdic acid, there is formed a yellow liquid, which becomes green on boiling; deep-indigo on addition of ammonic hydrate; green again on heating; then colorless.

NEW REACTION OF THE ALKALOIDS.*

If strychnin be dissolved in concentrated sulphuric acid, to which is added a little ceric oxide (sesquioxide of cerium), an intense blue color is developed, similar to that produced in the ordinary mode of testing by potassic dichromate. The color is, however, more durable, and passes gradually into a cherry red, which remains unchanged for several days. Other alkaloids, treated in the same manner, give rise to a variety of color-reactions, as follows:

Brucin ($C_{21}H_{22}N_2O_2$)—Orange, and finally yellow.

Morphin ($C_{34}H_{38}N_2O_6$)—Brown, olive-green, and finally brown.

Narcotin (C_5H_7N)—Brown, passing to cherry-red.

---

* Vierteljahresschrift fuer Prak. Pharm.

Codein ($C_{18}H_{21}NO_3$ or $C_{36}H_{42}N_2O_6$)—Olive-green, and finally brown.

Quinin ($C_{20}H_{24}N_2O_2$)—Pale-yellow.

Veratrin ($C_{32}H_{52}N_2O_8$)—Reddish-brown.

Atropin ($C_{17}H_{23}NO_3$)—Yellowish-brown.

Solanin ($C_{43}H_{71}NO_{16}$?)—Yellow and finally brown.

Emetin ($C_{30}H_{44}N_2O_8$)—Brown.

Colchicin ($C_{17}H_{19}NO_5$)—Green, and finally dirty-brown.

Conin ($C_8H_{15}N$)—Clear yellow.

Piperin ($C_{17}H_{19}NO_3$)—Colors the sulphuric acid blood-red; an addition of ceric oxide, dark-brown.

STRYCHNIN.

The following table comprises the various tests for strychnia made by Mr. W. T. Wenzell (Am. Jour. Phar., Sept. 1870). The solution of strychnin was made by dissolving the alkaloid in water with the aid of sulphuric acid:

GRAINS STRYCHNIN.	$KO.2CrO_3$ and SO_4H test (solid).	CrO_3 and SO_4H test (1-500).	$KO.Mn_2O_7$ and SO_4H test (1-2000).
1-100,000.	Color-reaction, distinct and well-defined.	Color of reaction, very fine and distinct.	Reaction very brilliant and durable.
1-300,000.	Reaction weak and evanescent.	Color fine and distinct.	Colors brilliant and reaction distinct.
1-600,000.	No reaction.	Colors still definable, but weak.	Reaction distinct and colors fine.
1-900,000.		No reaction.	Reaction faint, but succession of colors well-defined.
1-1.200,000.			Reaction very faint.

REACTIONS OF FAT OILS

(WATT'S DIC. CHEM.,

OILS.	Caustic Soda. Sp. Gr., 1.340.	Sulphuric Acid. Sp. Gr., 1.475.	Sulphuric Acid. Sp. Gr., 1.530.	Sulphuric Acid. Sp. Gr., 1.635.	Nitric Acid. Sp. Gr., 1.180.
Olive	Slight yellow.	Green tinge.	Greenish white.	Light green.	Greenish.
Gallipoli	Ditto.	Ditto.	Gray.	Brown.	Ditto.
India nut	Thick and white.	....	Dirty white.	Light brown.	....
Pale Rape-seed	Dirty yellowish white.	....	Pink.	Brown.	....
Poppy	Ditto.	....	Dirty white.	....	....
French nut	Ditto.	Brownish.	Gray.	Brown.	Yellow.
Sesame	Ditto.	Green tinge.	Greenish. Dirty white.	....	Orange yellow.
Castor	White.	....	Dirty white.	....	....
Hemp-seed	Thick brownish yellow.	Intense green.	Intense green.	Intense green.	Dirty green.
Linseed	Fluid yellow.	Green.	Dirty green.	Green.	Yellow.
Lard	Pinkish white.	Dirty white.	Dirty white.	Light brown.	....
Neat's-foot	Dirty yellowish white.	Yellow tinge.	Brownish dirty white.	Brown.	Light yellow.
Sperm	Dark red.	Light red.	Red.	Intense brown.	Slight yellow.
Seal	Ditto.	Ditto.	Ditto.	Ditto.	Pink.
Cod-liver	Ditto.	Purple.	Purple.	Ditto.	....

WITH ACIDS AND ALKALIES.

Vol. IV, p. 188.)

Nitric Acid. Sp. Gr., 1.220.	Nitric Acid. Sp. Gr., 1.38.	+ Caustic Soda. Sp. Gr. 1.34.	Phosphoric Acid. Syrupy.	Sulphuric Acid + Nitric Acid.	Aqua Regia.	+ Caustic Soda. Sp. Gr., 1.340.
Greenish.	Greenish.	Fluid white mass.	Slight green.	Orange yellow.	....	Fluid white mass.
Ditto.	Ditto.	Fibrous ditto.	Ditto.	Dark brown.	....	Fibrous yellowish white mass.
....	....	Ditto.	....	Orange white.	....	Fibrous white mass.
....	....	Fluid ditto.	....	Dark brown.	....	Fibrous yellowish white mass.
Orange yellow.	Red.	Light red mass.	....	Slight yellow.	....	Fluid intense rose-colored mass.
Red.	Dark red.	Fibrous red mass.	Brown yellow.	Dark brown.	Yellow.	Fibrous orange mass.
Ditto.	Ditto.	Fluid red mass with brown liquor underneath.	....	Green becoming intense red.	Ditto.	Fluid orange mass with brown liquor beneath.
....	....	Fibrous white mass.	....	Brownish red.	....	Fibrous pale rose-colored mass.
Greenish dirty brown.	Greenish dirty brown.	Fibrous light brown mass.	Green.	Green becoming black.	Green.	Fibrous light brown mass.
Yellow.	Green becoming brown.	Fluid yellow mass.	Brown yellow green.	Ditto.	Greenish yellow.	Fluid orange mass.
....	Very slight yellow.	Fluid mass.	....	Brown.	....	Fluid pink mass.
Light yellow.	Light brown.	Fibrous white mass.	....	Dark brown.	Slight yellow.	Fibrous brownish yellow mass.
Ditto.	Red.	Fluid mass.	Dark red.	Ditto.	Ditto.	Fluid orange yellow mass.
Light red.	Ditto.	Ditto.	Ditto.	Ditto.	Ditto.	Ditto.
....	Ditto.	Ditto.	Ditto.	Ditto.	Yellow.	Ditto.

SCHEME FOR THE ANALYSIS OF FATTY

ARRANGED BY

5 vols. oil mixed with 1 vol. potash lye of 1·34, and strongly agitated. The mass is—	Snow white. Oil of almonds, very good rape-seed oil, bleached olive oil.	Yellowish. Poppy-seed oil, olive oil, rape-seed oil, sesame oil.	Greenish. Linseed oil, hemp-seed oil, oils containing Cu, and artif. dyes.
Mix in beaker carefully equal vol. of oil and red fuming nitric acid. A middle zone forms on point of contact. This is	Narrow and light green; oil becomes flocculent and opaque. Oil of almonds.	Dark-green; pink above. Poppy-seed oil.	Broad and beautiful light-blue green. Olive oil.
Mix in a beaker the oil with concentrated sulphuric acid. Layers where oil and acid meet are colored—	10 drops of oil, 2 of concentrated sulphuric acid.		
	Beautiful green, with brown stripes, Rape-seed oil.	Yellow; after agitating, brown and olive-green. Poppy-seed oil, madia oil.	Red, soon changing to black, stripes undulating through the liquid. Train oil.
In the elaidine test the oil mass is—	Solidified, crumbling, and white. Olive oil, oil of almonds, bleached rape-seed oil.	Solidified, crumbling, and yellowish. Rape-seed oil.	Solidified and red. Sesame oil.
In boiling with water and oxide of lead a plaster is formed, the consistence of which is—	Solid. Olive oil.	Smeary. Rape-seed oil, oil of almonds, sesame oil.	Smeary, but drying after some time. Drying oils.
Solubility of 1 part oil in alcohol—	1 : 1 Castor oil.	1 : 25 Poppy-seed oil.	1 : 30 Hemp-seed oil.
Specific gravity of oils is	0·918 Poppy-seed oil, and oil of brass. nap.	0·914 Oil of almonds, oil of brass. camp.	0·918 Olive oil.
No. of degrees Centigrade at which the oils change from solid to liquid state.	—27° Hemp-seed oil.	—18° Castor oil. +2°·5+6° to +8°. Olive oil, lard oil.	—16° to —20° Linseed oil. —20° to —25° Oil of almonds.

NOTE.—See *Amer. Chem.*, December, 1878.

OILS AT ORDINARY TEMPERATURES.

G. GLASSNER.

Pink color. Refined rape-seed oil.	Brown and stiff. Hemp-seed oil.	Yellowish-brown and fluid. Linseed oil.	Red. Train oil.
Brown-red. Cod-liver oil.	Green, red above. Linseed oil.	Brown-red, greenish below. Rape-seed oil.	The oil colors throughout red, after some time. Linseed oil.
Equal volumes oil and acid.			
Without bisulphide of carbon.			With bisulphide of carbon.
When agitated, fine dark-green. Rape-seed oil.	Green. Linseed oil, hemp-seed oil.	Red. Train oil.	With 20 times its vol. CS_2, splendid violet, quickly changing to brown coloration. Train oil.
Wax-like and white. Castor oil.	The elaidine mass shows oil drops *and stripes.* Oil mixtures containing drying oils.	Unchanged. Linseed oil, poppy-seed oil, nut oil.	Ethereal oils, added to the olive to correct the smell, float on the elaidine.
1 : 40 Linseed oil.	1 : 60 Oil of almonds.		
0·923 Sesame oil.	0·924 Sunflower oil.	0·950 — 0·70 Castor oil.	0·930 Linseed oil.
—16° Sunflower oil.	—6° Oil of brass. napus.	—40° Oil of brass. camp.	—5° Sesame oil.

FAT OILS.

The following table* exhibits a list of the principal vegetable fat oils, together with their specific gravities and solidifying points. The specific gravity marked with an asterisk are according to the determinations (taken as 15° C.) by Cloey (Bull. Soc. Chem. 1865, p. 46); the rest and the solidifying points are taken from *Gmelin's Handbook.* The numbers in the last column denote the temperatures at which the oils become perfectly solid; nearly all of them, however, become viscous or semi-solid at temperatures somewhat higher.

NAME OF OIL.	NAME OF PLANT WHICH YIELDS IT.	SPECIFIC GRAVITY.	SOLIDIFYING POINT.
1. DRYING OIL.			
Cress-seed oil.......	Lepidium sativum....	0.924	−15° C.
Oil of deadly nightshade..........	Atropa belladonna....	0.925	−27.5°
Oil of gold of pleasure seed...	Camelina sativa......	0.93075*	−19°
Gourd-seed oil......	Cucurbita peps.......	0.9231	−15°
Grape seed oil......	Vitis vinifera	0.9202	−11°
Hemp-seed oil......	Cannabis sativa.......	0.93075*	−27.5°
Oil of honesty......	Hesperis matronalis...	0.9232	below −15°
Linseed oil..... ...	Linum usitatissimum.	0.93515*	below −20°
Oil of madi	Madia sativa	0.9286 at 15°	below −10°
Poppy oil	Papaver somniferum..	0.92702*	−18°
Sunflower oil.......	Helianthus aunuus...	0.92504*	−16°
Oil of Scotch fir seed	Pinus sylvestus......	0.9312	−30°
Oil of silver fir cones	Abies picea dec.......	0.926	
Oil of spruce fir	Abies excelsa dec.....	0.9283	below −15°
Fatty oil of spruce fir	....	0.904	
Tobacco-seed oil....	Nicotiana tabacum....	0.9232	−15°
Walnut or nut oil..	Juglans regia........	0.92878*	−18°
Weld-seed oil......	Reseda luteola.......	0.9358	below −15°
NON-DRYING OILS. (*Vegetable.*)			
Almond oil.........	Amygdalus communis.	0.91844*	−21°
Beech-nut oil.......	Fagus sylvatica......	0.923	−17.5°
Oil from seed of....	Butea frondosa.......	0.917	+10°
Oil from seed of....	Calophyllum inophyllum	0.942	+5°
Oil from seed of ...	Canarium commune ..	....	+5 to 2.5°
Castor oil..........	Ricinus communis....	0.9639*	−18°
Cotton-seed oil......	Gossypium barbadeuse	0.9306	
Colza oil...........	Brassica campestris oleifera....	0.9136 at 15°	−6.25°

---

* Watt's Dic. Chem., vol. iv, p. 180.

FAT OILS—(*Continued*).

NAME OF OIL.	NAME OF PLANT WHICH YIELDS IT.	SPECIFIC GRAVITY.	SOLIDIFYING POINT.
Croton oil	Croton tiglium	0.94263*	
Oil of cyperus-grass.	Cyperus esculentus (root)	0.918	
Oil of Daphne.... Oleum seminum coccognidii	Daphne mezereum	0.914–0.921	
Earth-nut oil	Arachis hypogœa	0.918	
Ergot oil	Secale cornutum	0.922	−37°
Hazel-nut oil	Corylus avellana	0.91987*	−19°
Henbane-seed oil	Hyoscyamus nigra	0.913*	
Horse-chestnut oil	Æsculus hippocastanum	0.915	+8°
Mesua oil	Mesua ferrera	0.954	+5°
Black mustard oil	Sinapis nigra	0.92102*	below 0°
White mustard oil	Sinapis alba	0.93383*	does not solidify.
Oil from seed of	Nigella sativa	0.92	+2°
Oil from root and seed of	Pinus quadrifolia	0.935	
Parsley oil	Petroselinum sativum.	1.078 at 12°	becomes turbid at −12°, but does not solidify.
Plum-kernel oil	Prunus domestica	0.9127	−8.7°
Oil from seed of	Pougamia glabia	0.915	+8°
Summer rape-seed oil	Brassica prœcox	0.91555*	
Winter rape-seed oil	Brassica napus	0.91648*	a little below 0°
Sesame oil	Sesamum orientale	0.92415*	−5°
Spindle-tree oil	Euonymus europœus.	0.95717*	−12° to −15°
Spurge oil	Euphorbia lathyris	0.92613*	−11¼°
Oil from seed of	Sterculia fœtida	0.923	below +3°
Oil from various kinds of	Thea and camellia	0.927	forms an emulsion at 4.5°

The following table * exhibits the rotary power of a considerable number of volatile oils, together with their refractive indices A, D and H, as determined by Gladstone (Chem. Soc. J., xvii, 3). Also their specific gravities. The rotary power was determined for a column of liquid 10 inches long; the same length of a solution of equal parts of cane-sugar and water produced a deviation of +105°.

---

* Watt's Dic. Chem., vol. iv, p. 185.

SPECIFIC GRAVITIES AND OPTICAL PROPERTIES OF ESSENTIAL OILS.

CRUDE OILS.	SPECIFIC GRAVITY AT 15°.5 C.	REFRACTIVE INDICES.				ROTATION.
		Temp.	A.	D.	H.	
Anise	.9852	16°.5	1.5483	1.5566	1.6118	− 1°
Atherosperma moschatum	1.0425	14°	1.5172	1.5274	1.5628	+ 7°
Bay	.8808	18°.5	1.4944	1.5022	1.5420	− 6°
Bergamot	.8825	22°	1.4559	1.4625	1.4779G.	+ 23°
" Florence	.8804	26°.5	1.4547	1.4614	1.4760G.	+ 40°
Birch-bark	.9005	8°	1.4851	1.4921	1.5172	+ 38°
Cajeput	.9203	25°.5	1.4561	1.4611	1.4778	0°
Calamus	.9388	10°	1.4965	1.5031	1.5204G.	+ 43°.5
" Hamburg	.9410	11°	1.4843	1.4911	1.5144	+ 42° ?
Caraway	.8845	19°	1.4601	1.4671	1.4886	+ 63°
" Hamburg, 1st dist.	.9121	10°	1.4829	1.4903	1.5142	
" " 2d dist.	.8832	10°.5	.....	1.4784		
Cascarilla	.8956	10°	1.4844	1.4918	1.5158	+ 26°
Cassia	1.0297	19°.5	1.5602	1.5748	1.6243G.	0°
Cedar	.9622	23°	1.4978	1.5035	1.5238	+ 3°
Cedrat	.8584	18°	1.4671	1.4731	1.4952	+156°
Citronella	.8908	21°	1.4599	1.4659	1.4866	− 4°
" Penang	.8847	15°.5	1.4604	1.4665	1.4875	− 1°
Cloves	1.0475	17°	1.5213	1.5312	1.5666	− 4°
Coriander	.8775	10°	1.4592	1.4652	1.4805G.	+ 21° ?
Cubebs	.9414	10°	1.4953	1.5011	1.5160G.	
Dill	.8922	11°.5	1.4764	1.4884	1.5072	+206°
Elder	.8584	8°.5	1.4686	1.4749	1.4965	+ 14°.5
Eucalyptus amygdalina	.8812	13°.5	1.4717	1.4788	1.5021	−136°
" oleosa	.9322	13°.5	1.4661	1.4718	1.4909	+ 4°
Indian Geranium	.9043	21°.5	1.4653	1.4714	1.4868G.	− 4°
Lavender	.8903	20°	1.4585	1.4648	1.4862	− 20°
Lemon	.8498	16°.5	1.4667	1.4727	1.4946	+164°
Lemon grass	.8932	24°	......	1.4705	....	+ 3° ?
" Penang	.8766	13°.5	1.4756	1.4837	1.5042	0°
Melaleuca ericifolia	.9030	9°	1.4665	1.4712	1.4901	+ 26°
" linarifolia	.9016	9°	1.4710	1.4772	1.4971	+ 11°
Mint	.9342	19°	1.4767	1.4840	1.5015G.	−116°
"	.9105	14°.5	1.4756	1.4822	1.5037	− 13°
Myrtle	.8911	14°	1.4623	1.4680	1.4879	+ 21°
Myrrh	1.0189	7°.5	1.5196	1.5278	1.5472G.	−136°
Neroli	.8789	18°	1.4614	1.4676	1.4835G.	+ 15°
"	.8743	10°	1.4673	1.4741	1.4831F.	+ 28°
Nutmeg	.8826	24°	1.4644	1.4709	1.4934	+ 44°
" Penang	.9069	16°	1.4749	1.4818	1.5053	+ 9°
Orange-peel	.8509	20°	1.4633	1.4699	1.4916	+ 32° ?
" " Florence	.8864	20°	1.4707	1.4774	1.4980	+216°
Parsley	.9926	8°.5	1.5068	1.5162	1.5417G.	− 9°
Patchouli	.9554	21°	1.4990	1.5050	1.5194G.	
" Penang	.9592	21°	1.4980	1.5040	1.5183G.	−120°
" French	1.0119	14°	1.5074	1.5132	1.5202F.	
Peppermint	.9028	14°.5	1.4612	1.4670	1.4854	− 72°

SPECIFIC GRAVITIES, ETC., OF ESSENTIAL OILS (*Continued*).

CRUDE OILS.	Specific Gravity at 15°.5 C.	Refractive Indices.				Rotation.
		Temp.	A.	D.	H.	
Peppermint, Florence....	.9116	14°	1.4628	1.4682	1.4867	− 44°
Petit grain..............	.8765	21°	1.4536	1.4600	1.4808	+ 26°
Rose....................	.8912	25°	1.4567	1.4627	1.4835	− 7°
Rosemary	.9080	16°.5	1.4632	1.4688	1.4867	+ 17°
Rosewood...............	.9064	17°	1.4843	1.4903	1.5113	− 16°
Sandalwood.............	.9750	24°	1.4959	1.5021	1.5227	− 50°
Thyme..................	.8843	19°	1.4695	1.4754	1.4909G.	
Turpentine.............	.8727	13°	1.4672	1.4732	1.4938	− 79°
Verbena................	.8812	20°	1.4791	1.4870	1.5059G.	− 6°
Wintergreen............	1.1423	15°	1.5163	1.5278	1.5737	+ 3°
Wormwood.............	.9122	18°	1.4631	1.4688	1.4756F.	

SPECIFIC GRAVITIES, BOILING POINTS, AND OPTICAL PROPERTIES OF HYDROCARBONS FROM ESSENTIAL OILS.*—(Gladstone.)

Source of Hydrocarbon.	Specific Gravity at 20° C.	Boiling Point.	Refractive Index A at 20° C.	Dispersion at 20° C.	Sensitiveness.	Specific Refractive Energy.	Rotation.
Orange peel..............	.8460	174° C.	1.4645	.0277	.0048	.549	+154°
" " Florence.....	.8468	174°	1.4650	.0281	.0049	.5491	+260°
Cedrat..................	.8466	173°	1.4650	.0280	.0049	.5492	+180°
Lemon..................	.8468	173°	1.4660	.0280	.0049	.5502	+172°
Bergamot................	.8466	175°	1.4619	.0295	.0049	.5456	+76°
" Florence........	.8464	176°	1.4602	.0287	.0048	.5487	+82°
Neroli..................	.8466	173°	1.4614	.0291	.0047	.5450	+76°
Petit grain..............	.8470	174°	1.4617	.0282	.0046	5439	+60°
Caraway, Hamburg, 1st dist.	.8466	176°	1.4645	.0286	.0048	.5486	+180°
Dill.....................	.8467	173°	1.4646	.0288	.0046	.5486	+242°
Cascarilla...............	.8467	172°	1.4652	.0305	.0049	.5494	+0°
Elder....................	.8468	172°	1.4631	.0269	.0047	.5468	+15°
Bay.....................	.8508	171°	1.4542	.0260	.0047	.5338	−22°
Gaultherilene.............	.8510	168°	1.4614	.0271	.0049	.5422	
Nutmeg.................	.8518	167°	1.4630	.0284	.0047	.5435	+49°
" Penang........	.8527	166°	1.4634	.0274	.0049	.5434	+4°
Carverie	.8530	166°	1.4610	.0261	.0048	.5440	−20°
" Hamburg, 2d dist.	.8545	...	1.4641	.0263	.0048	.5431	+86°
Wormwood..............	.8565	160°	1.4590	.0253	.0047	.5359	+46°
Terebene............. ..	.8583	160°	1.4670	.0275	.0048	.5440	0°
Anise...................	.8580	160°	1.4607	.0268	.9047	.5368	
Mint....................	.8600	160°	1.4622	.0255	.0048	.5374	+30°
Peppermint	.8602	175°	1.4577	.0267	.0047	.5321	−60°

SPECIFIC GRAVITIES, ETC., HYDROCARBONS—(*Continued.*)

SOURCE OF HYDROCARBON.	Specific Gravity at 20° C.	Boiling Point.	Refractive Index A at 20° C.	Dispersion at 20° C.	Sensitiveness.	Specific Refractive Energy.	Rotation.
Laurel turpentine.........	.8618	160°	1.4637	.0260	.0047	.5380	+94°
Thyme	.8635	160°	1.4617	.0282	.0048	.5346	−75°
Turpentine, I............	.8644	160°	1.4612	.0250	.0047	.5335	+48°
" II............	.8555	160°	1.4590	.0256	.0047	.5365	−87°
" III............	.8614	160°	1.4621	.0249	....	.5364	−90°
" IV............	.8600	160°	1.4613	.0254	.0047	.5364	−88°
Eucalyptus amygdalene...	8642	171°	1.4696	.0323	.0049	.5434	−142°
Myrtle....................	.8690	163°	1.4565	.0248	.0047	.5253	+64°
Parsley...................	.8732	160°	1.4665	.0291	.0046	.5355	−44°
Rosemary.................	.8805	163°	1.4583	.0241	.0046	.5205	+8°
Cloves....................	.9041	249°	1.4898	.0284	.0045	.5417	
Rosewood.................	.9042	249°	1.4878	.0277	.0045	.5395	−11°
Cubebs....................	.9062	260°	1.4950	.0302	.0041	.5462	+59°
Calamus..................	.9180	260°	1.4930	.0322	.0042	.5370	+55°
" Hamburg........	.9275	260°	1.4976	.0337	.0043	.5365	+22°
Cascarilla.................	.9212	254°	1.4926	.0307	.0042	.5347	+72°
Patchouli.................	.9211	254°	1.4966	.0274	.0042	.5391	
" Penang.........	.9278	257°	1.4963	.0275	.0044	.5349	−90°
" French	.9255	260°	1.5009	.0262	.0042	.5412	
Colophene................	.9391	315°	1.5084	.0309	.0041	.5413	0°

* This table exhibits the densities and optical properties of a considerable number of polymeric hydrocarbons. The oils are arranged according to their specific gravities at 20° C. The column headed "*Dispersion at 20° C.*," gives the difference between the refractive indices of the lines H and A. The "sensitiveness" is the amount of diminution of the refractive index when the temperature rises 10°; it is calculated for the line A. The "*Specific refractive energy*" is the refractive index minus unity, divided by the density. In this table it is taken for A; that is, the column represents $\frac{\mu A-1}{D}$. (Watt's Dic. Chem., vol. iv, p. 187.)

Gladstone proposes (Chem. Soc. J. [2], x, i) to distinguish the several hydrocarbons by the following names:

Hydrocarbon from Bay.................Laurylene.
" " Calamus................Calamene.
" " Dill....................Anethene.
" " Elder..................Sambucene.
" " Eucalyptus amygdalina.Eucalyptene.
" " Myrtle.................Myrtene.
" " Nutmeg.................Myristicene.
" " Rosewood.............Rhodine.

TABLE OF OFFICIAL TESTS FOR IMPURITIES IN PHARMACOPŒIAL PREPARATIONS.

ATTFIELD'S TABLE.

NAME OF PREPARATION.	IMPURITIES.	TEST.
Acaciæ Gummi	Starch	Iodine.
Acetum	More than one thousandth H_2SO_4	Quantitative Analysis.
Acidum Aceticum—Acetic Acid	Traces of Pb or Cu.	Sulphuretted Hydrogen.
	H_2SO_4	$BaCl_2$ or $Ba2NO_3$.
	HCl	$AgNO_3$.
	Sulphurous Acid	Nascent Hydrogen.
Acid. Acetic. Glac.	Sulphurous Acid	Nascent Hydrogen.
Acidum Boracicum	Alkaline Salts	Insolubility in Alcohol.
Acidum Citricum	Traces of Cu. or Pb.	H_2S.
	Tartaric Acid	Acetate of K.
	Sulphuric Acid	$BaCl_2$ or $Ba2NO_3$.
	Mineral Matter	Incineration.
Acidum Gallicum	Tannic Acid	Gelatine.
Acidum Hydrochloricum	Sulphuric Acid	$BaCl_2$ or $Ba2NO_3$.
	Arsenic	H_2S.
	Sulphurous Acid	Nascent Hydrogen.
Acidum Hydrocyanicum Dilutum	Sulphuric Acid	$BaCl_2$ or $Ba2NO_3$.
	Hydrochloric Acid	$AgNO_3$ insoluble in HNO_3.
Acidum Nitricum	Mineral Matter	Evaporation and ignition.
	Sulphuric Acid	$BaCl_2$ or $Ba2NO_3$.
	Hydrochloric Acid	$AgNO_3$.
Acidum Oxalicum	Mineral Matter	Incineration.
Acidum Phosphoricum Dilutum	Pb or Pt	H_2S.
	Sulphuric Acid	$BaCl_2$ or $Ba2No_3$.
	Hydrochloric Acid	$AgNO_3$ and HNO_3.
	Metaphosphoric Acid.	Albumen.
	Nitric Acid	$FeSo_4$ and H_2SO_4.
	Phosphorous Acid	Corrosive Sublimate.
Acidum Sulphuricum	Mineral Matter	Evaporate and ignite.
	Nitric Acid	$FeSO_4$.
	As or Pb	H_2S.
Acidum Tannicum	Mineral Matter	Incineration.
Acidum Tartaricum	Metallic Matter, as Pb	H_2S.
	Oxalic Acid	$CaSO_4$.
	Calcium Tartrate	Ammonia Oxalate.
	Calcium Sulphate	" "
	Mineral Matter	Incineration.
Aconitia	Mineral Matter	Incineration.
Adeps Preparatus	NaCl	$AgNO_3$.
	Starch (flour)	Iodine.
Æther	Alcohol	Boiling-point and Sp. Gr.
Æther purus	Alcohol and Water	Sp. Gr.
Alcohol	Resin or Oil	Opalescence on dilution.
	Water	Anhydrous $CuSO_4$.
Alcohol Amylicum	Other Spirit. Matter.	Boiling-point and Sp. Gr.
Alum	Iron (Sulphate)	Yellow or Red Prussiate.

NAME OF PREPARATION.	IMPURITIES.	TEST.
Ammonia Benzoas	Fixed Salts	Non-volatility.
Ammoniæ Carbonas	Fixed Salts	Non-volatility.
	Ammonium Sulphate.	$BaCl_2$ or $Ba2NO_3$.
	" Chloride.	$AgNO_3$.
Ammoniæ Chloridum	Fixed Salts	Non-volatility.
Amylum	Alkaline Matter	Red Litmus.
	Acid Matter	Blue Litmus.
Antimonium Nigrum.	Silica	Insoluble in HCl.
Antimonii Oxidum	Higher Oxides of Sb.	Tartrate of K.
Antimonium Tartrate.	General	Quantitative Analysis.
Aqua Aurantic Floris.	Pb.Cu.Sn	H_2S.
Aqua Distillata	Fixed Salts	Evaporation and Ignition.
	Sn, Pb, and Cu	H_2S.
	Calcium Salts	Ammonium Oxalate.
	Chlorides	$AgNO_3$.
	Sulphates	$BaCl_2$ or $Ba2NO_3$.
	Carbonates	Lime Water.
Argenti Nitras	Other Nitrates, etc.	Quantitative Analysis.
Argenti Oxidum	Metallic Silver	Effervescence with HNO_3.
	General	Quantitative Analysis.
Argentum Purificatum	Copper	NH_4HO to HNO_3 solution.
Atropia	Mineral Matter	Incineration.
Atropiæ Sulphas	Mineral Matter	Incineration.
Balsamum Peruvianum	Fixed Oil	Invisibility with Alcohol.
	Alcohol	Non-diminution of volume when mixed with Water.
Beberiæ Sulphas	Mineral Matter	Incineration.
Bismuth Carbonas	$Bi3NO_3$ or NH_4NO_3	Indigo Sulphate.
	Lead Carbonate.	Dilute H_2SO_4.
	Oxychloride of Bi	$AgNO_3$.
Bismuth Subnitras	Oxynitrate of Pb	Dilute H_2SO_4.
	Oxychloride of Bi	$AgNO_3$.
Bismuthum Purificatum	Copper	NH_4HO to HNO_3 solution.
Borax	General	Quantitative Analysis.
Bromum	General	Sp. Gr. Boiling-point.
	Iodine	Starch.
Cadmii Iodidum	Zinc Iodide	KHO in excess, then sulphydrate of NH_4.
	General	Quantitative Analysis.
Calcii Chloridum	Ca Hypochlorite	Quantitative Analysis.
	Carbonic Oxide	HCl.
Calcis Carbonas Precipitata	Al_2O_3,FeO and Phosphates	Saccharine solution of CaO to solution in HNO_3.
	Chlorides	$AgNO_3+HNO_3$.
Calcis Phosphas	Carbonate of Ca	Effervesces with Acids.
	Alumina	Solution of Potash.
	Sand	Insoluble in Acids.
Calx	Carbonate of Ca	Effervesces with Acids.
	Al_2O_3, FeO, etc	Saccharine solution of Lime to solution in Acids.
Calxchlorata	General	Quantitative Analysis.
Cambogia	Starch	Iodine (green).

NAME OF PREPARATION.	IMPURITIES.	TEST.
Camphora	Fixed Salts	Non-volatility.
Carbo Animalis Purificatus	Earthy Salts	Incineration by help of red oxide of Hg.
Carbo Ligni	More than 2% Ash	Incineration.
Catechu Pallidum	Starch	Iodine.
Cera Alba	Soft Fats	Melting point.
Cera Flava	Soft Fats	Melting point.
	Resin	Soluble in Alcohol. Insoluble in Turpentine.
	Flour	Iodine.
Ceri Oxalas	Carbonate and Oxalates	Ash, soluble in acids with effervescence.
	Alumina	Ins. of Hydrate in NH_4HO.
	General	More or less of 48 per cent. Ash.
Cataceum	Soft Fats	Melting point.
Chloroform	General	Specific Gravity.
	Hydrocarbons	Sulphuric Acid.
	Non-volatile matter.	Residue on evaporation.
Copaiba	Wood Oil	Gelatinous at 270° F. Incomplete sol. in Benzol.
Creasotum	Carbolic Acid	Oxidation. Non-vol. at 212° F. Dextro rotation of Polarized ray. Crystallization on cooling.
Cupri Sulphas	Ferrous Sulphate	HNO_3 and NH_4HO.
Elatrium	Chalk	Effervesces with Acids.
	General	Quantitative Analysis.
Fel Bovinum Purificatum	Mucus, crude bile	Incomplete sol. in Spirit.
Ferri Arsenias	Sodium Sulphate	$BaCl_2$ or $Ba2NO_3$.
	General	Quantitative Analysis.
Ferri Carbonas Saccharata	$(NH_4)_2SO_4$	$BaCl_2$ or $Ba2NO_3$.
	General	Quantitative Analysis.
Ferri et Ammoniæ Citras	Tartrate of Fe and NH_4	Ebullition with KHO and saturated with $H_2O.\bar{A} = KHC_4H_4O_6$.
	General	Quantitative Analysis.
	K or Na Salts	Alkalinity of Ash.
Ferri et Quinæ Citras	K or Na Salts	Alkalinity of Ash.
	General	Quantitative Analysis.
	Other Alkaloids	Insolubility of precipitated Alkaloid in Ether.
Ferri Oxidum Magneticum	Metallic Iron	Effervesces with Acids.
	General	Quantitative Analysis.
Ferri Peroxidum Humidum	Ferrous Hydrate	Acid solution.
	Ferric Oxyhydrate	Insol. in cold, dilute HCl.
Ferri Phosphas	Ferri Arsenias	Slip of Cu in Acid solution.
	General	Quantitative Analysis.

NAME OF PREPARATION.	IMPURITIES.	TEST.
Ferric Sulphas	Ferric Oxysulphate.	Insoluble in H_2O.
Ferri Sulphas	Ferric Compounds.	Precipitate of S in aqueous solution by H_2S.
Granulata	Copper, &c.	H_2S.
Ferrum Radactum	Less than 50%	Quantitative Analysis.
Ferrum Tartaratum	Ferrous Compounds.	Red Prussiate to Acid sol.
	Ammoniacal Salts	Soda.
	General	Quantitative Analysis.
Glycerinum	General	Specific Gravity.
Hydrargyri Iodidum Rubrum	Fixed Salts	Non-volatility.
Hydrargyri Iodidum Viride	Red Iodide	Insoluble in Ether.
Hydrargyri Oxidum Rubrum	Fixed Salts, Nitrate of Mercury	Non-volatility. Orange vapor on heating in tube.
Hydrargyri Subchloridum	Corrosive Sublimate.	Treatment with Ether.
	Fixed Salts	Non-volatility.
Hydrargyri Sulphas	Fixed Salts	Non-volatility.
Hydrargyrum	Pb, Sn, Zn, Bi, Cu	Non-volatility.
Hydrargyrum Ammoniatum	Fixed Salts	Non-volatility.
Hydrargyrum Cum Creta	Mercuric Oxide	Stannous Chloride to solution in HCl.
Iodum	Fixed Salts	Non-volatility.
	Cyanide of Iodine	Physical characteristics.
	General	Quantitative Analysis.
Jalapæ Resina	Resin	Soluble in Turpentine.
Limonis Succus	Deficiency of Citric Acid	Quantitative Analysis.
Liquor Ammoniæ	General	Sp. Gr. and Quant. Anal.
Liquor Ammoniæ Fortior	General impurity or deficiency	Sp. Gr. and Quant. Anal.
	$(NH_4)_2CO_3$	Lime Water.
	Calcium Salts	Oxalate of Ammonia.
	Iron Salts	Sulphydrate of Ammonium.
	Sulphur Salts	Ammonio Sulphate of Copper.
	NH_4Cl	$AgNO_3$ to Acid solution.
	$(NH_4)_2SO_4$	$BaCl_2$ to Acidified solution.
Liquor Antimonii Chloridi	General impurity or deficiency	Specific Gravity and Quantitative Analysis.
Liquor Arsenicalis		
Liquor Arsenici Hydrochloricus		
Liquor Bismuthi et Ammoniæ Citrate		
Liquor Calcis	Deficiency in strength	Quantitative Analysis.
Liq. Calcis Chloratæ	General impurity or deficiency	Specific Gravity.
Liquor Calcis Saccharatus		Quantitative Analysis.

NAME OF PREPARATION.	IMPURITIES.	TEST.
Liquor Chlori	General quality	Specific Gravity.
	Fixed matter	Residue on evaporation.
	Deficiency in strength	Quantitative Analysis.
Liquor Ferri Perchloride Fort. Liquor Ferri Pernitrates Liquor Ferri Persulphates	Ferrous Salts	Red Prussiate.
	General impurity or deficiency	Specific Gravity and Quantitative Analysis.
Liquor Hydrargyri Nitric Acid	Deficiency in strength	Specific Gravity.
	Mercurous Salts	HCl.
Liquor Lithiæ Effervescens	General impurity or deficiency	Specific Gravity. Quantitative Analysis.
Liquor Magnesia Carbonas	Other Mg Salts	Bitter taste ($MgCl_2$ or $MgSO_4$).
Liquor Plumbi Subacetatis	General impurity or deficiency	Quantitative Analysis.
Liquor Potassæ	General impurity or deficiency	Specific Gravity and Quantitative Analysis.
	General impurity or deficiency	Specific Gravity and Quantitative Analysis.
	K_2CO_3	Effervesces Acids Ca2HO.
	Calcium Salts	Oxalate of Ammonia.
	More than traces of Silica	Insoluble in Acid after evaporation.
	Sulphates	$BaCl_2$ or $Ba2NO_3$.
	Chlorides	$AgNO_3$ to Acid solution.
	Alumina.	Ammonia to Acid solution.
Liquor Potassæ Effervescens	Deficient in strength.	Quantitative Analysis.
	Na Bicarbonate	Tartaric Acid, etc.
Liquor Sodæ	Gen. imp. or def.	Sp. Gr. and Quant. Anal.
	Calcium salts	Ammonia Oxalate.
	Na_2CO_3	Efferves. Acids and Ca2HO.
	More than traces of Silica	Insol. in Acids after evap.
	Sulphates	$BaCl_2$ to Acid solution.
	Chlorides	$AgNO_3$ to Acid solution.
	Alumina	Ammonia to Acid solution.
Liquor Sodæ Chloratæ	Salts of K or NH_4	Perchloride of Pt to Acids.
	Gen. imp. or def.	Sp. Gr. and Quant. Anal.
	Calcium salts	Ammonia Oxalate.
Liquor Sodæ Effervescens	Deficient in strength.	Quantitative Analysis.
Lithiæ Carbonas	Gen. imp. or def.	Quantitative Analysis.
	Calcium salts	Ammonia Oxalate, etc.
	Alumina	Lime-water, etc.
Lithiæ Citras	Deficient in strength.	Quantitative Analysis.
Magnesia Magnesia Levis	$MgCo_3$	Effervesces with Acids.
	Ca2HO or $CaCO_3$	Ammonia Oxalate, etc.
	$MgSO_4$ or Na_2SO_4	$BaCl_2$ to Acid solution.
Magnesia Carbonas Magnesia Carb. Levis	Alumina	Ammonia to Acid solution.
	$MgSO_4$ or Na_2SO_4	$BaCl_2$ to Acid solution.
	$CaCO_3$	$H_2O.\bar{O}$ to NH_4HO solution.
	Fe, Pb, etc.	H_2S to Acid sol.+NH_4HO.
	Gen. imp. or def.	Quantitative Analysis.

NAME OF PREPARATION.	IMPURITIES.	TEST.
Magnesiæ Sulphas	$CaSo_4$	Ammonia Oxalate.
	$FeSO_4$	Chlorinated NaO.
	General impurity	Quantitative Analysis.
Manna	Deficiency of Mannite	Quantitative Analysis.
Mel	Starch (flour)	Iodine.
Morphiæ Hydrochloras	General impurity	Quantitative Analysis.
Olea Distillata	Fixed oil	Permanent greasy stain on paper.
	Alcohol	Loss in volume on shaking with water.
Opium	Deficient in Morphia.	Quantitative Analysis.
Plumbi Acetas	General	Quantitative Analysis.
Plumbi Carbonas	$PbSO_4$, $BaSO_4$, or Silicates	Insoluble in Acetic Acid.
	Calcium (chalk)	Ammonia Oxalate, after removing the Pb.
Potassa Caustica	More than traces of Chlorine.	$AgNO_3$ to Acid solution.
	Sulphate.	$BaCl_2$ to Acid solution.
	Gen. imp., H_2O, etc.	Quantitative Analysis.
Potassa Sulphurata	Excess of Carbonate or Sulphate	More than 25% insoluble in Spirit.
Potassæ Acetas	Fe, etc.	Ammonium Sulphydrate.
	K_2CO_3	Effervesces with Acids. Insol. in Spirit. Alkalinates.
Potassæ Bicarbonas	General	Quantitative Analysis.
Potassæ Carbonas	More than traces of Silicates	Insol. in Acids after evap.
	Sulphate	$BaCl_2$ to Acid solution.
	Chloride	$AgNO_3$ to Acid solution.
	General	Quantitative Analysis.
Potassæ Chloras	KCl	$AgNO_3$.
	$CaCl_2$	Ammonia Oxalate.
Potassæ Citras	General	Quantitative Analysis.
Potassæ Nitras	K_2SO_4	$BaCl_2$.
	KCl	$AgNo_3$.
Potassæ Permanganas.	General	Quantitative Analysis.
Potassæ Sulphas	$KHSO_4$	Test Paper.
	$CaSO_4$	Ammonia Oxalate.
Potassæ Tartras Potassæ Tart. Acida.	General	Quantitative Analysis.
Potassii Bromidum	Free Bromine	Odor.
	KI	Chlorine Water and Starch.
	General	Quantitative Analysis.
Potassi Ferridcyanide.	Ferrocyanide of K.	Ferric Salt.
Potassii Iodidum	Iodate of K	$H_2O.\overline{T}$ and Starch.
	KCl	$AgNO_3$, etc.
	K_2CO_3	Sacc. solution of Lime.
Quiniæ Sulphas	Salicin	H_2SO_4.
	General	Quantitative Analysis.
Rhei Radix	Turmeric	Boracic Acid.

NAME OF PREPARATION.	IMPURITIES.	TEST.
Santoninum	Mineral Matter	Incineration.
	Earthy, Soap, etc.	Insoluble in Spirits.
Sapo Durus	Oil	Oil stain, Paper.
	K compounds	Deliquescence of Ash.
Sapo Mollis	Earthy, Soap, etc.	Insoluble in Spirits.
	Oil	Oily stain, Paper.
Scammoniæ Resina	Resin of Guaiacum	Inner surf. of potato paring.
	Resin of Jalap	Insoluble in Ether.
Scammonium	$CaCo_3$, $MgCO_3$	Effervesces with Acids.
	Starch (flour)	Solution of Iodine.
Sinapis	Starch (flour)	Solution of Iodine.
Soda Caustica	More than traces of Chloride.	$AgNO_3$ to Acid solutions.
	Sulphate.	$BaCl_2$ to Acid solutions.
	Gen. imp., Water, &c.	Quantitative Analysis.
Soda Tartarata	General	Quantitative Analysis.
Sodæ Acetas	Acid or Alkaline imp.	Test Paper.
	Na_2SO_4 or $CaSO_4$	$BaCl_2$ to Acid solution.
	NaCl or $CaCl_2$	$AgNO_3$ to Acid solution.
Sodæ Arsenias	Excess of H_2O of crystallization	Quantitative Analysis.
	General	Quantitative Analysis.
Sodæ Bicarbonas	Na_2CO_3	Mercuric Chloride.
	More than traces of Chlorides	$AgNO_3$ to Acid solution.
	Sulphates	$BaCl_2$ to Acid solution.
Sodæ Hyposulphic	General	Quantitative Analysis.
Sodæ Nitras	NaCl	$AgNO_3$.
	Na_2SO_4	$BaCl_2$ or $Ba2NO_3$.
Sodæ Phosphas	More than traces of Sulphates	$BaCl_2$ to Acid solution.
	Def. of H_2O of crystallization or excess	Quantitative Analysis.
Sodæ Sulphas	Ammonium Salts Ferric Salts	Solution KHO heated.
	General	Quantitative Analysis.
Sodæ Valerianas	NaO or Na_2CO_3	Test Paper. Insoluble in Spirits.
Spiritus Ætheris Nitrosi	General	Sp. Gr.
	More than trace of Acid	Effervesces with Bicarbonate of Soda.
	Free Acid	More than feeble efferves. with Bicarb. of Soda.
	Deficiency of Nitrite of Ethyl	Quantitative Analysis.
Spiritus Ammonio Aromat. Spiritus Chloroformii	General	Specific Gravity.
Spiritus Tenuior	Gen. (excess of H_2O).	Specific Gravity.
Strychnia	Brucia	Nitric Acid.
	Mineral Matter	Incineration.
Spiritus Rectificatus	Gen. (excess of H_2).	Specific Gravity.
	Resin or Oil	Opalescence on dilution.
	More than trace of Fusel Oil	$AgNO_3$.

NAME OF PREPARATION.	IMPURITIES.	TEST.
Sulphur Precipitatum.	$CaSO_4$	Appear. under microscope —residue on ignition.
Sulphur Sublimatum	Earthy Matter	Incineration.
	H_2SO_4 or H_2SO_3	Litmus-paper.
	Sulphide of Arsenicum	Ammonia.
Sulphuris Iodidum	Deficiency of Iodine	Quantitative Analysis.
Syrupi	Deficiency of Sugar	Specific Gravity.
Tamarindus	Traces of Cu	Iron.
Veratria	Mineral Matter	Incineration.
Zinci Acetas	Sulphates	$BaCl_2$ or $Ba2NO_3$.
	Chlorides	$AgNO_3$.
	As, Cd, Cu, Pb	H_2S.
	Acetate of Iron	HNO_3+NH_4HO.
	Copper Acetate	NH_4HO.
Zinci Carbonas	Chlorides	$AgNO_3$ to Acid solution.
	Sulphates	$BaCl_2$ to Acid solution.
	Copper Carbonate	NH_4HO to Acid solution.
Zinci Chloridum	As, Cd, Cu, Pb	H_2S.
	Sulphates	$BaCl_2$ or $Ba2NO_3$.
	$CaCl_2$	Ammonium Oxalate.
	$FeCl_2$	Ferridcyanide of K.
	Fe_2Cl_6	Ferrocyanide of K.
	$ZnCO_3$	Effervesces with Acids.
Zinci Oxidum	Na_2SO_4 or $ZnSO_4$	$BaCl_2$ to Acid solution.
	Chlorides,	$AgNO_3$ to Acid solution.
	Copper Oxide	NH_4HO to Acid solution.
Zinci Sulphas	As, Cd, Cu, Pb,	H_2S.
	Iron Sulphate	Tincture of Galls.
	Copper Sulphate	$CuSO_4$ add NH_4HO.
Zinci Valerianas	$ZnSO_4$	$BaCl_2$ or $Ba2NO_3$.
	Butyrate of Zinc	Acetate of Cu, etc.

INFLUENCE OF FIXED ORGANIC SUBSTANCES ON THE PRECIPITATON OF METALLIC OXIDES FROM SALINE SOLUTIONS BY ALKALIES.

The following results have been obtained by H. Grothe (J. pr. Chem., xcii. 175): 1. The alteration produced in the reactions of different metallic solutions with alkalies by the presence of fixed organic bodies, exhibit great diversities, scarcely any two metallic bodies being similarly affected; so that these alterations do not afford properties characteristic of groups of metallic oxides, but rather of individual oxides. 2. Of non-volatile organic substances, citric acid acts most strongly in modifying these reactions; then follows tartaric acid; then sugar, starch, and gum, which, however, act but feebly, and require to be added in large excess. 3. The precipitating action of ammonic hydrate is diminished by these bodies much more than that of sodic carbonate. 4. Solutions which are not precipitated in presence of fixed organic bodies by alkaline hydrates or carbonates, are for the most part precipitated by alkaline orthophosphates, pyrophosphates, arsenates, and borates. 5. Sodic orthophosphate may be used as a reagent in nearly all the cases in which the precipitation of a metallic oxide is hindered by the presence of non-volatile organic substances.

The following table exhibits the reactions of the more important metallic salts with ammonic hydrate, and with sodic carbonate, borate, phosphate, pyrophosphate, arsenate, and borate, in presence of tartaric acid, citric acid, and sugar: *p* denotes perfect precipitation; *i*, imperfect precipitation; a *dash*, no precipitation:

		Ammonic Hydrate.	Sodic Carbonate.	Sodic Orthophosphate.	Sodic Pyrophosphate.	Sodic Arsenate.	Sodic Borate.
Aluminium Salts	Tartaric Acid	—	—	p.	p.	p.	p.
	Citric Acid	—	—	—	—	—	—
	Sugar	i.	i.	p.	p.	p.	p.
Manganous Salts	Tartaric Acid	—	p.	i.	i.	p.	p.
	Citric Acid	p.	i.	p.	p.	p.	p.
	Sugar	p.	p.	p.	p.	p.	p.
Manganic Salts	Tartaric Acid	—	p.	p.	i.	p.	p.
	Citric Acid	—	p.	i.	p.	p.	i.
	Sugar	p.	i.	p.	p.	p.	p.
Zinc Salts	Tartaric Acid	i.	i.	p.	p.	p.	p.
	Citric Acid	—	i.	p.	p.	p.	p.
	Sugar	p.	p.	p.	p.	p.	p.
Nickel Salts	Tartaric Acid	—	—	i.	i.	i.	i.
	Citric Acid	—	i.	i.	i.	i.	i.
	Sugar	i.	i.	i.	i.	i.	i.
Cobaltous Salts	Tartaric Acid	—	i.	i.	i.	i.	i.
	Citric Acid	i.	i.	i.	i.	i.	i.
	Sugar	—	p.	p.	p.	i.	p.
Uranic Salts	Tartaric Acid	—	—	—	—	—	—
	Citric Acid	—	—	—	—	—	—
	Sugar	i.	—	—	—	—	—
Ferrous Salts	Tartaric Acid	—	i.	p.	p.	p.	p.
	Citric Acid	—	—	—	—	—	—
	Sugar	—	p.	p.	p.	p.	p.
Ferric Salts	Tartaric Acid	—	—	p.	p.	p.	p.
	Citric Acid	—	—	—	—	—	—
	Sugar	—	p.	p.	p.	p.	p.
Cupric Salts	Tartaric Acid	—	—	p.	i.	p.	p.
	Citric Acid	—	—	—	—	—	—
	Sugar	i.	p.	p.	p.	p.	p.
Cadmium Salts	Tartaric Acid	—	i.	p.	p.	p.	p.
	Citric Acid	i.	p.	p.	p.	p.	p.
	Sugar	—	p.	p.	p.	p.	p.
Lead Salts	Tartaric Acid	i.	p.	p.	p.	p.	p.
	Citric Acid	i.	p.	p.	p.	p.	p.
	Sugar	—	i.	p.	p.	p.	p.
Bismuth Salts	Tartaric Acid	—	p.	p.	p.	p.	p.
	Citric Acid	—	p.	p.	p.	p.	p.
	Sugar	—	p.	p.	p.	p.	p.
Chromic Salts (Green solution.)	Tartaric Acid	i.	—	—	—	i.	—
	Citric Acid	p.	—	—	—	—	—
	Sugar	i.	—	—	—	p.	—
Chromic Salts (violet solution.)	Tartaric Acid	p.	p.	p.	p.	p.	p.
	Citric Acid	p.	p.	p.	p.	p.	p.
	Sugar	p.	p.	p.	p.	p.	p.

Blowpipe Analysis.

CHARACTERISTIC TESTS OF THE ELEMENTS AND THEIR SALTS BEFORE THE BLOWPIPE.

By P. CASAMAJOR.

REACTIONS PRESENTED BY BEADS OF BORAX AND SALT OF PHOSPHORUS WITH METALS.

METALS.	BORAX.		SALT OF PHOSPHORUS.	
	OXIDATION FLAME.	REDUCTION FLAME.	OXIDATION FLAME.	REDUCTION FLAME.
Molybdenum	Colorless.	Brown; reddish-brown.	Colorless	Fine green, hot; dirty green, cold.
Tungsten	“	Yellow, hot; brown, cold.	Colorless	Blue: iron present, red.
Tellurium	“	Gray	Colorless	Gray.
Bismuth	“	Gray	Yellow, hot; colorless, cold	Gray.
Titanium	“	Violet; too much, black.	Colorless	Violet; iron present, red.
Antimony	Yellow, hot; colorless, cold	Gray	Colorless	Colorless; iron present, red.
Lead	Yellow, hot; colorless, cold	Lead	Colorless	Colorless.
Chromium	Green	Fine green	Green	Green.
Copper	Green	Reddish-brown	Green	Red; reddish-brown.
Uranium	Yellow	Dirty green	Green	Green.
Cerium	Red-hot; yellow, cold	Colorless	Red-hot; green, cold	Colorless.
Nickel	Red-hot; yellow, cold	Gray	Red-hot; yellow, cold	Colorless.
Iron	Red-hot; yellow, cold	Bottle-green	Red-hot; yellow, cold	Colorless.
Manganese	Violet	Colorless	Violet	Colorless.
Cobalt	Blue	Blue	Blue	Blue.
Silver			Yellow	Gray, or colorless.

(All others are colorless in all cases.)

Chlorine	*SP* and CuO, purple flame; with SO_4Cu, stains silver. *SP* (open tube), gives ClH; with MnO_2 give chlorine.
Iodine	*SP* and CuO, green flame. *SP* (open tube), violet vapors.
Bromine	*SP* and CuO, purplish flame. *SP* (tube) $BrH + MnO_2$ gives Br.
Fluorine	*SP* attacks tube; Brazil paper, yellow.

Sulphur	On charcoal, SO_2, soda; (reduction-flame), stains silver.
Selenium	On charcoal, rotten horseradish; open tube, red sublimate.
Tellurium	On charcoal, white, volatile ring, green flame; open tube, white, fusible volatile powder.
Nitrate	On charcoal, incandescence; *SP*, open tube, NO_2.
Arsenic	On charcoal, garlic smell; open tube, As_2O_3; closed tube, etc., As.
Borates	*SP* + fluor spar, siskin-green flame.
Phosphates	Bo_2O_3 and steel needle No. 9, brittle globule in reduction-flame.
Carbonate	With acids, effervescence.
Silica	*SP*, silicious skeleton, heated with soda and treated with acid, jelly.
Gold	On charcoal, yellow button; malleable; unoxidizable; no ring.
Platinum	On charcoal, gray powder, infusible; bright by friction.
Silver	On charcoal, white button: hard, malleable, unoxidizable.
Mercury	Closed tube, mercury; whitens gold and copper.
Lead	On charcoal, soft button; ring; orange, hot; yellow, cold.
Tin	On charcoal, reduction-flame, metallic button; oxydation-flame, white crust.
Antimony	On charcoal, brittle; white vapors even after heating; white, volatile ring; flame, greenish-blue.
Zinc	On charcoal, no button; dense vapor; ring; yellow, hot; white, cold; with nitrate of cobalt, green.
Cadmium	On charcoal, no button; dense vapor; brown ring.
Copper	On charcoal, red button.
Cobalt	On charcoal, reduction-flame, with *soda*, magnetic gray powder.
Nickel	Same as cobalt.
Iron	Same as cobalt.
Manganese	On charcoal, with *soda*, turquoise bead; with saltpetre, green.
Aluminum	With nitrate of cobalt, blue (common to many substances).
Magnesia	With nitrate of cobalt, pale red.
Ammonia	Volatile salts, with *soda*, ammonia vapors.
Potassa	Soluble salts, with *soda*, no precipitate; purple flame.
Soda	Soluble salts, with *soda*, no precipitate; yellow flame.
Baryta	*Soda* precipitates soluble salts; pale-green flame.
Strontia	*Soda* precipitates soluble salts; crimson flame.
Lime	*Soda* precipitates soluble salts; pale-red flame.

Soda is carbonate of soda. *SP*, salt of phosphorus.

Bisulphate of potassa is used generally instead of *SP* for determining *Chlorine, Iodine, Bromine, Fluorine, Nitrate, Borate.*—(See Amer. Chem.)

TABLE OF VOLATILE ELEMENTS

FROM WATT'S DICT.

	Metallic Film.	Oxide-film.	Oxide-film with Stannous Chloride.	Oxide-film with Stannous Chloride and Soda.	Oxide-film with Argentic Nitrate and Ammonia.
Te.	Black; thin part brown.	White.	Black.	Black.	Yellowish-white.
Se.	Cherry red; thin part brick red.	White.	Brick-red.	Black.	White.
Sb.	Black; thin part brown.	White.	White.	White.	Black; insoluble in Ammonia.
As.	Black; thin part brown.	White.	White.	White.	Lemon-yellow or reddish-brown; soluble in Ammonia.
Bi.	Black; thin part brown.	Yellowish-white.	White.	Black.	White.
Hg.	Gray; non-coherent thin film.				
Fe.	Black; thin part brown.	White.	White.	White.	White.
Pb.	Black; thin part brown.	Yellow-ochre color.	White.	White.	White.
Cd.	Black; thin part brown.	Blackish-brown; thin part white.	White.	White.	White: in the thin part turns bluish-black.
Zn.	Black; thin part brown.	White.	White.	White.	White.
Sn.	Black; thin part brown.	Yellowish-white.	White.	White.	White.

WHICH CAN BE REDUCED AS FILMS.

OF CHEMISTRY.

Iodide-film.	Iodide-film with Ammonia.	Sulphide-film.	Sulphide-film with Ammonic Sulphide.	Remarks.
Brown: disappears for a time on breathing.	Disappears altogether on blowing.	Black to blackish-brown.	Disappears for a time.	Elements whose reduction-films are scarcely dissolved in dilute Nitric Acid.
Brown; does not wholly disappear on breathing.	Does not disappear on blowing.	Yellow to orange.	Orange and then disappears for a time.	
Orange-red to yellow; disappears on breathing.	Disappears altogether on blowing.	Orange.	Disappears for a time.	
Orange-yellow; disappears for a time on breathing.	Disappears altogether on blowing.	Lemon colored.	Does not disappear.	
Bluish-brown; thin parts pink; disappears for a time on breathing.	Pink to orange; chestnut colored when blowing.	Burnt umber color to coffee color.	Does not disappear.	Elements whose reduction-films are with difficulty dissolved in dilute Nitric Acid.
Carmine-colored and lemon-yellow; does not disappear on breathing.	Disappears for a time on blowing.	Black.	Does not disappear.	
Lemon-yellow; does not disappear on breathing.	Does not disappear on blowing.	Black; thin parts bluish-gray.	Does not disappear.	
Orange-yellow to lemon color; does not disappear on breathing.	Disappears for a time on blowing.	Brownish-red to black.	Does not disappear.	Elements whose reduction-films are instantly dissolved in dilute Nitric Acid.
White.	White.	Lemon colored.	Does not disappear.	
White.	White.	White.	Does not disappear.	
Yellowish-white.	Yellowish-white.	White.	Does not disappear.	

SCHEME* FOR THE QUALITATIVE DETERMINATION OF SUBSTANCES BY THE BLOWPIPE.

The substance may contain As, Sb, S, Se, Fe, Mn, Cu, Ni, Pb, Bi, Ag, Au, Hg, Zn, Cd, Sn, Cl, Br, I, CO_2, SiO_2, HNO_3, H_2O, etc.

1. Treat on Ch (charcoal) in the O.F. (oxidizing flame) to find volatile substances such as, As, Sb, S, Se, Pb, Bi, Ag, Zn, Cd, etc. (p. 66, et seq.) [This number, and all others, refer to the pages of Plattner's Manual, translated by H. B. Cornwall, 1872. Owing to the additions to this scheme, as also Casamajor's table on the preceding page, reference to Plattner's Manual will be unnecessary.]

a. If there are volatile substances present, form a coating and test it with S.Ph (salt of phosphorus) and tin on Ch for Sb (p. 99), or to distinguish between Pb and Bi (p. 280).

b. If there are no volatile substances present, divide a part of the substance into three portions and proceed as in *A*.

a. Yellow coat, yielding with S.Ph a black bead; disappearing with blue flame, no part of it yielding green Sb flame; Pb and Bi.

b. Yellow coat, generally with white border, yielding black or gray bead with S.Ph, disappearing with blue flame; also the border disappearing with green flame; Pb and Sb.

c. Yellow coat, very similar to *b*, but yielding no blue flame; Bi and Sb. (See note at end of Scheme.)

2. If As, Sb, S, Se are present, roast a large quantity thoroughly on Ch (p. 77). Divide the substance into three portions and proceed as in *A*.

A. Treatment of the First Portion.—Dissolve a very small quantity in borax on platinum-wire in the O. F. and observe the color produced. Various colors will be formed by the combination of the oxides. Saturate the bead and shake it off into a porcelain dish; repeat this once or twice (p. 79).

a. Treat these beads on Ch with a small piece of lead, silver or gold in a strong R. F. (reducing flame), p. 118.

---

* Scheme is by T. Egleston, E. M., with a few additions by Author.

b. Fe, Mn, Co, etc., remain in the bead (p. 115).

If the bead spreads out on the Ch, it must be collected to a globule by continued blowing.

Make a borax-bead on platinum-wire and dissolve in it *some* of the *fragments* of the *bead*, reserving the rest for accident.

c. Ni, Cu, Ag, Au, Sn, Pb, Bi are reduced, and collect by the lead-button (p. 115).

Remove the lead-button from the bead while hot, or by breaking the latter, when cold, on an anvil between paper, carefully preserving all the fragments.

d. If Co is present the bead will be blue.

If a large amount of Fe is present, add a little borax to prove the presence or absence of Co (p. 222).

If Mn is present, the bead, when treated on platinum-wire in the O.F., will become dark-violet or black.

e. If no Co is present, the bead will be almost colorless.

Look here for Cr, Ti, Mo, U, W, V, Ta. Mo will give a cloudy-brown or black with the borax-bead in the R. F., owing to the molybdic acid being reduced.

f. Treat the button *c* on Ch in the O. F. until all the lead, etc., is driven off, Ni, Cu, Ag, Au remaining behind; or separate the lead with boracic acid (p. 442).

g. Treat the residue *g* on Ch in O.F. with S.Ph bead, removing the button while the bead is hot.

h. If Ni and Cu are present, the bead will be green when cold (p. 292). If Ni only, yellow. If Cu only, blue.

Prove Cu by treating with tin on Ch in R.F. (p. 293).

i. For Ag and Au, make the special test No. 8.

B. TREATMENT OF THE SECOND PORTION.—Drive off the volatile substances in the O.F. on Ch. Treat with the R.F, or mix with soda, and then treat with R.F. for Zn, Cd, Sn. If a white coating is formed, test with cobalt solution (pp. 251, 256, 276). Tin gives greenish-blue; zinc, green. If Zn is found, it is not necessary to look for Sn and *vice versa*, as they very rarely occur together. Cd gives a brown coat and variegated tarnish.

C. TREATMENT OF THE THIRD PORTION.—Dissolve some of the substance in S.Ph on platinum-wire in O.F., observing whether $\ddot{\mathrm{Si}}$ is present or not, and test for Mn with nitrate of potassa and soda (p. 210).

3. Test for As with soda on Ch in the R.F., or with dry soda in a closed tube (p. 345 et seq.). On charcoal it gives garlic odor; in the tube, a metallic mirror.

4. Dissolves in S.Ph on platinum-wire in the O.F. (if the substance is not metallic and does not contain any S), and test for Sb on Ch with tin in the R.F. (See 1, *a*, p. 99.)

5. Test for Se on Ch; it gives a horse-radish odor (p. 368).

6. In absence of Se, fuse with soda in the R.F., and test for S on silver-foil (p. 365). By moistening the fused mass, and letting it stand on the foil, the latter turns black if S be present. In the presence of Se, test in open tube (p. 366).

7. Test for Hg with *dry* soda in a closed tube; a metallic mirror is formed (p. 304).

8. Mix some of the substance with assay lead and borax glass, and fuse on Ch in the R.F. (p. 401). Cupel the lead-button for Ag (p. 407). Test with nitric acid for Au, dissolving the silver (p. 320).

9. Test for Cl and I with a bead of S.Ph saturated with oxide of copper. Cl gives blue flame; I, intense green (pp. 373, 374, 375).

10. Test for Br with bisulphate of potassa in a matrass, gives brownish-yellow fumes; test also for Cl (p. 374).

11. Test for H_2O in a closed tube; drops collect on the interior (p. 353).

12. Test for borates: dip substance in glycerine and hold in flame—green color. If barium is present, remove the same, then apply the test. Discovered by Mr. Iles. (See Amer. Chem., Apr. 1876.)

13. Test on platinum-wire, or in platinum-pointed forceps, for coloration of the flame (p. 72 et seq.).

14. Test for CO_2 with hydrochloric acid, letting the gas pass over lime-water (p. 360).

15. Test for HNO_3 with bisulphate of potassa in a matrass; yellow-colored fumes and acid reaction (p. 354).

16. Test for Te in an open tube; forms a grayish-white sublimate, which fuses to clear transparent drops when strongly heated. Te burns with a bluish-green flame (p. 354).

DETECTION OF BISMUTH IN THE PRESENCE OF LEAD AND ANTIMONY.

By H. B. CORNWALL, E. M.

One part *teroxide of bismuth*, fifty parts *oxide of lead*, and fifty parts *teroxide of antimony* are mixed with an equal volume of sulphur, and treated B.B. in a deep cavity on coal with the blue flame for a few minutes. The resulting fused sulphides remove to a flat coal, and treat alternately with O.F. and R.F. until the antimonial fumes cease to come off, and an impure blue lead flame appears. Powder the residue and treat a portion of it with iodine mixed on coal. No *bismuth* will be detected. But if the other portion is treated in an open tube (4 in. long and not less than $\frac{1}{3}$ in. wide, over a Bunsen gas-burner) with a mixture of 5 parts sulphur and 1 part iodide of potassium by weight; and about equal volumes of this and of the metallic oxide, a distinct bismuth sublimate will be formed about one-third of an inch above the lower edge of the yellow sublimate.

The bismuth sublimate forms a *red ring*. If sulphides are under treatment, remove the excess of antimony on coal.

Care must be taken not to confound with the bismuth sublimate a sublimate of iodine, which may condense on the upper part of the tube, but at a greater distance from the assay.

Specific Gravities.

DETERMINATION OF SPECIFIC GRAVITIES.

SPECIFIC GRAVITIES OF POWDERS OR SMALL SOLIDS.

(*Brand and Taylor's Chemistry.*)

The specific gravity of *solids in powder or in small pieces* may conveniently be determined by the bottle. Thus: weigh the powder, pour it into the bottle, and fill it with water at 62° F., taking care to dislodge all adhering bubbles of air. Then weigh it and deduct the known weight of the bottle; the remainder is the conjoint weight of the powder and water. Deduct from this last sum the found weight of the powder, and the difference is the weight of the water; deduct this difference from the known weight of the water required to fill the bottle, and the remainder is the weight of a volume of water equal to the volume of the solid in powder; then as this is to the known weight of water, required to fill the bottle :: Sp. Gr. water : Sp. Gr. powder. Example:

	Grains.
Weight of water in the bottle	1000
" of native platinum grains (in air)	40
	1040
Weight of water and platinum in bottle	1037.5
Difference = Volume of water displaced	2.5

40 ÷ 2.5 = 16 Sp. Gr. of native platinum.

When the substance is soluble in water, another liquid of known specific gravity which does not act upon the solid, must be employed. Alcohol, oil of turpentine, or olive oil may be used, or, in some cases, the substance may be coated with varnish. Example—Required Sp. Gr. of Sugar:

	Grains.
Weight of sugar in air	400
" " " in oil of turpentine	182.5
Weight of an equal bulk of oil	217.5
Known Sp. Gr. of turpentine	0.870

Then 0.870 : 1000 : : 217.5 : 250, and 400 ÷ 250 = 1.6, which is the Sp. Gr. of the sugar.

SPECIFIC GRAVITY OF SOLIDS HEAVIER THAN WATER.

(*Brand and Taylor's Chemistry.*)

Weigh the solid in air, then suspend it by a fine thread (horse-hair) to one arm of a balance; exactly counterpoise it, and immerse the solid so counterpoised in distilled water at 62° F., and note how much less it weighs now than when weighed in air. The difference between the two is the weight of a volume of water, exactly equal to that of the immersed solid. Divide the weight of the solid in air by this difference, and the result is the Sp. Gr. of the solid. Thus in reference to a small bar of aluminum:

	Grains.
Weight of Aluminum in air	46.3
" of " in water	29.0
Difference = Volume of water	17.3

46.3 ÷ 17.3 = 2.6 Sp. Gr. of Aluminum.

A knowledge of the Sp. Gr. of solids enables a chemist to ascertain the weight of bodies from their volume. A cubic foot of water contains 1728 cubic inches, and weighs 1000 ounces (strictly 998 ounces 62.4 pounds Av.); hence a cubic foot of sulphur (Sp. Gr. 1.957) would weigh 1957 ounces, and a cubic foot of marble (Sp. Gr. 2.5) would weigh 2500 ounces. A cubic foot of air weighs 535.161 grains.

SPECIFIC GRAVITY OF SOLIDS LIGHTER THAN WATER.

(*Brand and Taylor's Chemistry.*)

1. Find the weight of the solid (*a*) in air. 2. Take a piece of metal heavy enough to make (*a*) sink in water, and find its weight in air and in water. 3. Tie together (*a*) and the metal, and find the weight of the compound mass in water. The difference between the weight of the metal in air and in water is the weight of a volume of water equal to that of the metal; deduct this from the difference between the weights in air and in water of the compound mass, and the remainder is the weight of a volume of water equal to (*a*). Now divide the

weight of (*a*) by the remainder, and obtain the Sp. Gr. Thus with reference to beef-fat:

	Grains.
Weight of fat in air	117.3
Add brass weight to sink it	1000.0
Weight of compound mass in air	1117.3

	Grains.
Loss of weight by the compound mass in water	245.5
" " brass weight (1000) in water	119.4
Weight of the water displaced by the fat	126.1

Hence 117.3 ÷ 126.1 = 0.930 Sp. Gr. of beef-fat.

SPECIFIC GRAVITY OF GASES.

The weighing of the air and gas should take place at the same temperature and pressure, or a calculation should be made. In reference to gases and vapors, *air* is taken as the standard of unity.

Gases.—A light glass flask, of about forty or fifty cubic inches capacity is employed. This is capable of being screwed to the air-pump plate, and of being suspended to a scale-beam and accurately balanced. The flask is exhausted, balanced, filled with dry air, and again balanced. The increase in weight represents the weight of the volume of dry air in the flask, at the pressure and temperature at which it was filled. The experiment is repeated with the dry gas, the Sp. Gr. of which it is proposed to determine. The following is the Sp. Gr. of carbonic oxide (CO_2):

	Grains.
Weight of the flask with dry air	2033.8
" " " exhausted	2021.4
Weight of dry air in flask	12.4

	Grains.
Weight of the flask with dry carbonic oxide	2040.24
" " " exhausted	2021.40
Weight of dry carbonic oxide in flask	18.84

Hence, 18.84 ÷ 12.4 = 1.520 Sp. Gr. of carbonic oxide.

The weight of 100 cubic inches of any gas may be found by multiplying the specific gravity of the gas or vapor by 31 [one hundred cubic inches of dry air at a mean temperature of (62° F.), and a mean pressure (30 inches), are considered to weigh 31 grains]. Thus, nitrogen has a Sp. Gr. of 0.967 and $0.967 \times 31 = 29.98$ grains, the weight of a hundred cubic inches of the gas.

A knowledge of the Sp. Gr. of gases enables a chemist to control the results of an analysis of a compound gas. Thus, if 2 volumes of ammonia consist of one volume of nitrogen and three volumes of hydrogen, it follows that the sum of the specific gravities of its constituents, divided by 2, should exactly represent the Sp. Gr. of the gas.

SPECIFIC GRAVITY OF VAPORS.

(*Brand and Taylor's Chemistry.*)

The weights of equal volumes of vapor and air are compared under the same temperature and pressure. A thin glass globe of about three inches diameter is drawn out at its neck to a narrow tube, six or seven inches long, the point of the tube being cut across with a file, but not sealed. The globe is then weighed, and the temperature and pressure at the time observed. In order to introduce a volatile liquid, the globe is warmed so as to expel a portion of its air, and the end of the tube is then dipped into the liquid. As the globe cools, the air within contracts and the liquid is forced into it by atmospheric pressure. When a sufficient quantity (from 100 to 150 grains) of liquid have entered, the globe is finally enclosed in a wire-holder, and immersed in a bath of water, oil, or other medium, heated to 50° or 60° above the boiling point of the liquid in the globe. Under these circumstances, a stream of vapor rushes rapidly through the orifice, carrying with it the air of the globe. When this ceases the point of the tube is sealed by a blowpipe flame, the temperature being observed at the same minute. The globe is removed from the bath, and when cool is cleaned and weighed. The next point to be determined is the *capacity* of the globe. For this purpose the neck is broken under the surface of water or mercury, when the cold fluid enters the globe and fills it completely, if the operation has been properly conducted, and all the air has been expelled by the vapor. By pouring out the water or mercury into a graduated vessel, the capacity of the globe is accurately ascertained. The data necessary for the calculation is thus obtained:

1. The weight of the globe full of air at the common temperature and pressure.
2. The weight of the globe, and of the vapor filling it, at the temperature of the bath, and under the same pressure.
3. The capacity of the globe.

Having these results, there can be obtained by calculation:

4. The weight of the empty globe.
5. The weight of the vapor filling the globe at the temperature of the bath, as well as its volume at this or at any other temperature that may be required.

Let it be assumed that the object is to determine the specific gravity of the vapor of *chloroform.*

1. The weight of the globe full of air at 60° F. and bar. 30, is found to be 2012.4 grains.

2. The liquid chloroform having been introduced into the globe in the manner described, the globe is maintained at a temperature of 200° in the bath until nothing but vapor remains in the interior. The aperture of the small tube is then sealed. The globe, when dry and cooled to 60° F., is found to weigh 2040 grains. This gives the weight of the globe and vapor together.

3. The capacity of the globe is determined by breaking the point of the tube under water. The liquid rushes in and entirely fills the vessel. When this liquid is poured into a graduated glass, it is found that at 60° F. there are 40 cubic inches; hence, 40 cubic inches of air were contained in the globe at common temperature and pressure.

4. The weight of this air would be 12.4 grains (100 cubic inches : 31 grs. :: 40 cubic inches : 12.4 grs.), and as the globe and air weighed together 2012.4 grains, then 2012.4 — 12.4 = 2000 grains, the weight of the empty globe.

5. The weight of the *vapor* filling the globe may now be determined. The globe was found to weigh, on cooling, 2040 grains; hence, 2040 — 2000 = 40 grains, the weight of the vapor. It is now necessary to determine either the weight of the air which would fill the globe at the temperature of the bath, or the volume of vapor which, by calculation, would be contained in the globe when cooled to 60° F. The reduction of the volume by cooling from 200° F. to 60° F. is the more simple process. Thus 40 cubic inches at 60° F. (648 : 508 :: 40 : 30.78). According to Gay-Lussac, 1000 volumes of air at 32° are increased to 1375 volumes at 212° F. Hence, the increase is $\frac{375}{180}$ or 2.08, for each degree between 32° F. and 212° F.; and 1000 ÷ 2.08 = 480. Hence, the increase for each degree is equal to 1-480th part of the volume at 32° F.; or, assuming that the volume of gas at this temperature is 480 cubic inches, there will be an addition of *one cubic inch* for every degree of increase of temperature up to 212° F.

The mean temperature is taken at 60° F., and 480 cubic inches at this temperature would become (60 — 32 + 480) 508 cubic inches. The number 32 is deducted from the temperatures, because it is from this degree (32° F.) that the rate of expansion, on which the calculation is based, commences. Hence, assuming that chloroform vapor was cooled to 60°, and could still exist as vapor at that temperature, it is obvious that its specific gravity would be determined by ascertaining the weight of 30.78 cubic inches of air at the same temperature and pressure. 100 cubic inches of air weigh 31 grains; hence, 100 : 31 :: 3078 : 9.54. Hence, at the same temperature, 60°, 30.78 cubic inches of chloroform would weigh only 9.54 grains; and 40 ÷ 9.54 = 4.19, which is nearly the specific gravity of the vapor of chloroform, as determined by calculation from its elementary composition. The following is a summary of the results:

Capacity of the globe at 60° = 40 cubic inches.
Weight of the globe with dry air = 2012.4 grains.
" " air by calculation = 12.4 "
Weight of the globe without air = 2000 "

Weight of the globe with chloroform vapor = 2040 grains.
" " chloroform vapor = 40 "

40 cubic inches of air or vapor at 200°, reduced to 30.78 cubic inches at 60°.

Weight of 30.78 cubic inches of air at 60° = 9.54 grains.
" " " chloroform vapor at 60° = 40 "

Hence,

Wt. of air.		Wt. of chlor. vapor.		Sp. Gr. air.		Sp. Gr. chlor. vapor.
9.54	:	40	::	1.000	:	4.192.

It may be observed that the ascertained Sp. Gr. of chloroform vapor is 4.20; and the Sp. Gr. of the vapor calculated from its elementary composition is 4.1805; differences which are comparatively unimportant.

SPECIFIC GRAVITY

Corresponding to Degrees of BAUMÉ'S HYDROMETER.

14° R. 17.5° C. (Sp. Gr. = $\frac{144}{144 - B}$ correct.)

DEGREE.	SPECIFIC GRAVITY.	DEGREE.	SPECIFIC GRAVITY.	DEGREE.	SPECIFIC GRAVITY.
.0	1.0000	24.5	1.2050	48.5	1.5079
0.5	1.0035	25.0	1.2101	49.0	1.5158
1.0	1.0070	25.5	1.2152	49.5	1.5238
1.5	1.0105	26,0	1.2203	50.0	1.5319
2.0	1.0141	26.5	1.2255	50.5	1.5401
2.5	1.0177	27 0	1.2308	51.0	1.5484
3.0	1.0213	27.5	1.2361	51.5	1.5568
3.5	1.0249	28.0	1.2414	52.0	1.5652
4.0	1.0286	28.5	1.2468	52.5	1.5737
4.5	1.0323	29.0	1.2522	53.0	1.5824
5.0	1.0360	29.5	1.2576	53.5	1.5911
5.5	1.0397	30.0	1.2632	54.0	1 6000
6.0	1.0435	30.5	1.2687	54.5	1.6089
6.5	1.0473	31.0	1.2743	55.0	1.6179
7.0	1.0511	31.5	1.2800	55.5	1.6271
7.5	1.0549	32.0	1.2857	56.0	1.6363
8.0	1.0588	32.5	1.2915	56.5	1.6457
8.5	1.0627	33.0	1.2973	57.0	1.6551
9.0	1.0667	33.5	1.3032	57.5	1.6647
9.5	1.0706	34.0	1.3091	58.0	1 6744
10.0	1.0746	34.5	1.3151	58.5	1.6842
10.5	1.0787	35.0	1.3211	59.0	1 6941
11.0	1.0827	35.5	1.3272	59.5	1.7041
11.5	1.0868	36.0	1.3333	60.0	1.7142
12.0	1.0909	36.5	1.3395	60.5	1.7245
12.5	1.0951	37.0	1.3458	61.0	1.7349
13.0	1.0992	37.5	1.3521	61.5	1.7454
13 5	1.1034	38.0	1.3585	62.0	1.7560
14.0	1.1111	38.5	1.3649	62.5	1.7668
14.5	1.1120	39.0	1.3714	63.0	1.7777
15.0	1.1163	39.5	1.3780	63.5	1.7888
15.5	1.1206	40.0	1.3846	64 0	1.7999
16.0	1.1250	40.5	1.3913	64.5	1.8112
16.5	1.1294	41.0	1.3981	65.0	1.8227
17.0	1.1339	41.5	1.4049	65.5	1.8343
17.5	1.1383	42.0	1.4118	66.0	1.8461
18.0	1.1429	42.5	1.4187	66.5	1.8580
18.5	1.1475	43.0	1.4267	67.0	1.8701
19.0	1.1520	43.5	1.4328	67.5	1.8828
19.5	1.1566	44.0	1.4400	68.0	1.8947
20.0	1.1613	44.5	1.4472	68.5	1.9071
20.5	1.1660	45.0	1.4545	69.0	1.9200
21.0	1.1707	45.5	1.4619	69.5	1.9328
21.5	1.1755	46.0	1.4694	70.0	1.9459
22.0	1.1803	46.5	1.4769	70.5	1.9591
22.5	1.1852	47.0	1.4845	71.0	1.9726
23.0	1.1901	47.5	1.4922	71.5	1.9862
23.5	1.1950	48.0	1.5000	72.0	2.0000
24.0	1.2000				

SPECIFIC GRAVITY

FOR LIQUIDS LIGHTER THAN WATER.

$$\frac{14.4}{\text{Sp. Gr.}} - 134 = \text{B}^\circ\,; \qquad \frac{144}{\text{B}^\circ + 134} = \text{Sp. Gr.}$$

TABLE BY DR. W. H. PILE.

Degrees of Hydrometer.	Specific Gravity (Baumé).	Degrees of Hydrometer.	Specific Gravity (Baumé).	Degrees of Hydrometer.	Specific Gravity (Baumé).	Degrees of Hydrometer.	Specific Gravity (Baumé).
10	1.0000	27	.8917	44	.8045	61	.7329
11	.9929	28	.8860	45	.8000	62	.7290
12	.9859	29	.8805	46	.7954	63	.7253
13	.9790	30	.8750	47	.7909	64	.7216
14	.9722	31	.8695	48	.7865	65	.7179
15	.9655	32	.8641	49	.7821	66	.7142
16	.9589	33	.8588	50	.7777	67	.7106
17	.9523	34	.8536	51	.7734	68	.7070
18	.9459	35	.8484	52	.7692	69	.7035
19	.9395	36	.8433	53	.7650	70	.7000
20	.9333	37	.8383	54	.7608	71	.6965
21	.9271	38	.8333	55	.7567	72	.6930
22	.9210	39	.8284	56	.7526	73	.6896
23	.9150	40	.8235	57	.7486	74	.6863
24	.9090	41	.8187	58	.7446	75	.6829
25	.9032	42	.8139	59	.7407	76	.6796
26	.8974	43	.8092	60	.7368	77	.6763

DEGREES TWADDLE'S HYDROMETER

AND THE CORRESPONDING SPECIFIC GRAVITIES.

Degrees.	Specific Gravity.	Degrees.	Specific Gravity.	Degrees.	Specific Gravity.	Degrees.	Specific Gravity.
1	1.005	8	1.040	15	1.075	22	1.110
2	1.010	9	1.045	16	1.080	23	1.115
3	1.015	10	1.050	17	1.085	24	1.120
4	1.020	11	1.055	18	1.090	25	1.125
5	1.025	12	1.060	19	1.095	26	1.130
6	1.030	13	1.065	20	1.100	27	1.135
7	1.035	14	1.070	21	1.105	28	1.140

PROPORTION OF ABSOLUTE ALCOHOL

BY WEIGHT IN 100 PARTS OF SPIRIT,

OF DIFFERENT SPECIFIC GRAVITIES AT 60° F. (15°.5 C.)

(Fownes. *Phil. Trans.*, 1847.)

Alcohol per cent.	Specific Gravity.	Alcohol per cent.	Specific Gravity.	Alcohol per cent.	Specific Gravity.	Alcohol per cent.	Specific Gravity.
0	1.0000	25	.9652	51	.9160	76	.8581
0	.9991	26	.9638	52	.9135	77	.8557
1	.9981	27	.9623	53	.9113	78	.8533
2	.9965	28	.9609	54	.9090	79	.8508
3	.9947	29	.9593	55	.9069	80	.8483
4	.9930	30	.9578	56	.9047	81	.8459
5	.9914	31	.9560	57	.9025	82	.8434
6	.9898	32	.9544	58	.9001	83	.8408
7	.9884	33	.9528	59	.8979	84	.8382
8	.9869	34	.9511	60	.8956	85	.8357
9	.9855	35	.9490	61	.8932	86	.8331
10	.9841	36	.9470	62	.8908	87	.8305
11	.9828	37	.9452	63	.8886	88	.8279
12	.9815	38	.9434	64	.8863	89	.8254
13	.9802	39	.9416	65	.8840	90	.8228
14	.9789	40	.9396	66	.8816	91	.8199
15	.9778	41	.9376	67	.8793	92	.8172
16	.9766	42	.9356	68	.8769	93	.8145
17	.9753	43	.9335	69	.8745	94	.8118
18	.9741	44	.9314	70	.8721	95	.8089
19	.9728	45	.9292	71	.8696	96	.8061
20	.9716	46	.9270	72	.8672	97	.8031
21	.9704	47	.9249	73	.8649	98	.8001
22	.9691	48	.9228	74	.8625	99	.7969
23	.9678	49	.9206	75	.8603	100	.7938
24	.9665	50	.9184				

In this table every alternate number is the result of a direct synthetical experiment; absolute alcohol and distilled water being weighed out in the proper proportions, and mixed by agitation in stoppered bottles; after a lapse of three or four days, each specimen was brought exactly to 60° F., and the specific gravity determined with great care.

TABLE

Of the Proportion by Volume of Absolute or Real Alcohol in 100 Volumes of Spirits of different Specific Gravities (Gay-Lussac) at 59° F. (15° C.).

100 Volumes of Spirits.		100 Volumes of Spirits.		100 Volumes of Spirits.	
Specific Gravity.	Contain Volumes of real Alcohol.	Specific Gravity.	Contain Volumes of real Alcohol.	Specific Gravity.	Contain Volumes of real Alcohol.
1.0000	0	0.9608	34	0.8956	68
.9985	1	.9594	35	.8932	69
.9970	2	.9581	36	.8907	70
.9956	3	.9567	37	.8882	71
.9942	4	.9553	38	.8857	72
.9929	5	.9538	39	.8831	73
.9916	6	.9523	40	.8805	74
.9903	7	.9507	41	.8779	75
.9891	8	.9491	42	.8753	76
.9878	9	.9474	43	.8726	77
.9867	10	.9457	44	.8699	78
.9855	11	.9440	45	.8672	79
.9844	12	.9422	46	.8645	80
.9833	13	.9404	47	.8617	81
.9822	14	.9386	48	.8589	82
.9812	15	.9367	49	.8560	83
.9802	16	.9348	50	.8531	84
.9792	17	.9329	51	.8502	85
.9782	18	.9309	52	.8472	86
.9773	19	.9289	53	.8442	87
.9763	20	.9269	54	.8411	88
.9753	21	.9248	55	.8379	89
.9742	22	.9227	56	.8346	90
.9732	23	.9206	57	.8312	91
.9721	24	.9185	58	.8278	92
.9711	25	.9163	59	.8242	93
.9700	26	.9141	60	.8206	94
.9690	27	.9119	61	.8168	95
.9679	28	.9096	62	.8128	96
.9668	29	.9073	63	.8086	97
.9657	30	.9050	64	.8042	98
.9645	31	.9027	65	.8006	99
.9633	32	.9004	66	.7947	100
.9621	33	.8980	67		

QUANTITIES OF ABSOLUTE ALCOHOL BY WEIGHT,

IN MIXTURES OF ALCOHOL AND WATER OF THE FOLLOWING SPECIFIC GRAVITIES.—(Drinkwater.)

Specific Gravity at 60° F. (15°.5 C.)	Alcohol by W'ght in 100 parts.	Specific Gravity at 60° F. (15°.5 C.)	Alcohol by W'ght in 100 parts.	Specific Gravity at 60° F. (15°.5 C.)	Alcohol by W'ght in 100 parts.	Specific Gravity at 60° F. (15°.5 C.)	Alcohol by W'ght in 100 parts.
1.0000	0.00	0.9959	2.22	0.9918	4.64	0.9877	7.30
.9999	0.05	.9958	2.28	.9917	4.70	.9876	7.37
.9998	0.11	.9957	2.34	.9916	4.76	.9875	7.43
.9997	0.16	.9956	2.39	.9915	4.82	.9874	7.50
.9996	0.21	.9955	2.45	.9914	4.88	.9873	7.57
.9995	0.26	.9954	2.51	.9913	4.94	.9872	7.64
.9994	0.32	.9953	2.57	.9912	5.01	.9871	7.71
.9993	0.37	.9952	2.62	.9911	5.07	.9870	7.78
.9992	0.42	.9951	2.68	.9910	5.13	.9869	7.85
.9991	0.47	.9950	2.74	.9909	5.20	.9868	7.92
.9990	0.53	.9949	2.79	.9908	5.26	.9867	7.99
.9989	0.58	.9948	2.85	.9907	5.32	.9866	8.06
.9988	0.64	.9947	2.91	.9906	5.39	.9865	8.13
.9987	0.69	.9946	2.97	.9905	5.45	.9864	8.20
.9986	0.74	.9945	3 02	.9904	5.51	.9863	8.27
.9985	0.80	.9944	3.08	.9903	5.58	.9862	8.34
.9984	0.85	.9943	3.14	.9902	5.64	.9861	8.41
.9983	0.91	.9942	3.20	.9901	5.70	.9860	8.48
.9982	0.96	.9941	3.26	.9900	5.77	.9859	8.55
.9981	1.02	.9940	3.32	.9899	5.83	.9858	8.62
.9980	1.07	.9939	3.37	.9898	5.89	.9857	8.70
.9979	1.12	.9938	3.43	.9897	5.96	.9856	8.77
.9978	1.18	.9937	3.49	.9896	6.02	.9855	8.84
.9977	1.23	.9936	3.55	.9895	6.09	.9854	8.91
.9976	1.29	.9935	3.61	.9894	6.15	.9853	8.98
.9975	1.34	.9934	3.67	.9893	6.22	.9852	9.05
.9974	1.40	.9933	3.73	.9892	6.29	.9851	9.12
.9973	1.45	.9932	3.78	.9891	6.35	.9850	9.20
.9972	1.51	.9931	3.84	.9890	6.42	.9849	9.27
.9971	1.56	.9930	3.90	.9889	6.49	.9848	9.34
.9970	1.61	.9929	3.96	.9888	6.55	.9847	9.41
.9969	1.67	.9928	4.02	.9887	6.62	.9846	9.49
.9968	1.73	.9927	4.08	.9886	6.69	.9845	9.56
.9967	1.78	.9926	4.14	.9885	6.75	.9844	9.63
.9966	1.83	.9925	4.20	.9884	6.82	.9843	9.70
.9965	1.89	.9924	4.27	.9883	6.89	.9842	9.78
.9964	1.94	.9923	4.33	.9882	6.95	.9841	9.85
.9963	1.99	.9922	4.39	.9881	7.02	.9840	9.92
.9962	2.05	.9921	4.45	.9880	7.09	.9839	9.99
.9961	2.11	.9920	4.51	.9879	7.16	.9838	10.07
.9960	2.17	.9919	4.57	.9878	7.23		

This Table is founded on synthetic experiments, in which eleven different mixtures of alcohol and water were made, containing respectively 0.5, 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 per cent of alcohol by weight: the alcohol employed had a specific gravity of 0.7938 at 60° F. or 15°.5 C.

TABLE*

OF THE QUANTITY OF REAL ALCOHOL CONTAINED IN 1 AQUEOUS ALCOHOL BY WEIGHT AND BY VOLUME A DENSITIES. (Temperature, 15° C.)

SPECIFIC GRAVITY.	100 VOLUMES CONTAIN:		100 PARTS BY WEIGHT CONTAIN:	SPECIFIC GRAVITY.	100 VOLUME CONTAIN:	
	Alcohol.	*Water.*	*Alcohol.*		*Alcohol.*	*Wate*
[illegible]	100	0.00	100.00	.9348	50	53.7
[illegible]	99	1.28	98.38	.9366	49	54.7
[illegible]	98	2.54	96.83	.9385	48	55.6
[illegible]	97	3.77	95.35	.9403	47	56.6
[illegible]	96	4.97	93.89	.9421	46	57.6
[illegible]	95	6.16	92.45	.9439	45	58.6
[illegible]	94	7.32	91.08	.9456	44	59.5
[illegible]	93	8.48	89.72	.9473	43	60.5
[illegible]	92	9.62	88.37	.9490	42	61.5
[illegible]	91	10.76	87.04	.9506	41	62.4
[illegible]	90	11.88	85.74	.9522	40	63.4
[illegible]	89	13.01	84.47	.9538	39	64.3
[illegible]	88	14.12	83.22	.9553	38	65.3
[illegible]	87	15.23	81.96	.9568	37	66.2
[illegible]	86	16.32	80.72	.9582	36	67.2
[illegible]	85	17.42	79.51	.9595	35	68.1
[illegible]	84	18.52	78.29	.9607	34	69.0
[illegible]	83	19.61	77.09	.9620	33	69.9
[illegible]	82	20.68	75.91	.9633	32	70.8
[illegible]	81	21.76	74.75	.9645	31	71.8
[illegible]	80	22.82	73.59	.9657	30	72.7
[illegible]	79	23.90	72.43	.9668	29	73.6
[illegible]	78	24.96	71.20	.9679	28	74.5
[illegible]	77	26.03	70.16	.9690	27	75.4
[illegible]	76	27.09	69.04	.9700	26	76.3
[illegible]	75	28.15	67.93	.9711	25	77.2
[illegible]	74	29.20	66.82	.9721	24	78.1
[illegible]	73	30.26	65.72	.9731	23	79.0
[illegible]	72	31.30	64.64	.9741	22	79.9
[illegible]	71	32.35	63.58	.9751	21	80.8
[illegible]	70	33.39	62.50	.9761	20	81.7
[illegible]	69	34.44	61.43	.9771	19	82.6
[illegible]	68	35.47	60.38	.9781	18	83.5
[illegible]	67	36.51	59.33	.9791	17	84.3
.9002	66	37.54	58.29	.9801	16	85.2
.9026	65	38.58	57.25	.9812	15	86.1
.9049	64	39.60	56.23	.9822	14	87.0
.9072	63	40.63	55.21	.9833	13	88.0
.9095	62	41.65	54.20	.9844	12	88.9
.9117	61	42.67	53.19	.9855	11	89.8
.9139	60	43.68	52.20	.9867	10	90.7
.9161	59	44.70	51.20	.9878	9	91.6
.9183	58	45.72	50.21	.9890	8	92.5
.9205	57	46.73	49.24	.9902	7	93.4
.9226	56	47.73	48.26	.9915	6	94.3
.9247	55	48.74	47.29	.9928	5	95.3
.9267	54	49.74	46.33	.9942	4	96.2
.9288	53	50.74	45.37	.9956	3	97.1
.9308	52	51.74	44.41	.9970	2	98.1
.9328	51	52.73	43.47	.9985	1	99.0

* Exam. Med. Chemicals, Hoffmann, p. 119.

TABLE*

OF THE QUANTITY BY WEIGHT OF HYDROCHLORIC-ACID GAS CONTAINED IN 100 PARTS BY WEIGHT OF AQUEOUS HYDROCHLORIC ACID AT DIFFERENT DENSITIES. (Temperature, 16° C.)

SPECIFIC GRAVITY.	PER CENT OF HYDRO-CHLORIC ACID.	SPECIFIC GRAVITY.	PER CENT OF HYDRO-CHLORIC ACID.	SPECIFIC GRAVITY.	PER CENT OF HYDRO-CHLORIC ACID.	SPECIFIC GRAVITY.	PER CENT OF HYDRO-CHLORIC ACID.
1.2013	41	1.1551	31.25	1.1056	21.5	1.0573	11.75
1.2002	40.75	1.1539	31	1.1044	21.25	1.0561	11.5
1.1991	40.5	1.1526	30.75	1.1031	21	1.0549	11.25
1.1980	40.25	1.1513	30.5	1.1019	20.75	1.0537	11
1.1969	40	1.1501	30.25	1.1007	20.5	1.0524	10.75
1.1958	39.75	1.1488	30	1.0994	20.25	1.0512	10.5
1.1947	39.5	1.1475	29.75	1.0982	20	1.0500	10.25
1.1936	39.25	1.1462	29.5	1.0969	19.75	1.0488	10
1.1925	39	1.1450	29.25	1.0957	19.5	1.0475	9.75
1.1913	38.75	1.1437	29	1.0945	19.25	1.0463	9.5
1.1902	38.5	1.1424	28.75	1.0932	19	1.0451	9.25
1.1890	38.25	1.1412	28.5	1.0920	18.75	1.0439	9
1.1878	38	1.1399	28.25	1.0907	18.5	1.0427	8.75
1.1867	37.75	1.1386	28	1.0895	18.25	1.0414	8.5
1.1855	37.5	1.1373	27.75	1.0883	18	1.0402	8.25
1.1844	37.25	1.1361	27.5	1.0870	17.75	1.0390	8
1.1833	37	1.1348	27.25	1.0858	17.5	1.0378	7.75
1.1821	36.75	1.1335	27	1.0845	17.25	1.0366	7.5
1.1810	36.5	1.1323	26.75	1.0833	17	1.0353	7.25
1.1798	36.25	1.1310	26.5	1.0821	16.75	1.0341	7
1.1787	36	1.1297	26.25	1.0807	16.5	1.0329	6.75
1.1775	35.75	1.1284	26	1.0795	16.25	1.0317	6.5
1.1763	35.5	1.1272	25.75	1.0783	16	1.0305	6.25
1.1752	35.25	1.1259	25.5	1.0770	15.75	1.0292	6
1.1739	35	1.1246	25.25	1.0758	15.5	1.0280	5.75
1.1727	34.75	1.1234	25	1.0746	15.25	1.0268	5.5
1.1714	34.5	1.1221	24.75	1.0733	15	1.0256	5.25
1.1702	34.25	1.1208	24.5	1.0721	14.75	1.0244	5
1.1689	34	1.1196	24.25	1.0709	14.5	1.0231	4.75
1.1677	33.75	1.1183	24	1.0696	14.25	1.0219	4.5
1.1664	33.5	1.1170	23.75	1.0684	14	1.0207	4.25
1.1652	33.25	1.1157	23.5	1.0672	13.75	1.0195	4
1.1639	33	1.1145	23.25	1.0659	13.5	1.0170	3.5
1.1627	32.75	1.1132	23	1.0647	13.25	1.0146	3
1.1614	32.5	1.1119	22.75	1.0635	13	1.0122	2.5
1.1602	32.25	1.1107	22.5	1.0622	12.75	1.0097	2
1.1589	32	1.1094	22.25	1.0610	12.5	1.0073	1.5
1.1577	31.75	1.1081	22	1.0598	12.25	1.0048	1
1.1564	31.5	1.1069	21.75	1.0585	12	1.0024	0.5

* Taken from "Manual Chem. Anal.," by Fred. Hoffmann, p. 87.

The density of the aqueous acid being decreased by an increase of temperature, and increased by a decrease of temperature, the consequent change of the specific gravity amounts for each degree of the Centigrade thermometer in either direction—

For acids of a specific gravity of 1.1739	to those of 1.1386	to about 0.0005
" " " 1.1335	" 1.0982	" 0.0004
" " " 1.0932	" 1.0635	" 0.0003

For instance: An acid of a specific gravity of 1.1234 at 16° C., containing 25 per cent of hydrochloric-acid gas, will have at 18.5° C. a specific gravity of (1.1234 — 0.004 × 2.5 =) 1.1224, and at 13.5° C. a specific gravity of (1.1234 + 0.004 × 2.5 =) 1.1244.

TABLE*

OF THE QUANTITY BY WEIGHT OF NITRIC OXIDE (N_2O_5) AND OF MONOHYDRATED NITRIC ACID CONTAINED IN 100 PARTS BY WEIGHT OF AQUEOUS NITRIC ACID AT DIFFERENT DENSITIES. (Temperature, 17.5° C.)

SPECIFIC GRAVITY.	PER CENT OF N_2O_5.	PER CENT OF N_2O_5 + H_2O.	SPECIFIC GRAVITY.	PER CENT OF N_2O_5.	PER CENT OF N_2O_5 + H_2O.	SPECIFIC GRAVITY.	PER CENT OF N_2O_5.	PER CENT OF N_2O_5 + H_2O.
1.523	85	99.16	1.472	72	84.00	1.417	59	68.83
1.521	84.5	98.58	1.470	71.5	83.41	1.414	58.5	68.25
1.519	84	98.00	1.469	71	82.83	1.412	58	67.66
1.517	83.5	97.41	1.467	70.5	82.24	1.409	57.5	67.08
1.516	83	96.83	1.465	70	81.66	1.406	57	66.50
1.514	82.5	96.24	1.462	69.5	81.08	1.403	56.5	65.91
1.512	82	95.66	1.460	69	80.50	1.400	56	65.33
1.510	81.5	95.08	1.458	68.5	79.91	1.397	55.5	64.75
1.508	81	94.50	1.456	68	79.33	1.394	55	64.16
1.506	80.5	93.91	1.454	67.5	78.75	1.392	54.5	63.58
1.504	80	93.33	1.451	67	78.16	1.389	54	63.00
1.502	79.5	92.74	1.449	66.5	77.58	1.386	53 5	62.41
1.500	79	92.16	1.447	66	77.00	1.383	53	61.83
1.498	78.5	91.58	1.444	65.5	76.41	1.380	52.5	61.25
1.496	78	91.00	1.442	65	75.83	1.377	52	60.66
1,494	77.5	90.41	1.440	64.5	75.25	1.374	51.5	60.08
1.492	77	89.83	1.438	64	74.66	1.371	51	59.50
1.490	76.5	89.24	1.436	63.5	74.08	1.368	50.5	58.91
1.488	76	88.66	1.434	63	73.50	1.364	50	58.33
1.486	75.5	88.08	1.432	62.5	72.91	1.361	49.5	57.75
1.484	75	87.50	1.430	62	72.33	1.358	49	57.16
1.482	74.5	86.91	1.428	61.5	71.75	1.355	48.5	56.58
1.480	74	86.33	1.426	61	71.16	1.352	48	56.00
1.478	73.5	85.74	1.424	60.5	70.58	1.349	47.5	55.41
1.476	73	85.16	1.422	60	70.00	1.345	47	54.83
1.474	72.5	84.58	1.419	59.5	69.41	1.342	46.5	54.25

---

* Taken from "Man. Chem. Anal.," by Fred. Hoffmann, 1873, p. 94.

Specific Gravity.	Per cent of N_2O_5.	Per cent of $N_2O_5 + H_2O$.	Specific Gravity.	Per cent of N_2O_5.	Per cent of $N_2O_5 + H_2O$.	Specific Gravity.	Per cent of N_2O_5.	Per cent of $N_2O_5 + H_2O$.
1.338	46	53.66	1.236	32.5	37.91	1.132	19	22.16
1.334	45.5	53.08	1.232	32	37.33	1.129	18.5	21.58
1.330	45	52.50	1.228	31.5	36.75	1.125	18	21.00
1.327	44.5	51.91	1.224	31	36.16	1.122	17.5	20.41
1.323	44	51.33	1.220	30.5	35.58	1.118	17	19.83
1.319	43.5	50.75	1.217	30	35.00	1.114	16.5	19.25
1.315	43	50.16	1.213	29.5	34.41	1.111	16	18.66
1.312	42.5	49.58	1.209	29	33.83	1.107	15.5	18.08
1.308	42	49.00	1.205	28.5	33.25	1.104	15	17.50
1.304	41.5	48.41	1.201	28	32.66	1.100	14.5	16.91
1.301	41	47.83	1.198	27.5	32.08	1.096	14	16.33
1.297	40.5	47.25	1.194	27	31.50	1.092	13.5	15.74
1.294	40	46.66	1.190	26.5	30.91	1.089	13	15.16
1.290	39.5	46.08	1.186	26	30.33	1.086	12.5	14.58
1.287	39	45.50	1.182	25.5	29.74	1.082	12	14.00
1.283	38.5	44.91	1.178	25	29.16	1.078	11.5	13.41
1.279	38	44.33	1.174	24.5	28.58	1.075	11	12.83
1.275	37.5	43.75	1.170	24	28.00	1.071	10.5	12.25
1.271	37	43.16	1.167	23.5	27.41	1.068	10	11.66
1.267	36.5	42.58	1.163	23	26.83	1.064	9.5	11.07
1.263	36	42.00	1.159	22.5	26.25	1.060	9	10.50
1.259	35.5	41.41	1.155	22	25.66	1.056	8.5	9.91
1.255	35	40.83	1.151	21.5	25.08	1.053	8	9.33
1.251	34.5	40.25	1.147	21	24.49	1.050	7.5	8.84
1.247	34	39.66	1.143	20.5	23.91	1.045	7	8.16
1.243	33.5	39.08	1.140	20	23.33	1.038	6	7.00
1.239	33	38.50	1.136	19.5	22.74	1.032	5	5.83

NOTE.—With the decrease and increase of temperature, the density of Nitric Acid suffers a corresponding increase or decrease, amounting for each degree of the Centigrade thermometer in either direction—

For acids of a sp. gr. of 1.492 to those of 1.476 to 0.00213 in the average.
" " 1.472 " 1.456 " 0.002 " "
" " 1.454 " 1.434 " 0.00186 " "
" " 1.430 " 1.412 " 0.00171 " "
" " 1.406 " 1.383 " 0.00155 " "
" " 1.377 " 1.352 " 0.00141 " "
" " 1.345 " 1.315 " 0.00128 " "
" " 1.308 " 1.279 " 0.00114 " "
" " 1.271 " 1.239 " 0.001 " "
" " 1.232 " 1.201 " 0.00085 " "
" " 1.194 " 1.163 " 0.00071 " "
" " 1.155 " 1.125 " 0.0005 " "

For instance: An acid of 1.178 specific gravity at 17.5° C., containing 25 per cent of anhydrous, or 29.16 per cent of monohydrated, Nitric Acid, will have, at 20° C., a specific gravity of (1.178 − 0.00072 × 2.5 =) 1.762, and at 15° C., a specific gravity of (1.178 + 0.00072 × 2.5 =) 1.1798.

TABLE*

OF THE QUANTITY BY WEIGHT OF PHOSPHORIC OXIDE (P_2O_5) AND OF TRI-HYDRATED PHOSPHORIC ACID CONTAINED IN 100 PARTS BY WEIGHT OF AQUEOUS PHOSPHORIC ACID AT DIFFERENT DENSITIES.

(TEMPERATURE, 17.5° C.)

SPECIFIC GRAVITY.	PER CENT OF P_2O_5.	PER CENT OF $P_2O_5+3H_2O$.	SPECIFIC GRAVITY.	PER CENT OF P_2O_5.	PER CENT OF $P_2O_5+3H_2O$.
1.809	68	93.67	1.469	46.5	64.06
1.800	67.5	92.99	1.462	46	63.37
1.792	67	92.30	1.455	45.5	62.68
1.783	66.5	91.61	1.448	45	61.99
1.775	66	90.92	1.441	44.5	61.30
1.766	65.5	90.23	1.435	44	60.61
1.758	65	89.54	1.428	43.5	59.92
1.750	64.5	88.85	1.422	43	59.23
1.741	64	88.16	1.415	42.5	58.55
1.733	63.5	87.48	1.409	42	57.86
1.725	63	86.79	1.402	41:5	57.17
1.717	62.5	86.10	1.396	41	56.48
1.709	62	85.41	1.389	40.5	55.79
1.701	61.5	84.72	1.383	40	55.10
1.693	61	84.03	1.377	39.5	54.41
1.685	60.5	83.34	1.371	39	53.72
1.677	60	82.65	1.365	38.5	53.04
1.669	59.5	81.97	1.359	38	52.35
1.661	59	81.28	1.354	37.5	51.66
1.653	58.5	80.59	1.348	37	50.97
1.645	58	79.90	1.342	36.5	50.28
1.637	57.5	79.21	1.336	36	49.59
1.629	57	78.52	1.330	35.5	48.90
1.621	56.5	77.83	1.325	35	48.21
1.613	56	77.14	1.319	34.5	47.52
1.605	55.5	76.45	1.314	34	46.84
1.597	55	75.77	1.308	33.5	46.15
1.589	54.5	75.08	1.303	33	45.46
1.581	54	74.39	1.298	32.5	44.77
1.574	53.5	73.70	1.292	32	44.08
1.566	53	73.01	1.287	31.5	43.39
1.559	52.5	72.32	1.281	31	42.70
1.551	52	71.63	1.276	30.5	42.01
1.543	51.5	70.94	1.271	30	41.33
1.536	51	70.26	1.265	29.5	40.64
1.528	50.5	69.57	1.260	20	39.95
1.521	50	68.88	1.255	28.5	39.26
1.513	49 5	68.19	1.249	28	38.57
1.505	49	67.50	1.244	27.5	37.88
1.498	48.5	66.81	1.239	27	37.19
1.491	48	66.12	1.233	26.5	36.50
1.484	47.5	65.43	1.228	26	35.82
1.476	47	64.75	1.223	25.5	35.13

---

[*] Loc. cit. (Hoffman), p. 101.

TABLE OF THE QUANTITY BY WEIGHT, ETC.—(*Continued.*)

SPECIFIC GRAVITY.	PER CENT OF P_2O_5.	PER CENT OF $P_2O_5+3H_2O$.	SPECIFIC GRAVITY.	PER CENT OF P_2O_5.	PER CENT OF $P_2O_5+3H_2O$.
1.218	25	34.44	1.109	13.5	18.60
1.213	24.5	33.75	1.104	13	17.91
1.208	24	33.06	1.100	12.5	17.22
1.203	23.5	32.37	1.096	12	16.53
1.198	23	31.68	1.091	11.5	15.84
1.193	22.5	30.99	1.087	11	15.15
1.188	22	30.31	1.083	10.5	14.46
1.183	21.5	29.62	1.079	10	13.77
1.178	21	28.93	1.074	9.5	13.09
1.174	20.5	28.24	1.070	9	12.40
1.169	20	27.55	1.066	8.5	11.71
1.164	19.5	26 86	1.062	8	11.02
1.159	19	26.17	1.058	7.5	10.33
1.155	18.5	25.48	1.053	7	9.64
1.150	18	24.80	1.049	6.5	8.95
1.145	17.5	24.11	1.045	6	8.26
1.140	17	23.42	1.041	5.5	7.57
1.135	16.5	22.73	1.037	5	6.89
1.130	16	22.04	1.033	4.5	6 20
1.126	15.5	21.35	1.029	4	5.51
1.122	15	20.66	1.025	3.5	4.82
1.118	14.5	19.97	1.021	3	4.13
1.113	14	19.28	1.017	2.5	3.44

NOTE.—With the decrease or increase of temperature, the density of phosphoric acid suffers a corresponding increase or decrease, amounting for each degree of the Centigrade thermometer in either direction:

For acids of a specific gravity of 1.809 to those of 1.613 to about 0.601.
“ “ “ “ “ “ 1.597 “ 1.462 “ 0.00082.
“ “ “ “ “ “ 1.448 “ 1.336 “ 0.00068.
“ “ “ “ “ “ 1.325 “ 1.228 “ 0.00052.
“ “ “ “ “ “ 1.218 “ 1.122 “ 0.0004.
“ “ “ “ “ “ 1.113 “ 1.079 “ 0.00035.

For instance: An acid of 1.130 Sp. Gr. at 17.5° C., containing 16 per cent. of phosphoric oxide (P_2O_5) or 22.04 per cent of tri-hydrated phosphoric acid, will have, at 20° C., a Sp. Gr. of (1.130 – 0.0004 × 2.5 =) 1.129, and at 15° C., a Sp. Gr. of (1.130 + 0.0004 × 2.5 =) 1.131.

TABLE*

OF THE QUANTITY BY WEIGHT OF SULPHURIC OXIDE (SO_3) AND OF MONOHYDRATED SULPHURIC ACID CONTAINED IN 100 PARTS BY WEIGHT OF AQUEOUS SULPHURIC ACIDS AT DIFFERENT DENSITIES. (*Temperature, 17.5° C.*)

Specific Gravity.	Per cent of SO_3.	Per cent of $SO_3 + H_2O$.	Specific Gravity.	Per cent of SO_3.	Per cent of $SO_3 + H_2O$.	Specific Gravity.	Per cent of SO_3.	Per cent of $SO_3 + H_2O$.
1.841	81.6	100	1.559	53.8	66	1.235	26.1	32
1.840	80.8	99	1.547	53.0	65	1.257	25.3	31
1.839	80.0	98	1.536	52.2	64	1.219	24.5	30
1.838	79.2	97	1.525	51.4	63	1.211	23.6	29
1.837	78.3	96	1.514	50.6	62	1.202	22.8	28
1.835	77.5	95	1.503	49.8	61	1.194	22.0	27
1.833	76.7	94	1.493	49.0	60	1.186	21.2	26
1.830	75.9	93	1.482	48.1	59	1.178	20.4	25
1.826	75.1	92	1.471	47.3	58	1.170	19.6	24
1.821	74.3	91	1.461	46.5	57	1.163	18.7	23
1.815	73.4	90	1.450	45.7	56	1.155	17.9	22
1.808	72.6	89	1.440	44.9	55	1.147	17.1	21
1.800	71.8	88	1.430	44.0	54	1.140	16.3	20
1.791	71.0	87	1.420	43.2	53	1.132	15.5	19
1.782	70.1	86	1.411	42.4	52	1.125	14.7	18
1.774	69.4	85	1.401	41.6	51	1.117	13.8	17
1.765	68.5	84	1.392	40.8	50	1.110	13.0	16
1.755	67.7	83	1.382	40.0	49	1.103	12.2	15
1.744	66.9	82	1.373	39.2	48	1.095	11.4	14
1.733	66.1	81	1.364	38.3	47	1.088	10.6	13
1.722	65.3	80	1.354	37.5	46	1.081	9.8	12
1.711	64.4	79	1.345	36.7	45	1.074	9.0	11
1.699	63.6	78	1.336	35.9	44	1.067	8.1	10
1.688	62.8	77	1.328	35.1	43	1.060	7.3	9
1.676	62.0	76	1.319	34.3	42	1.053	6.5	8
1.665	61.2	75	1.310	33.4	41	1.046	5.7	7
1.653	60.4	74	1.302	32.6	40	1.039	4.9	6
1.641	59.6	73	1.293	31.8	39	1.032	4.1	5
1.629	58.7	72	1.285	31.0	38	1.025	3.2	4
1.617	57.9	71	1.276	30.2	37	1.019	2.4	3
1.605	57.1	70	1.268	29.4	36	1.012	1.6	2
1.593	56.3	69	1.260	28.5	35	1.006	0.8	1
1.582	55.5	68	1.251	27.7	34	1.003	0.4	0.5
1.570	54.7	67	1.243	26.9	33	0.000	0.	0

---

* Loc. cit. (Hoffmann), p. 108.

Note.—With the decrease and increase of temperature, the density of sulphuric acid suffers a corresponding increase or decrease, amounting for each degree of the Centigrade thermometer in either direction:

For acids of a Sp. Gr. of 1.841 to those of 1.782 to about 0.0014.
" " 1.774 " 1.665 " 0.0012.
" " 1.653 " 1.302 " 0.001.
" " 1.293 " 1.219 " 0.00075.
" " 1.211 " 1.140 " 0.00045.
" " 1.132 " 1.067 " 0.00047.

TABLE*

Of the Quantity by Weight of Pure Ethylic Ether contained in 100 Parts by Weight of Ether at different Densities.

(Temperature, 17.5° C.)

Specific Gravity.	Per cent of Ethylic Ether.	Specific Gravity.	Per cent of Ethylic Ether.	Specific Gravity.	Per cent of Ethylic Ether.	Specific Gravity.	Per cent of Ethylic Ether.
0.7185	100	0.7310	87	0.7456	74	0.7614	61
.7198	99	.7320	86	.7468	73	.7627	60
.7206	98	.7331	85	.7480	72	.7640	59
.7215	97	.7342	84	.7492	71	.7653	58
.7224	96	.7353	83	.7504	70	.7666	57
.7233	95	.7364	82	.7516	69	.7680	56
.7242	94	.7375	81	.7528	68	.7693	55
.7251	93	.7386	80	.7540	67	.7707	54
.7260	92	.7397	79	.7552	66	.7721	53
.7270	91	.7408	78	.7564	65	.7735	52
.7280	90	.7420	77	.7576	64	.7750	51
.7290	89	.7432	76	.7588	63	.7764	50
.7300	88	.7444	75	.7601	62	.7778	49

Note.—With the decrease and increase of temperature, the density of ether suffers a corresponding increase or decrease, amounting for each degree of the Centigrade thermometer in either direction:

For ether of a Sp. Gr. of 0.7198 to that of 0.7331, about 0.0013.
" " .7342 " .7504, " .0011.
" " .7516 " .7627, " .0009.
" " .7640 " .7764, " .0008.

For instance: An ether of 0.7206 specific gravity at 17.5° C., containing 98 per cent ethyl oxide, will have, at 20° C., a specific gravity of (0.7206 − 0.0013 × 2.5 =) 0.7173, and, at 15° C., a specific gravity of (0.7206 + 0.0013 × 2.5 =) 0.7239.

---

* Loc. cit. (Hoffmann), p. 116.

TABLE*

OF THE QUANTITY BY WEIGHT OF AMMONIA CON BY WEIGHT OF AMMONIC HYDRATE AT DIFFERE perature, 14° C.)

SPECIFIC GRAVITY.	PER CENT OF AMMONIA.	SPECIFIC GRAVITY.	PER CENT OF AMMONIA.
0.8907	33.0	0.9127	24.2
.8911	32.8	.9133	24.0
.8916	32.6	.9139	23.8
.8920	32.4	.9145	23.6
.8925	32.2	.9150	23.4
.8929	32.0	.9156	23.2
.8934	31.8	.9162	23.0
.8938	31.6	.9168	22.8
.89[illegible]3	31.4	.9174	22.6
.89[illegible]8	31.2	.9180	22.4
.8953	31.0	.9185	22.2
.8957	30.8	.9191	22.0
.8962	30.6	.9197	21.8
.8967	30.4	.9203	21.6
.8971	30.2	.9209	21.4
.8976	30.0	.9215	21.2
.8981	29.8	.9221	21.0
.8986	29.6	.9227	20.8
.8991	29.4	.9233	20.6
.8996	29.2	.9239	20.4
.9001	29.0	.9245	20.2
.9006	28.8	.9251	20.0
.9011	28.6	.9257	19.8
.9016	28.4	.9264	19.6
.9021	28.2	.9271	19.4
.9026	28.0	.9277	19.2
.9031	27.8	.9283	19.0
.9036	27.6	.9289	18.8
.9041	27.4	.9296	18.6
.9047	27.2	.9302	18.4
.9052	27.0	.9308	18.2
.9057	26.8	.9314	18.0
.9063	26.6	.9321	17.8
.9068	26.4	.9327	17.6
.9073	26.2	.9333	17.4
.9078	26.0	.9340	17.2
.9083	25.8	.9347	17.0
.9089	25.6	.9353	16.8
.9094	25.4	.9360	16.6
.9100	25.2	.9366	16.4
.9106	25.0	.9373	16.2
.9111	24.8	.9380	16.0
.9116	24.6	.9386	15.8
.9122	24.4	.9393	15.6

---

* Loc. cit. (Hoffman), p. 145.

TABLE OF THE QUANTITY BY WEIGHT OF AMMONIA, ETC.—(*Continued.*)

SPECIFIC GRAVITY.	PER CENT OF AMMONIA.	SPECIFIC GRAVITY.	PER CENT OF AMMONIA.	SPECIFIC GRAVITY.	PER CENT OF AMMONIA.
0.9725	6.6	0.9815	4.4	0.9907	2.2
.9733	6.4	.9823	4.2	.9915	2.0
.9741	6.2	.9831	4.0	.9924	1.8
.9749	6.0	.9839	3.8	.9932	1.6
.9757	5.8	.9847	3.6	.9941	1.4
.9765	5.6	.9855	3.4	.9950	1.2
.9773	5.4	.9863	3.2	.9959	1.0
.9781	5.2	.9873	3.0	.9967	0.8
.9790	5.0	.9882	2.8	.9975	0.6
.9799	4.8	.9890	2.6	.9983	0.4
.9807	4.6	.9899	2.4	.9991	0.2

NOTE.—With the decrease and increase of temperature, the density of ammonic hydrate suffers a corresponding increase or decrease, amounting for each degree of the Centigrade thermometer in either direction :

For ammonic hydrate of a Sp. Gr. of 0.9001 to that of 0.9221 to about 0.00055.
" " " " " 0.9251 " 0.9414 " 0.0004.
" " " " " 0.9520 " 0.9670 " 0.0003.
" " " " " 0.9709 " 0.9831 " 0.0002.

For instance: Ammonic hydrate of 0.9593 specific gravity at 14° C., containing 10 per cent of ammonia, will have, at 18° C., a specific gravity of (0.9593 – 0.0003 × 4 =) 0.9581, and at 12° C., a specific gravity of (0.9593 + 0.0003 × 2 =) 0.9599.

TABLE*

OF THE QUANTITY BY WEIGHT OF POTASSIC OXIDE CONTAINED IN 100 PARTS BY WEIGHT OF POTASSIC HYDRATE AT DIFFERENT DENSITIES. (Temperature, 17.5° C.)

SPECIFIC GRAVITY.	PER CENT OF POT. OXIDE.	SPECIFIC GRAVITY.	PER CENT OF POT. OXIDE.	SPECIFIC GRAVITY.	PER CENT OF POT. OXIDE.
1.576	45	1.358	30	1.171	15
1.568	44.5	1.352	29.5	1.165	14.5
1.560	44	1.345	29	1.159	14
1.553	43.5	1.339	28.5	1.153	13.5
1.545	43	1.332	28	1.147	13
1.537	42.5	1.326	27.5	1.141	12.5
1.530	42	1.320	27	1.135	12
1.522	41.5	1.313	26.5	1.129	11.5
1.514	41	1.307	26	1.123	11
1.507	40.5	1.301	25.5	1.117	10.5
1.500	40	1.294	25	1.111	10
1.492	39.5	1.288	24.5	1.105	9.5
1.484	39	1.282	24	1.099	9
1.477	38.5	1.275	23.5	1.094	8.5
1.470	38	1.269	23	1.088	8
1.463	37.5	1.263	22.5	1.082	7.5
1.456	37	1.257	22	1.076	7
1.449	36.5	1.250	21.5	1.070	6.5
1.442	36	1.244	21	1.065	6
1.435	35.5	1.238	20.5	1.059	5.5
1.428	35	1.231	20	1.054	5
1.421	34.5	1.225	19.5	1.048	4.5
1.414	34	1.219	19	1.042	4
1.407	33.5	1.213	18.5	1.037	3.5
1.400	33	1.207	18	1.031	3
1.393	32.5	1.201	17.5	1.026	2.5
1.386	32	1.195	17	1.021	2
1.379	31.5	1.189	16.5	1.015	1.5
1.372	31	1.183	16		
1.365	30.5	1.177	15.5		

NOTE.—With the decrease and increase of temperature, the density of the solution suffers a corresponding increase or decrease, amounting, for each degree of the Centigrade thermometer, in either direction :

For solution of a specific gravity of	1.576	to that of	1.500	to about	0.00055.
" " " " "	1.484	"	1.358	"	0.0005.
" " " " "	1.345	"	1.231	"	0.0004.
" " " " "	1.219	"	1.111	"	0.00033.

---

* Loc. cit. (Hoffmann), p. 254.

TABLE[*]

OF THE QUANTITY BY WEIGHT OF SODIC OXIDE CONTAINED IN 100 PARTS BY WEIGHT OF SODIC HYDRATE AT DIFFERENT DENSITIES. (Temperature, 17.5° C.)

SPECIFIC GRAVITY.	PER CENT OF SOD. OXIDE.	SPECIFIC GRAVITY.	PER CENT OF SOD. OXIDE.	SPECIFIC GRAVITY.	PER CENT OF SOD. OXIDE.
1.500	35	1.353	25	1.210	15
1.492	34.5	1.345	24.5	1.203	14.5
1.485	34	1.338	24	1.195	14
1.477	33.5	1.331	23.5	1.188	13.5
1.470	33	1.324	23	1.181	13
1.463	32.5	1.317	22.5	1.174	12.5
1.455	32	1.309	22	1.167	12
1.448	31.5	1.302	21.5	1.160	11.5
1.440	31	1.295	21	1.153	11
1.433	30.5	1.288	20.5	1.146	10.5
1.426	30	1.281	20	1.139	10
1.418	29.5	1.274	19.5	1.132	9.5
1.411	29	1.266	19	1.125	9
1.404	28.5	1.259	18.5	1.118	8.5
1.396	28	1.252	18	1.111	8
1.389	27.5	1.245	17.5	1.104	7.5
1.382	27	1.238	17	1.097	7
1.375	26.5	1.231	16.5	1.090	6.5
1.367	26	1.224	16	1.083	6
1.360	25.5	1.217	15.5	1.076	5.5

(Liquor Natri Caustici of the Pharmacopœa Germanica has a specific gravity of from 1.330 to 1.334, and contains from 30 to 31 per cent of sodic hydrate, or about 23.5 per cent of sodic oxide.)

NOTE.—With the decrease and increase of temperature, the density of the solution suffers a corresponding increase and decrease, amounting for each degree of the Centigrade thermometer, in either direction :

For solution of a specific gravity of 1.500 to that of 1.353 to about 0.00045.
" " " " 1.345 " 1.210 " 0.0004.
" " " " 1.203 " 1.076 " 0.00039.

---

[*] Loc. cit. (Hoffmann), p. 255.

DENSITY OF AQUEOUS ACETIC ACID.

By OUDEMAUS.

$C_2H_4O_2$ Per cent.	Density.			$C_2H_4O_2$ Per cent.	Density.		
	At 0° C.	At 15°.	At 40°.		At 0° C.	At 15°.	At 40°.
0	0.999	0.9992	0.9924	51	1.0740	1.0623	1.0416
1	1.0016	1.0007	0.9936	52	1.0749	1.0631	1.0423
2	1.0033	1.0022	0.9948	53	1.0758	1.0638	1.0429
3	1.0051	1.0037	0.9960	54	1.0767	1 0646	1.0434
4	1.0069	1.0052	0.9972	55	1.0775	1.0653	1.0440
5	1.0088	1.0067	0.9984	56	1.0783	1.0660	1.0445
6	1.0106	1.0083	0.9996	57	1.0791	1.0666	1.0450
7	1.0124	1.0098	1.0008	58	1.0798	1.0673	1.0455
8	1.0142	1.0113	1.0020	59	1.0806	1.0679	1.0460
9	1.0159	1.0127	1.0032	60	1.0813	1.0685	1.0464
10	1.0176	1.0142	1.0044	61	1.0820	1.0691	1.0468
11	1.0194	1.0157	1.0056	62	1.0826	1.0697	1.0472
12	1.0211	1.0171	1.0067	63	1.0832	1.0702	1.0475
13	1.0228	1.0185	1.0079	64	1.0838	1.0707	1.0479
14	1.0245	1.0200	1.0090	65	1.0845	1.0712	1.0482
15	1.0262	1.0214	1.0101	66	1.0851	1.0717	1.0485
16	1.0279	1.0228	1.0112	67	1.0856	1.0721	1.0488
17	1.0295	1.0242	1.0123	68	1.0861	1.0725	1.0491
18	1.0311	1.0256	1.0134	69	1.0866	1.0729	1.0493
19	1.0327	1.0270	1.0144	70	1.0871	1.0733	1.0495
20	1.0343	1.0284	1.0155	71	1.0875	1.0737	1.0497
21	1.0359	1.0298	1.0166	72	1.0879	1.0740	1.0498
22	1.0374	1 0311	1.0176	73	1.0883	1.0742	1.0499
23	1.0390	1.0324	1.0187	74	1.0886	1.0744	1.0500
24	1.0405	1.0337	1.0197	75	1.0888	1.0746	1.0501
25	1.0420	1 0350	1.0207	76	1.0891	1.0747	1.0501
26	1.0435	1.0363	1.0217	77	1.0893	1.0748	1.0501
27	1.0450	1.0375	1.0227	78	1.0894	1.0748	1.0500
28	1.0465	1.0388	1.0236	79	1.0896	1.0748	1.0499
29	1.0479	1.0400	1.0246	80	1.0897	1.0748	1.0497
30	1.0493	1.0412	1.0255	81	1.0897	1.0747	1.0495
31	1,0507	1.0424	1.0264	82	1.0897	1.0746	1.0492
32	1.0520	1.0436	1.0274	83	1.0896	1.0744	1.0489
33	1.0534	1.0447	1.0283	84	1.0894	1.0742	1.0485
34	1.0547	1.0459	1.0291	85	1.0892	1.0739	1.0481
35	1.0560	1.0470	1.0300	86	1.0889	1.0736	1.0475
36	1.0573	1.0481	1.0308	87	1.0885	1.0731	1.0469
37	1.0585	1.0492	1.0316	88	1.0881	1.0726	1.0462
38	1.0598	1.0502	1.0324	89	1.0876	1.0720	1.0455
39	1.0610	1.0513	1.0332	90	1.0871	1.0713	1.0447
40	1.0622	1.0523	1.0340	91		1.0705	1.0438
41	1.0634	1.0533	1.0348	92		1.0696	1.0428
42	1.0646	1.0543	1.0355	93		1.0686	1.0416
43	1.0657	1.0552	1.0363	94		1.0674	1.0403
44	1.0668	1.0562	1.0370	95		1.0660	1.0388
45	1.0679	1.0571	1.0377	96		1.0644	1.0370
46	1.0690	1.0580	1.0384	97		1.0625	1.0350
47	1.0700	1.0589	1.0391	98		1 0604	1.0327
48	1.0710	1.0598	1.0397	99		1.0580	1.0301
49	1.0720	1.0607	1.0404	100		1.0553	1.0273
50	1.0730	1.0615	1.0410				

TABLE*

OF THE QUANTITY BY WEIGHT OF WATER CONTAINED IN 100 PARTS BY WEIGHT OF GLYCERIN AT DIFFERENT DENSITIES. (Temperature 17.5° C.)

SPECIFIC GRAVITY.	PER CENT OF WATER.	SPECIFIC GRAVITY.	PER CENT OF WATER.	SPECIFIC GRAVITY.	PER CENT OF WATER.	SPECIFIC GRAVITY.	PER CENT OF WATER.
1.267	0	1.224	13	1.185	26	1.147	39
1.264	1	1.221	14	1.182	27	1.145	40
1.260	2	1.218	15	1.179	28	1.142	41
1.257	3	1.215	16	1.176	29	1.139	42
1.254	4	1.212	17	1.173	30	1.136	43
1.250	5	1.209	18	1.170	31	1.134	44
1.247	6	1.206	19	1.167	32	1.131	45
1.244	7	1.203	20	1.164	33	1.128	46
1.240	8	1.200	21	1.161	34	1.126	47
1.237	9	1.197	22	1.159	35	1.123	48
1.234	10	1.194	23	1.156	36	1.120	49
1.231	11	1.191	24	1.153	37	1.118	50
1.228	12	1.188	25	1.150	38		

* Loc. cit. (Hoffmann), p. 224.

THE FOLLOWING ARE THE

SPECIFIC GRAVITIES OF OFFICIAL LIQUIDS.

(B. P. = British Pharmacy. U. S. P. = United States Pharmacy.)

ATTFIELD.

NAME.	SP. GR.
Acid, Acetic, B. P	1.044
" " U. S. P	1.047
" " diluted, B. P. and U. S. P	1.006
" " Glacial	1.065—1.066
" Carbolic	1.065
" Hydriodic, diluted	1.112
" Hydrochloric, B. P. and U. S. P	1.160
" " diluted, B. P	1.052
" " " U. S. P	1.038

NAME.	SP. GR.
Acid, Hydrocyanic, B. P. and U. S. P	.997
" Lactic, U. S. P	1.212
" Nitric, B. P. and U. S. P	1.420
" " diluted, B. P	1.101
" " " U. S. P	1.068
" Nitrohydrochloric	1.074
" Phosphoric, diluted, B. P	1.080
" " " U. S. P	1.056
" Sulphuric, B. P. and U. S. P	1.843
" " aromatic	.927
" " diluted, B. P	1.094
" " " U. S. P	1.082
" Sulphurous, solution of, B. P	1.040
" " " U. S. P	1.035
Alcohol, U. S. P	.835
" absolute	.795
" (rectified spirit, 84%)	.838
" (proof spirit, 49%)	.920
" dilutum, U. S. P	.941
" fortius, U. S. P	.817
" Amylic, B. P. and U. S. P	.818
Ammonia, aromatic spirit of, B. P	.870
" stronger water of, U. S. P	.900
" solution of, B. P	.959
" strong solution of, B. P	.891
Antimony, solution of Chloride of, B. P	1.470
Arsenic, Hydrochloric solutions of, B. P	1.009
Arsenical Solution (Liquor Arsenicalis), B. P	1.009
Benzol, B. P	.850
Bismuth and Ammonia, solution of Citrate of, B. P	1.122
Bromine	2.966
Chlorine, solution of, B. P	1.003
Chloroform, B. P. and U. S. P	1.490
" Spirit of, B. P	.871
Cinchonia, liquid extract Yellow, B. P. about	1.100
Creasote, B. P	1.071
" U. S. P	1.046
Ether, B. P	.735
" U. S. P	.750
" pure B. P	.720
" fortior, U. S. P	.728
Glycerine, B. P. and U. S. P	1.250
Iron, solution of Pernitrate of, B. P	1.107
" " " U. S. P	1.065

NAME.	SP. GR.
Iron, solution of Persulphate of, B. P	1.441
“ “ “ U. S. P	1.320
“ strong solution of Perchloride of, B. P	1.338
“ tincture of Perchloride of, B. P. and U. S. P	.992
Lead, solution of Sub-acetate of, B. P	1.260
“ “ “ U. S. P	1.267
Lime, Saccharated solution of, B. P	1.052
“ solution Chlorinated, B. P	1.035
Mercury (at 0° C. = 32° F.)	13.596
“ (at 15°.55 C. = 60° F.)	13.560
“ acid solution of Nitrate of	2.246
“ “ “ “ U. S. P	2.165
Nitre, Sweet Spirit of	.845
“ “ “ U. S. P	.837
Oil of Mustard, B. P	1.015
Potash, solution of, B. P	1.058
“ “ U. S. P	1.065
Soda, solution of, B. P	1.047
“ “ U. S. P	1.071
“ “ Chlorinated, B. P	1.103
“ “ “ U. S. P	1.045
Squill, Oxymel of, B. P	1.320
Syrup, B. P	1.330
“ U. S. P	1.317
“ of Buckthorn, B. P	1.320
“ of Ginger	
“ of Hemidesmus	1.335
“ of Iodide of Iron, B. P	1.385
“ of Lemon, B. P	1.340
“ of Mulberries, B. P	1.330
“ of Orange Flower, B. P	1.330
“ “ Peel, B. P	
“ of Phosphate of Iron, B. P	
“ of Poppies, B. P	1.320
“ of Red Poppy, B. P	1.330
“ of Red Roses, B. P	1.335
“ of Rhubarb, B. P	
“ of Senna, B. P	1.310
“ of Squill, B. P	
“ of Tolu, B. P	1.330
Treacle, B. P ... about	1.400

TABLE OF SPECIFIC GRAVITIES AND WEIGHTS.

(Trautwine.)

In this Table the Sp. Gr. of Gases and Air are compared with that of Water, instead of that of Air.

Names of Substances.	Average Sp. Gr.	Aver. Wt. of a cu. ft. in lbs.
Air, atmospheric; at 60° F., and under pressure of one atmosphere, 14.7 lbs. per sq. inch, weighs $\frac{1}{815}$ part as much as water at 60°	.00123	.0765
Alcohol pure	.793	49.43
" of commerce	.834	52.1
" proof spirit	.916	57.2
Ash, perfectly dry	.752	47.
1000 ft. board-measure weighs 1.748 tons.		
Ash, American white, dry average	.61	38.
1000 feet board-measure weighs, 1.414 tons.		
Aluminum	2.6	162.
Antimony, cast, 6.66 to 6.74 average	6.70	418.
" native	6.67	416.
Anthracite, 1.3 to 1.84; of Penn., 1.3 to 1.7, usually	1.5	93.5
A cubic yard of anthracite averages 1.75 cu. yards when broken to any market size, and loose.		
Anthracite, broken of any size, loose average	—	52 to 56
" " moderately shaken "	—	56 to 60
" heaped bushel, loose, 77 to 83 pounds		
A ton loose averages from 40 to 43 cu. ft.; at 54 lbs. per cu. ft., a cubic yard weighs .651 ton.		
Asphaltum, 1 to 1.8 average	1.4	87.3
Bismuth, cast; also native "	9.74	607.
Brass (copper and zinc), 7.8 to 8.4 "	8.1	504.
" rolled "	8.4	524.
Bronze (Cu 8 parts + Sn 1 part), gun metal, 8.4—8.6	8.5	529.
Brick, pressed	—	150.
" common hard	—	125.
" soft inferior	—	100.
Brick-work. (See Masonry.)		
Calcite, transparent, 2.52–2.73 average	2.62	164.
Carbonic anhydride gas is 1½ times as heavy as air	.00187	
Charcoals of pines and oaks average	—	15 to 30
Chalk, 2.2 to 2.8 "	2.5	156.
Clay, potter's dry, 1.8 to 2.1 "	1.9	119.
" dry in lump, loose "	—	63.
Coke, loose, of good coal "	—	23 to 32
" a heaped bushel, loose, 35 to 42 lbs.		
" a ton occupies 80 to 90 cubic feet.		
In coking, coal swells from 25 to 50 per cent.		
Equal weights of coke and coal evaporate about equal weight of water; and each about twice as much as equal weights of dry wood.		
Cherry, perfectly dry average	.672	42.
1000 feet board-measure weighs 1.562 tons.		

Names of Substances.	Average Sp. Gr.	Aver. Wt. of a cu. ft. in lbs.
Coal, bituminous, 1.2 to 1.5 average	1.35	84.
" " broken of any size, loose average	—	47 to 52
" " moderately shaken "	—	51 to 56
" " a heaped bushel, loose, 70 to 78 lbs.	—	
" " a ton occupies 43 to 48 cubic feet.	—	
A cubic yard, solid, averages about 1.75 yards when broken to any market size, and loose.		
Chestnut, perfectly dry average	.66	41.
1000 feet board-measure, weighs 1.525 tons.		
Cement, hydraulic, American, Rosendale; ground, loose average	—	60.
Copper, cast, 8.6 to 8.8 "	8.7	542.
" rolled, 8.7 to 8.9	8.8	548.
Cork	25.	15.6
Diamond, 3.44 to 3.55; usually 3.51 to 3.55	3.53	—
Earth, common loam, perfectly dry, loose	—	72 to 80
" slightly moist, loose	—	70 to 76
" common loam as a soft-flowing mud	—	104 to 112
" " " " " " " pressed in a box	—	110 to 120
Ether	716.	44.6
Elm, perfectly dry average	56.	35.
1000 feet board-measure weighs 1.302 tons.		
Ebony, dry average	1.22	76.1
Emerald, 2.67 to 2.73 "	2.7	—
Fat "	.93	58.
Flint "	2.6	162.
Feldspar, 2.4 to 2.6 "	2.5	156.
Garnet, 3.5 to 4.3; precious, 4.1 to 4.3 "	4.2	—
Glass, 2.5 to 3.45 "	2.98	186.
" common window "	2.52	157.
" Millville, N. J., thick-flooring "	2.53	158.
Granite, 2.62 to 2.76 "	2.69	168.
Gypsum (plaster of paris), 2.26 to 2.35 "	—	—
Gravel, about the same as sand. (See.)		
Gold, cast, pure 24 carat "	19.258	1204.
" native, pure, 19.3 to 19.4 "	19.32	1206.
" pure, hammered "	19.5	1217.
Gutta-percha "	.98	61.1
Hornblende, black, 3.1 to 3.4 "	3.25	203.
Hydrogen gas is 14½ times lighter than air; 16 times lighter than oxygen	—	.00527
Hemlock, perfectly dry average	.4	25.
1000 feet board-measure weighs .930 tons.		
Hickory, perfectly dry average	.85	53.
1000 feet board-measure weighs 1.971 tons.		
Iron, cast, 6.9 to 7.4 average	7.15	446.
" " usually assumed at "	7.21	450.
At 450 lbs., a cubic inch weighs .2604 lbs.; 8601.6 cubic inches a ton; and a lb. = 3.8400 cubic inches.		
Iron, wrought, 7.6 to 7.9; the purest has the greatest specific gravity average	7.77	485.

NAMES OF SUBSTANCES.	AVERAGE SP. GR.	AVER. WT. OF A CU. FT. IN LBS.
Iron, large rolled bars....................average	7.6	474
" " " " usually assumed at... "	7.69	480
" sheet.................................. "	—	485
At 480 lbs., a cubic inch weighs .2778 lbs.; and a lb.=3.6000 cu. in. Light iron indicates impurity.		
Ivory....................................average	1.82	114
Ice...................................... "	.94	58.7
India-rubber............................. "	.93	58
Lard..................................... "	.95	59.3
Lead, 11.35 to 11.47..................... "	11.41	711
Limestone and Marbles, 2.65 to 2.85........ "	2.75	172
Lime, Quick.............................. "	1.60	100
Lime, Quick, ground, loose, per struck bushel, 71 lbs....................................average	—	57
Mahogany, Spanish, dry*.................. "	.85	53
" Honduras, dry................. "	.56	35
Masonry of Granite or Limestone, well dressed throughout...........................average	—	165
Masonry of Granite, roughly scabbled, mortar rubble......................................average	—	138
Masonry of Granite, roughly scabbled, dry rubble......................................average	—	125
At 155 lbs. per cu. ft., a cu. yd. weighs 1.868 tons; and 14.45 cu. ft. = 1 ton.		
Masonry of Sandstone about $\frac{1}{8}$ part less than the foregoing.		
Masonry of Brickwork, pressed brick, fine joint, aver.	—	140
" " " medium quality..... "	—	125
" " " coarse inferior...... "	—	100
At 125 lbs. per cu. ft., a cu. yd. weighs 1.507 tons; and 17.92 cu. ft. = 1 ton.		
Mercury, at 32° Fah............................	13.62	849
" at 60° Fah............................	13.58	846
" at 212° Fah...........................	13.38	836
Mica, 2.75 to 3.1........................average	2.93	183
Mortar, hardened, 1.4 to 1.9............... "	1.65	103
Mud, dry, close................................	—	80 to 110
" wet, moderately pressed....................	—	110 to 130
" wet, fluid.................................	—	104 to 120
Naphtha..	.848	52.9
Nitrogen Gas is $\frac{1}{35}$ part lighter than air............	—	.0744
Oak, Live, perfectly dry, .88 to 1.02.........average	.95	59.3
" White, " " .78 to .88......... "	.83	51 8
" Red, Black, &c..................... "	—	32 to 45
Oils, Whale, Olive....................... "	.92	57.3
" of Turpentine........................ "	.87	54.3
Oxygen Gas, a little more than $\frac{1}{10}$ part heavier than air	.00136	.0846
Petroleum......................................	.878	54.8
Peat, dry, unpressed...........................	—	20 to 30
Pine, White, perfectly dry, .35 to 45.............	.40	25
1000 ft. board-measure weighs .930 ton.		
Pine, Yellow, Northern, .48 to .62................	.55	34.3
1000 ft. board-measure weighs 1.276 tons.		

---

* Green timbers usually weigh from $\frac{1}{5}$ to nearly $\frac{1}{2}$ more than dry.

NAMES OF SUBSTANCES.	AVERAGE SP. GR.	AVER. WT. OF A CU. FT. IN LBS.
Pine, Yellow, Southern, .64 to .80	.72	45
1000 ft. board-measure weighs 1.674 tons.		
Pitch	1.15	71.7
Plaster of Paris; see Gypsum.		
Platinum, 21 to 22	21.5	1342
" native, in grains, 16 to 19	17.5	—
Quartz, common, pure, 2.64 to 2.67	2.65	165
" " finely pulverized, loose	—	90
Ruby and Sapphire, 3.91 to 4.16	4.04	—
Salt, coarse, per struck bu., Syracuse, N. Y., 56 lbs.	—	45
" Liverpool, fine, for table use, 60 to 62 lbs.	—	49
Sand, of pure quartz, perfectly dried and loose, usually 112 to 133 lbs. per struck bushel	2.65	90 to 106
1 measure of solid quartz makes 1.75 measures of loose, rounded sand.		
Sand well shaken, 123 to 147 lbs. per struck bushel.	—	99 to 117
" " packed	—	101 to 119
At 130 lbs. per cu. ft., perfectly wet, 17.23 cu. ft. weigh 1 ton; and a cu. yd. = 1.567 tons.		
Extremely fine, even-grained sand, perfectly dry, may weigh as little as 70 to 80 lbs. per cu. ft.		
Sandstone, fit for building, dry, 2.1 to 2.73	2.41	150
Snow, fresh fallen	—	5 to 12
" moistened and compacted by rain	—	15 to 50
Sycamore, perfectly dry	.59	37
1000 ft. board-measure weighs 1.376 tons.		
Slate, 2.7 to 2.9 average	2.6	162
Silver "	10.5	655
Soapstone or Steatite, 2.65 to 2.8 "	2.73	170
Steel, 7.8 to 7.9 "	7.85	490
The heaviest contains least carbon.		
Sulphur "	2	125
Spruce, perfectly dry "	.4	25
1000 ft. board-measure weighs .930 ton.		
Spelter or Zinc, 6.8 to 7.2 "	7	437.5
Tallow "	.94	58.6
Tar "	1	62.4
Topaz "	3.55	—
Tin, cast, 7.2 to 7.5 "	7.35	459
Turf or Peat, dry, unpressed	—	20 to 30
Water, pure rain, or distilled, at 32° F., barom. 30 in.	—	62.375
" " " 60° F., " "	1	62.331
" " " 80° F., " "	—	62.190
" Sea, 1.026 to 1.030 average	1.028	64.08
Although the weight of fresh water is almost invariably assumed as 62½ lbs. per cu. ft., yet 62¼ would be nearer the truth, at ordinary temperatures of about 70°; or a lb. = 27.759 cu. in.; and a cu. in. = .5764 oz. Avoir., or .4323 oz. Troy, or 252.175 grains. The grain is the same in Troy, Avoirdupois, and Apothecaries' weights.		
Wax, Bees average	.97	60.5
Wines, .993 to 1.04 "	.998	62.3
Walnut, Black, perfectly dry "	.61	38
Zinc or Spelter, 6.8 to 7.2 "	7.00	437.5
Zircon, 4.5 to 4.75 "	4.63	—

Mineralogy.

MINERALOGY.*

It is my object under this division to consider only those minerals which have found more or less use in the arts.

Ores of the following elements will be considered:

1. Aluminium.
2. Antimony.
3. Arsenic.
4. Bismuth.
5. Cadmium.
6. Calcium.
7. Carbon.
8. Chromium.
9. Cobalt.
10. Copper.
11. Gold.
12. Iridium.
13. Iron.
14. Lead.
15. Lithium.
16. Magnesium.
17. Manganese.
18. Mercury.
19. Nickel.
20. Phosphorus.
21. Platinum.
22. Potassium.
23. Silicon.
24. Silver.
25. Sodium.
26. Strontium.
27. Sulphur.
28. Tin.
29. Zinc.
30. Zirconium.

---

* See Author's Preface.

I. ALUMINIUM.

The principal Aluminium minerals are:

MINERAL.	HARDNESS.	SP. GR.	FORMULA.	COMPOSITION.
Corundum......	9	3.909—4.16	$\dddot{\text{Al}}$	$\text{Al} = 53.4$
Diaspore........	6.5—7	3.3—3.5	$\dddot{\text{Al}}\ \dot{\text{H}}$	$\text{Al}_2\text{O}_3 = 85.1$
Aluminite......	1—2	1.66	$\dddot{\text{Al}}\ \dddot{\text{S}} + 9\text{H}$	$\text{Al}_2\text{O}_3 = 29.8$
Alunogen.......	1.5—2	1.6—1.8	$\dddot{\text{Al}}\ \dddot{\text{S}}_3\ 18\dot{\text{H}}$	$\text{Al}_2\text{O}_3 = 15.4$
Alunite.........	3.5—4	2.58—2.752	$\dot{\text{K}}\ \dddot{\text{S}} + 3\dddot{\text{Al}}\,\text{S} + 6\dot{\text{H}}$	$\text{Al}_2\text{O}_3 = 37.13$
Kalinite........	2—2.5	1.75	$\dot{\text{K}}\ \dddot{\text{S}} + \dddot{\text{Al}}\ \dddot{\text{S}}_3 + 24\dot{\text{H}}$	$\dddot{\text{Al}}\ \dddot{\text{S}} = 18.4$
Cryolite........	2.5	2.9—3	$3\text{Na F} + \text{Al}_2\text{F}_3$	$\text{Al} = 13$
Turquois.......	6	2.6—2.83	$\dddot{\text{Al}}_2\ \overset{\cdot\cdot\cdot\cdot\cdot}{\text{P}} + \dot{\text{H}}$	$\text{Al}_2\text{O}_3 = 46.9$
Wavellite.......	3.25—4	2.337	$.\,\dddot{\text{Al}}_3\ \overset{\cdot\cdot\cdot\cdot\cdot}{\text{P}}_2 + 12\dot{\text{H}}$	$\text{Al}_2\text{O}_3 = 37.3$
Chrysoberyl.....	8.5	3.5—3.84	$\dddot{\text{Be}}\ \dddot{\text{Al}}$	$\text{Al}_2\text{O}_3 = 80.2$

CORUNDUM.

Syn.—Corindon, Sapphire, Ruby, Oriental Amethyst, Smirgel, Emery. Color is red, blue, purple, yellow, brown, gray and white. Streak, colorless. Transparent, translucent to opaque. Lustre vitreous, sometimes pearly on the base, and occasionally showing a bright opalescent star of six rays in the direction of the axis. Crystallizes in a rhombohedron of 86°4′. Sp. Gr., 3.909–416.

The different varieties of corundum are much used in the arts. Large crystals of sapphire have been found at Newtown, N. J. Imperfect rubies have been found at Warwick, N. J., and bluish crystals in Delaware and Chester Co., Pennsylvania. In California, in Los Angeles Co., in the drift of San Fransisqueto Pass. In Canada, at Burgess, red and blue crystals have been found.

Red sapphire is the most highly esteemed. A crystal weighing four carats, perfect in transparency and color, has been valued at half the price of a diamond of the same size. Corundum, under certain conditions, absorbs water and changes to diaspore, and perhaps also to the mica-like mineral, margarite (Dana). Corundum may be found artificially by exposing to a high heat, 4 pts. of borax and 1 of alumina (Ebelmen); by decomposing potash alum by charcoal (Gaudin); by subjecting in a carbon vessel fluoride of aluminum to the action of boric acid, the process yielding large rhombohedral plates (Deville and Caron); by the addition to the last chromic fluoride, affording the red sapphire or ruby, or with less of the chromic fluoride, blue sapphire, or with much of this chromic fluoride, a fine green kind, by action of aluminic chloride on lime (Daubrée).

The following are elaborate analyses by J. Lawrence Smith, taken from elaborate papers in the Am. J. Sci., II, x, 354, xi, 53, xlii, 83. The column of hardness gives the effective abrasive power of the powdered mineral, that of sapphire being as 100:

	HARDNESS.	SP. GR.	$\dddot{Al}$.	MAGNETITE.	$\dot{Ca}$.	$\ddot{Si}$.	$\dot{H}$.
1. Sapphire, *India*........	100	4.06	97.51	1.89	—	0.80	— =100.20
2. Ruby, "	90	—	97.32	1.09	—	1.21	— = 99.62
3. Corundum, *Asia Minor*.	77	3.88	92.39	1.67	1.12	2.05	1.60 = 98.83
4. " *India*......	58	3.89	93.12	0.91	1.02	0.96	2.86 = 98.87
5. Emery, *Kulah*..... ..	57	4.28	63.50	$\dddot{Fe}$ { 33.25	0.92	1.61	1.90 =101.18
6. " *Chester*.........	33	—	44.01	50.21	—	3.13	2.00 = 99.35

CRYOLITE.

This mineral is only found in Greenland, and has a very extensive use in the arts (Formula, $3NaF.Al_2F_3$). Its composition is Al 13.0, $\dot{Na}$ 32.8, Fl 54.0. Sp. Gr. 2.9–3.

"It crystallizes as a doubly oblique rhombic prism 88° 30′, and has a perfect basal cleavage. Its lustre is vitreous or slightly pearly, and is nearly the same on the three cleavages on the crystal. Its fracture is lamellar or scaly. It is generally white, and has about the same kind of lustre as a stearine candle on the fracture. It is sometimes colored slightly red, or may be even brick red, when it is mixed with partially altered siderite. Occasionally it is black."

Heated in an open tube, it gives up HFl. Soluble in sulphuric acid, giving off HFl. It is easily fusible, even in the flame of a candle, without the aid of the blowpipe. If it is then thrown into water, there seems to be a commencement of decomposition, for an alkaline carbonate or lime-water throws down $\dddot{\text{Al}}$? Cryolite is shipped in large quantities to Europe and the United States (Pennsylvania), where it is used for making soda, and soda and alumina salts; also of late in Pennsylvania, for the manufacture of a white glass which is a very good imitation of porcelain.

2. ANTIMONY.

The principal Antimony minerals are:

MINERALS.	HARDNESS.	SP. GR.	FORMULA.	COMPOSITION.
Native Antimony	3.35	6.646—6.72	Sb (when pure).	Sb = 100
Senarmonite....	2—2.5	5.22—5.3	$\dddot{\text{Sb}}$	Sb = 83.56
Valentinite.....	2.5—3	5.566	$\dddot{\text{Sb}}$	Sb = 83.56
Stibnite.... ..	2	4.516—4.612	Sb_2S_3	Sb = 71.8
Kermesite......	1—1.5	4.5—4.6	$\dddot{\text{Sb}} + 2SbS_3$	Sb = 75.3

NATIVE ANTIMONY.

Crystallizes in rhombohedra of 87° 35′ (Rose). Lustre is metallic. Color and streak is tin-white. It is very brittle. It contains sometimes silver, iron or arsenic as impurities. Composition of a specimen from Andreasberg gave, according to Klaproth, antimony 98, silver 1, iron 0.25 = 99.25.

The mineral allemontite has the following composition ($SbAs_3$) = arsenic 65.22, antimony 34.78. Analysis by Rammelsberg of the Allemont ore: arsenic 62.15, antimony 37.85= 100 given 1Sb to 26As.

Antimony has been found native in the Harz, in Mexico; Huasco, Chili; South Ham, Canada; at Warren, N. J.

Allemontite occurs sparingly at Allemont, Przibram in Bohemia; Schladmig in Styria, and in the Harz.

STIBNITE.

Stibnite, or gray antimony, furnishes the antimony of commerce, and is therefore the principal ore. Sometimes the oxides senarmontite and valentinite are found in sufficient quantity to be mined. Stibnite is orthorhombic. Hardness = 2. Sp. Gr. = 4.516 (Haüy); 4.62 (Mohs). It is a lead-gray ore, usually fibrous or in prismatic crystals; it has a metallic lustre which is often bright. Streak is same as color, lead-gray.

Composition, Sb_2S_3 = sulphur 28.2, antimony 71.8 = 100 when pure. Eight analyses of stibnite from Arnsberg, Westphalia, gave Schneider a mean of Sb 71.48, S 28.52, excluding 0.33 per cent of quartz.

It fuses without the aid of a blowpipe. On charcoal it fuses, giving off sulphurous and antimonious fumes. On charcoal, in R. F., it gives antimony coat, and colors the flame greenish-blue.

Occurs with spathic iron in beds, but generally in veins. Often associated with blende, heavy spar and quartz. It is met in veins at Wolfsberg in the Harz; abundant near Padstow and Jiutagel; abundant also at Borneo. In the United States it is found in Maine, New Hampshire, and Maryland; abundant in the granitic range, south side of Tulare valley, near pass of San Amedio. Specimens found in Nevada are usually argentiferous (Humboldt mining region). It is also found in New Brunswick.

As stated above, this ore affords nearly all the antimony of commerce. "The crude antimony of the shops is obtained by simple fusion, which separates the accompanying rock. From this product most of the pharmaceutical preparations of antimony are made, and the pure metal extracted." "This ore was used by the ancients for coloring the hair, eyebrows, etc., to increase the apparent size of the eye." The ore changes on exposure by partial oxidation to *antimony blende* ($2Sb_2S_3+Sb_2O_3$), and by further oxidation to *valentinite* (Sb_2O_3). *Antimony ochre* ($Sb_2O_3+Sb_2O_5$), and also $Sb_2O_5+5\dot{H}$ are other results of alteration (Dana).

3. ARSENIC.

The principal Arsenic minerals are:

MINERAL.	HARDNESS.	SP. GR.	COMPOSITION.	PER CENT WHEN PURE.
Native Arsenic........	3.5	5.93	As	As = 100
Arsenolite.............	1.5	3.698	$\dddot{As}$	As = 75.76
Realgar...............	1.5—2	3.4—3.6	AsS	As = 70.1
Orpiment.............	1.5—2	3.48	As_2S_3	As = 61

NATIVE ARSENIC.

Native arsenic is one source of arsenic, but it is too rare to amount to much. It is found in veins in crystalline rocks, and in older schists, and is generally accompanied by other ores. It crystallizes as a rhombohedron of 85° 41′. Hardness = 3.5. Sp. Gr. 5.93. When pure, is composed only of arsenic; but it generally contains some antimony, and traces of iron, silver, gold or bismuth. The arsenical bismuth of Werner is arsenic containing 3 per cent. of bismuth (Hardness = 2. Gr. = 5.36–5.39). An antimonial arsenic, containing, according to Schultz, 7.97 per cent. of antimony, occurs at the Palmbaure mine, near Marienberg, Saxony. A similar compound, consisting, according to Genth, of arsenic 90.82 and antimony 9.18 ($=17As+1Sb$), occurs at Washoe Co., California.

Native arsenic gives metallic arsenic in a closed, and $\dddot{As}$ in an open tube. In the R. F. it volatilizes without residue and without melting, coloring the flame blue. It is not attacked by HCl, but is soluble in HNO_3. It is found in considerable quantity in the silver mines at Freiberg, Annaberg, Marienberg and Schneeberg. Abundant at Chauarcillo and elsewhere in Chili. In the United States, it has been observed by Jackson at Haverhill, N. H., in thin layers in dark-blue mica slate, stained by plumbago, and containing also white and magnetic pyrites; found also at Jackson, N. H., and on the east flank of Furlong Mountain, Greenwood, Me.

REALGAR.

Realgar has the following composition when pure: sulphur 29.9, arsenic 70.1 = 100 (AsS). A specimen from Spain gave S 30.00, As 70.25 (Hugo Miller, J. Ch. Soc., xi, 242). Hardness = 1.5–2. Sp. Gr. = 3.4–3.6. Lustre resinous. Color is bright-red and vitreous. Streak red when not decomposed, but generally orange-yellow.

In closed tube, it fuses and volatilizes without decomposition; in open tube gives sulphurous fumes and a white crystalline sublimate of arsenious acid. Soluble in caustic alkalies.

Realgar crystallizes as an inclined rhombic prism 74° 26′. It is always crystallized or crystalline. It is found in the Harz; at Tajowa in Hungary in beds of clay, and at Bumenthal, Switzerland, in dolomite.

ORPIMENT.

Formula As_2S_3 = sulphur 39, arsenic 61 = 100. Hardness = 1.5–2. Sp. Gr. = 3.48 (Hoidinger); 3.4 (Breithaupt). Its color is decided lemon-yellow; sometimes slightly orange-colored, owing to admixture of realgar. Streak is yellow—generally a little paler than color. Lustre pearly upon the faces of perfect cleavage; elsewhere resinous.

In a close tube it fuses and volatilizes, giving a dark-yellow sublimate; acts otherwise like realgar. Dissolves in nitrohydrochloric acid and caustic alkalies.

Orpiment crystallizes as a right rhombic prism 100° 40′. It is usually found in foliated and fibrous masses, and in this form is found at Kapnik in Transylvania, and at Felsobauza in Upper Hungary; in Fohnsdorf, Styria, found in brown coal. Small traces are met with in Edenville, Orange Co., N. Y., on arsenical iron.

The arsenic of commerce is mostly obtained from the arsenical ores of iron, cobalt and nickel, which see.

4. BISMUTH.

The principal Bismuth minerals are:

MINERAL.	HARDNESS.	SP. GR.	COMPOSITION.	PER CENT OF, WHEN PURE.
Native Bismuth...	2—2.5	9.727	Bi	Bi = 100
Bismuthinite.....	2	6.4—7.2	Bi_2S_3	Bi = 81.25
Alkinite..........	2—2.5	6.1—6.8	$3(CuPb)S+Bi_2S_3$	Bi = 36.2
Tetradymite......	1.5—2	7.2—7.9	Bi_2Te_3	Bi = 51.9

NATIVE BISMUTH.

Native bismuth is the source of bismuth in the arts. When pure contains only bismuth; it generally contains, though, traces of arsenic, sulphur and tellurium. A specimen analyzed by Genth (Am. J. Sci., II, xxvii, 247), gave Bi = 99.914, Te 0.042, Fe trace = 99.956. A specimen analyzed by Forbes (Phil. Mag., IV, xxix, 3), gave Bi 94.46, Te 5.09, As 0.38, S 0.07, Au trace = 100.00. Hardness = 2–2.5. Sp. Gr. = 9.727. Color silver-white, with a reddish tinge. Lustre metallic. Opaque. Streak same as color; subject to tarnish. Sectile. Brittle when cold, but when heated somewhat malleable. It melts in the flame of a candle. On Ch fuses and is entirely volatilized, leaving a yellow coating. It is not attacked by HCl. Fuses at 476° F. Dissolves in HNO_3; subsequent dilution causes a white precipitate. Crystallizes readily from fusion.

Bismuth is found native in veins in gneiss and other crystalline rocks and clay slate accompanying various ores. It is most abundant at the silver and cobalt mines of Saxony and Bohemia. Has been found at Lane's mine in Monroe, Conn.; also at Brewer's mines, Chesterfield District, South Carolina.

BISMUTHINITE.

Bisthmuthinite when pure has the following composition: Bismuth 81.25 + sulphur 18.75 = Bi_2S_3. When impure, it may contain in small quantities, Fe, Cu, Au, Pb, Te, Se. A specimen (Oravicza) analyzed by Hubert (Haid. Ber. iii, 401) gave Bi 74.55, S 19.46, Fe 0.40, Cu 3.13, Au, 0.53, Pb 2.26 = 100.33. Hardness = 2. Sp. Gr. 6.4–6.459; 7.2 : 7.16 Bolivia (Forbes). Color lead-gray or tin-white, with a yellowish or iridescent tarnish. Streak same as color. Lustre metallic. Opaque. Crystallizes as a right rhombic prism 91° 30′.

In an open tube gives sulphurous fumes and a bismuth sublimate, which before the blowpipe fuses into drops, brown while hot and opaque-yellow on cooling. Fus. = 1. Dissolves in nitric acid and gives a precipitate on diluting.

Sometimes found massive, with a foliated or reticulated structure. Generally found associated with other minerals. Accompanies molybdenite and apatite in quartz at Brandy Gill in Cumberland. Occurs with gold, pyrite chalcopyrite in Rowan Co., N. C. Found with chrysoberyl at Haddam, Ct. (according to Shepard).

5. CADMIUM.

The principal Cadmium mineral is

GREENOCKITE.

When pure, Greenockite has the following composition: Cd 77.7, S 22.3 = 100 (CdS or Cd_3S_3). A sample analyzed by Connel, gave cadmium 77.30 and sulphur 22.56 = 99.86. Hardness = 3–3.5. Sp. Gr. = 4.8 (Brooke); 4.9–4.999 (Breithaupt); 4.5, the artificial (Söchting).

"Lustre adamantine. Color honey-yellow, citron-yellow, orange-yellow, vein parallel with the axis, bronze-yellow. Streak-powder between orange-yellow and brick-red. Nearly transparent. Strongly double refraction." Not thermoelectric (Breithaupt).

In a closed tube assumes a carmine-red color while hot, fading to the original yellow on cooling.

In open tube gives sulphurous acid. Gives reddish-brown coating on charcoal in R. F. Soluble in hydrochloric acid with effervescence of hydrogen sulphide.

Found at Bishoptown, Scotland, in short hexagonal crystals, 136° 24′. Found at the Ueberoth zinc mine, near Friedensville, Lehigh Co., Pa.

Named after Lord Greenock (late Earl Cathcart).

6. CALCIUM.

The principal Calcium minerals are:

MINERAL.	HARDNESS.	SP. GR.	FORMULA.	COMPOSITION.
Anhydrite....	3—3.5	2.899—2.895	$\dot{Ca}\,\dddot{S}$	$\dot{Ca} = 41.2;\ \dddot{S} = 58.8$
Gypsum......	1.5—2	2.814—3.28	$\dot{Ca}\,\dddot{S} + 2\dot{H}$	$\dot{Ca} = 32.6;\ \dddot{S} = 46.5;\ \dot{H} = 20.9$
Fluorite......	4	3.01 —3.25	$Ca\ Fl$	$Ca = 51.3;\ Fl = 48.7$
Apatite	4.5—5	2.92 —3.25	$\dot{Ca}_3\overset{\cdot\cdot\cdot\cdot\cdot}{P}+\frac{1}{3}Ca\,(Cl, F)$	$Ca=48.43;\ \overset{\cdot\cdot\cdot\cdot\cdot}{P}=40.92\ (=89.35\ \overset{\cdot\cdot\cdot\cdot\cdot}{P},Ca),$ $Cl=6.81;\ Ca=3.84\ (=10.65\ Cl,Ca).$
Pharmacolite.	2—2.5	2.64 —2.73	$(\frac{2}{3}\dot{Ca}\ \frac{1}{3}\dot{H})_3\,\overset{\cdot\cdot\cdot\cdot\cdot}{As}$	$\dot{Ca} = 24.9;\ \overset{\cdot\cdot\cdot\cdot\cdot}{As} = 51.1;\ \dot{H} = 24$
Aragonite....	3.5—4	2.927—2.947	$\dot{Ca}\,\ddot{C}$	$\dot{Ca} = 56;\ \ddot{C} = 44$
Calcite	2.5—3.5	2.508—2.729	$\dot{Ca}\,\ddot{C}$	$\dot{Ca} = 56;\ \ddot{C} = 44$
Dolomite.....	3.5—4	2.8 —2.9	$\dot{Ca}\,\ddot{C} + \dot{Mg}\,\ddot{C}$	$\dot{Ca}\,\ddot{C} = 54.35;\ Mg\,\ddot{C} = 45.65$
Scheelite.....	4.5—5.8	5.9 —6.076	$\dot{Ca}\,\dddot{W}$	$\dot{Ca} = 19.4;\ \dddot{W} = 80.6$

GYPSUM.

Gypsum has the following composition when pure: Lime 32.6, sulphuric acid 46.5, water 20.9 = 100 ($\dot{Ca}\dddot{S}+2\dot{H}$).

The different varieties have the following composition:

	$\dddot{S}$.	$\dot{Ca}$.	$\dot{H}$.	$\ddot{Si}$.	$\dddot{Al}\dddot{Fe}$.
1. *Crystallized*........... ...	44.8	33.0	21.0	—	— = 98.8 Bucholz.
2. *Granular*..................	41.16	33.88	21.0	—	— = 99.04 Rose.
3. Albay, *fibrous*..............	44.19	29.41	20.18	6.43	0.64 = 100.85 Trobe.
4. Wienrode, *compact*.	45.76	31.87	19.90	2.80	0.60 = 100.93 Jüngst.
5. Osterode, "	45.95	32.62	20.70	0.42	0.50 = 100.19 "
6. " *white*............	46.61	32.44	20.74	0.15	— = 99.94 Hampe.
7. " *red*..............	46.50	31.99	21.56	—	0.45 = 100.80 "

Gypsum takes the form of a right rhombic prism of 138° 28′, and has three cleavages. Hardness = 1.5–2. Sp. Gr. = 2.314–2.328, when pure crystal. Massive varieties sometimes glistening, sometimes dull earthy. It has a vitreous lustre which, on some of the faces, may be adamantine.

Its colors are very variable, generally not very strong. The color is usually white, although it may be gray, flesh-red, honey-yellow, ochre-yellow, and blue; impure varieties are often black, brown, red, or reddish-brown. It often has $\ddot{Fe}$ interposed when it is red. Streak is white. It is often transparent or translucent.

Heat immediately expels the water from gypsum, and leaves it white. It then fuses at 2.5 to 3, coloring the flame reddish-yellow. On charcoal in R. F. it is reduced to sulphide. If not ignited above 260° C., it will unite with water if moistened, and becomes firmly solid. Soluble in muriatic acid and in 400 to 500 parts of water.

Gypsum often forms extensive beds in connection with stratified rocks, especially limestones and marlites or clay-beds. Fine specimens of gypsum are found at Bex in Switzerland; large cuticular crystals have been found at Montmartre near Paris. A noted locality of alabaster occurs at Castellina, 35 miles from Leghorn, whence it is taken to Florence for manufacture of vases, figures, etc. This species occurs in extensive beds in several of the United States, more particularly New York, Ohio, Illinois, Virginia, Tennessee, and Arkansas, and is usually associated with salt springs.

Also in Nova Scotia, Peru, etc. Handsome selenite and snowy gypsum occurs near Lockport, N. Y. Large-grouped crystals are found on the St. Mary's in clay in Maryland. Large beds of gypsum are found with rock salt in Washington Co., Virginia. Selenite and alabaster are found in Davidson Co., Tenn. It has the form of rosettes or flowers, vines, and shrubbery in Mammoth Cave, Ky. Abundant, also, west of the Mississippi in many places.

"*Plaster of Paris* (or gypsum that has been heated and ground up) is used for making moulds, taking casts of statues, medals, etc., for producing a hard finish on walls; also in the manufacture of artificial marble, as the scagliola tables of Leghorn, and in glazing of porcelain. The fibrous variety, when cut *en cabochon* and polished, resembles cat's-eye."

The Montmartre gypsum quarries, near Paris, have been famous for affording brown gypsum, which, on account of locality, is called Plaster of Paris.

CALCITE.

Calcite, when pure, is composed of carbonic acid 44, and lime 56 = 100 ($\dot{\mathrm{Ca}}\ddot{\mathrm{C}}$). A portion of the lime of calcite is frequently replaced by $\dot{\mathrm{Mg}}$, $\dot{\mathrm{Fe}}$, $\dot{\mathrm{Mn}}$, $\dot{\mathrm{Sr}}$, $\dot{\mathrm{Ba}}$, $\dot{\mathrm{Zn}}$, $\dot{\mathrm{Pb}}$. The color of calcite is usually white, but is sometimes yellowish, gray, red, green, blue, violet, yellow, brown, and black. $\dddot{\bar{\mathrm{Fe}}}$ produces different shades of red, from flesh-red or paler to opaque blood-red, and brownish-red according to the proportions present; the latter, Hausmann names Hœmatoconite, as in the marble *Rosseautico* of Italy. $\dddot{\bar{\mathrm{Fe}}}_2\dot{\mathrm{H}}_3$ causes yellowish to opaque ochre-yellow and yellowish-brown; the deeper sideroconite of Hausmann. Ferrous oxide, chromic oxide and ferric silicate cause shades of green.

When calcite is perfectly pure, it crystallizes in rhombohedra of 105° 5′. Hardness = 2.5–3.5; some earthy kinds (chalk, etc). Sp. Gr. = 2.508–2.778; pure crystals 2.7213–2.7234 (Beud); fibrous camellar and stalactite 2.70–2.72, but when pulverized, 2.729–2.7233. Streak is white or grayish. Lustre vitreous, sub-vitreous, earthy. Transparent, opaque. Double refraction strong.

When heated in a closed tube it sometimes decrepitates. It is infusible, but gives a very luminous flame, coloring it red (Ca). It is the same phenomena, on a small scale, that is produced with the Drummond Light. When heated on platinum foil with soda it fuses to a clear mass. The $\ddot{C}$ is expelled by heat and $\dot{Ca}$ remains; when this is moistened on the finger a sensation of heat is produced. It effervesces very readily with acids, even in the cold.

Andreasberg, in the Harz, is one of the best European localities of crystallized calcite. In Iceland, a single rhombohedron over six yards long and three high has been observed.

Crystals are found also in many parts of the United States, in New York in St. Lawrence and Jefferson counties, especially at Rossie lead-mine; one nearly transparent is in the cabinet of Yale College, weighing 165 pounds. In New Hampshire, Massachusetts, New Jersey; in Virginia, stalactites are found of great beauty; also in the large caves of Kentucky. At the Lake Superior copper-mines, splendid crystals are found, containing scales of native copper.

Corals, of which reefs are formed, consist mainly of carbonate of lime ($\dot{Ca}\ddot{C}$).

B. Silliman, Jr., obtained for a recent species of madrepora: carbonate of lime, 94.807; phosphates, fluorides, etc., 0.745; organic matter, 4.448. And the deposits of phosphates and fluorides afforded the percentage, $\ddot{Si}$ 12.5, $\dot{Ca}$ 7.5, $\dot{Mg}$ 4.2, $Mg\bar{F}$ 26.62, $Ca\bar{F}$ 26.34, $\dot{Mg}\overset{\cdot\cdot\cdot\cdot\cdot}{P}$ 8.00, $\ddot{\bar{Al}}$ and $\dddot{\bar{Fe}}$ 14.84.

Marble.—Under this name a number of varieties of calcite are included, which are sought after in the arts. In fact, when the granular limestones are compact, and are fit for polishing or for architectural or ornamental use, they are called marbles. The colors are various. *Statuary Marble* is pure white, fine-grained, and firm in texture. The *Parian* marble, from the island of Paros, and the *Carrara*, of Modena, Italy, are among the best statuary marbles.

What is sought after in marble is a uniform disposition of the coloring material; these colors may be uniform white, black, yellow, and red. Variegated marbles are also much sought after. Marbles colored in veins of black and white are called St. Anne.

The *Porter*, called sometimes Egyptian marble, is of black color, handsomely veined with yellow dolomite, and comes from Porto-venere, near Spezzia. Marbles are not necessarily exclusively composed of carbonate of lime; thus, the marble called *verd-antique* is filled with veins of serpentine and talc.

Shell Marbles include kinds consisting largely of fossil shells. *Madreporic* marble contains corals. *Encrinal* contains crinoidal remains.

Ruin Marble is a kind of compact calcareous marl, showing, when polished, pictures of fortifications, temples, etc., in ruins, due to oxide of iron.

Lithographic Stone is a very even-grained, compact limestone, usually of buff or drab color.

Breccia Marble is made of fragments of limestone cemented together. Colors are various.

Pudding-stone Marble consists of pebbles or rounded stones cemented.

Hydraulic limestone is an impure limestone. The French varieties contain 2 or 3 per cent. of magnesia and 10 to 20 of silica and alumina (clay). The varieties in the United States contain 20 to 40 per cent. of magnesia and 12 to 30 per cent. of silica and alumina. A variety worked extensively at Rondout, N. Y., contains, CO_2 34.20, lime 25.50, magnesia 12.35, silica 15.37, alumina 9.13, sesquioxide of iron 2.25. According to Prof. Beck (Min. N. Y., 78), oxide of iron is rather prejudicial to it than otherwise.

Carrara Marble has the following composition, according to Kæppel (J. Pr. Ch., lvii, 324): $\dot{\text{Ca}}\ddot{\text{C}}$ 98.765, $\dot{\text{Mg}}\ddot{\text{C}}$ 0.900, $\ddot{\text{Si}}$ 0.006, $\overset{\cdots}{\cancel{\text{Fe}}}$, $\overset{\cdots}{\cancel{\text{Mn}}}$, $\ddot{\cancel{\text{Al}}}$ 0.083, sand 0.1560, $\overset{\therefore\,\therefore}{\text{P}}$ and loss 0.090=100.

DOLOMITE.

When dolomite is pure, it has the following composition: $\dot{Ca}\ddot{C}$ 54.35, $\dot{Mg}\ddot{C}$ 45.65 ($\dot{Ca}\ddot{C}+\dot{Mg}\ddot{C}$). Crystallizes in rhombohedron, the angle of which, on account of its variation of composition, varies between 106° 10′ and 106° 20′. Hardness = 3.5–4. Specific gravity, 2.8–2.9, true dolomite. Lustre vitreous, inclining to pearly in some varieties. Colors are not very decided, although it may be white, reddish, or greenish-white; also rose-red, green, brown, gray, and black. A very rare variety, miemite, has a very decided green color (asparagus green), owing to the presence of iron. Part of the magnesia is replaced in some dolomites by protoxide of iron, manganese, and, more rarely, oxide of cobalt and zinc.

A sample of dolomite from Westchester County, N. Y., gave, according to Alsop (Ann. Lyc., N. Y., viii): $\dot{Ca}\ddot{C}$ 54.91, $\dot{Mg}\ddot{C}$ 43.63, $\dot{Fe}\ddot{C}$ 1.23, insol. 1.30 = 100 oz.

A sample of mierno, *miemite* (Rammelsberg, Min. Ch., 213), gave: $\dot{Ca}\ddot{C}$ 57.91, $\dot{Mg}\ddot{C}$ 38.97, $\dot{Fe}\ddot{C}$ 1.74, $\dot{Mn}\ddot{C}$, 0.57 = 99.19.

A sample of Jena, crystallized, uncolored, gave, according to Suckow: $\dot{Ca}\ddot{C}$ 55.2, $\dot{Mg}\ddot{C}$ 44.7 = 99.9.

T. S. Hunt says that dolomites make up the chief part of the Calciferous, Clinton, Trenton, Guelp, Niagara, and Onondaga limestones of Canada. Thus we see that the limestone strata of the globe is partly dolomitic.

Before the blowpipe it acts like calcite, but with nitrate of cobalt the presence of magnesia can be ascertained. Dolomite does not effervesce as easily as calcite, especially when pure. If in a powdered state and heated, the acid dissolves it. Terriferous dolomites become brown on exposure.

Dolomite is found at Salzburg, the Tyrol; Hungary, Freiberg, in Saxony. In the United States, in Vermont, at Roxbury; in Rhode Island, at Smithfield; New Jersey, at Hoboken; New York, at Lockport, Niagara Falls, and Rochester. Dolomite is sometimes used for making lime; some varieties are used as marble. It is also used in the manufacture of Epsom salts.

7. CARBON.

Carbon occurs in nature crystallized as the Diamond and as Graphite.

DIAMOND.

The diamond is nearly, chemically, pure carbon. It crystallizes in the Isometric system. Its forms are various. Its usual forms are, though, the octahedron and the hexoctahedron. Hardness = 10. Sp. Gr. = 3.52955 (Thompson); 3.55 (Pelouze). Color white or colorless; occasionally tinged yellow, red, orange, green, blue, brown, and sometimes black. Lustre brilliant adamantine. Transparent, translucent, and opaque. Fracture conchoidal. Index of refraction 2.439. Exhibits vitreous electricity when rubbed.

The crystals often contain numerous microscopic cavities, as detected by Brewster, and some are rendered nearly black by their number. The black planes of diamonds reflect all the light that strikes them at an angle exceeding 24° 13′, and hence comes the peculiar brilliancy of the gem. In black pebbles or masses called *carbonada*, occasionally 1000 carats in weight. Hardness = 10. Sp. Gr. = 3.012–3.416. Consist of pure carbon, excepting 0.27 to 2.07 per cent.

The diamond was burned in the academy at Florence for the first time in 1694, by a powerful burning-glass. The crystalline colorless varieties gave only 0.01 per cent. of ash. In the colored varieties the proportion is larger, the black diamond giving 2–3 per cent.

The Ancients knew nothing about cutting diamonds, and wore the natural stone. Louis Berquen of Bruges in Belgium, in 1456, discovered for the first time the method of cutting the diamond so as to increase its lustre. Diamonds not fit to cut are used for ends of tools for drilling or turning hard rocks, such as granite or porphyry. The small stones which have a very sharp edge are used for cutting glass. The clear stones of diamonds have long been used as jewels for watches. The black diamond has also been used for a long time for turning, and lately in this country for drilling the harder rocks.

A diamond of 5–6 carats is a very large stone; those of 12–20 are very rare, and very few are known that weigh more than 100 carats.

WEIGHT OF THE LARGEST DIAMONDS KNOWN.

NAME.	UNCUT.	CUT.	NAME.	UNCUT.	CUT.
Rajah	—	367 carats.	Piggott...........	—	82¼ carats.
Great Mogul.......	900 carats.	$279\frac{9}{16}$ "	Nassac...........	89¾ carats.	78⅝ "
Orloff..............	—	194¾ "	Dresden..........	—	76½ "
Koh-i-noor.........	793 "	186 "	Saucy............	—	53½ "
Portuguese.	—	148 "	Eugenie..........	—	51 "
Florentine.........	—	139½ "	Pasha............	—	49 "
Regent.	410 "	136¾ "	Dresden (green)..	—	48½ "
Star of the South...	254½ "	125½ "	Hope (blue)......	—	44½ "
Koh-i-noor (recut) .	—	$106\frac{1}{16}$ "	Polar Star........	–	40 "
Shah...............	—	95 "	Cumberland......	—	32 "
Sultan of Turkey...	—	84 "	Russian (red).....	—	10 "

As the diamond is very difficult to distinguish from some closely allied stones, it is better not to trust to the judgment alone, though some jewelers think they can detect the diamond with ease.

The following table, given by Prof. Egleston, affords a scientific means:

TABLE FOR DISTINGUISHING PRECIOUS STONES.

STONE.	DENSITY.	REFRACTION.	INDEX OF REFRACTION.	ELECTRICITY.
Diamond...........	3.52—3.55	Simple.	2.455	Positive, not durable.
Ruby, Sapphire, and Oriental Amethyst	3.9—4.3	Double, 1 axis.	1.765	Lasts several hours.
Chrysoberyl........	3.5—3.8	Double.	1.760	Lasts several hours.
White Topaz.......	3.4—3.6	Double, 2 axes.	1.635	More than 24 hours.
Chrysolite..........	3.3—3.5	Double.	1.660	Positive.
Emerald............	2.6—2.8	Double, 1 axis.	1.585	Positive.
Spinel..............	3.4—3.8	Simple.	1.755	Not tried.
Zircon..............	4.4—4.6	Double, 1 axis.	1.990	Positive, not durable.
Quartz..............	2.6—2.8	Double, 1 axis.	1.549	Positive, not durable.
Strass..............	Var. 3.5	Simple.	—	Not durable, variable.

Some diamonds have red, white and black spots, and if the diamond is heated to redness, protected from the air, these spots disappear. This would seem to speak for the formation of the diamond below red-heat. Jacquelin transformed the diamond into graphite by exposing it to an electrical current, which seems to prove that diamond and graphite are only allotropic conditions of carbon. The diamond has been formed probably, like coal, by a slow decomposition of substances containing carbon, whether vegetable or mineral, or even animal matters. Many attempts have been made to make the diamond artificially, but only very small crystals, if any, have been formed.

The finest diamonds have been obtained from the mines of India, which are no longer worked. There are diamond mines in the Urals and in Brazil. The Brazil mines were opened in 1727, and it is estimated that at least two tons of diamonds have been obtained from them. Diamonds are also largely found in Africa, in the province of Constantine. In the United States, a few crystals have been found in Rutherford Co., N. C., and Hall Co. (Am. J. Sci., II, ii, 253, and xv, 373); they have been found also in Portis mine, Franklin Co., N. C. (Genth); one handsome one, over one-third of an inch in diameter, was found in the village of Manchester, opposite Richmond, Va. Diamonds have also been found in California, Nevada and Colorado.

A diamond, when cut and polished, of the purest water (perfectly colorless, without any defects), weighing one carat, is valued at £12 in England; and the value of others is calculated by multiplying the square of the weight by 12, except for those exceeding 20 carats, the value of which increase at a much more rapid rate. The slightest tinge or color, or defect, affects greatly the commercial value.

GRAPHITE.

Graphite is also called Plumbago and Black Lead. Its composition is pure carbon, with often a little oxide of iron mechanically mixed.

The following analyses have been made of different graphites by C. Mène (C. R., lxiv, 1091, 1867):

LOCALITIES.	SP. GR.	CARBON.	VOL.	ASH.	COMPOSITION 100 PARTS ASH.				
					$\ddot{\text{Si}}$.	$\overset{\cdots}{\text{Al}}$.	$\dot{\text{Fe}}$.	$\dot{\text{Mg}}\,\dot{\text{Ca}}$.	Alk. and loss.
Ural, Mt. Alibert..	2.1759	94.03	0.72	5.25	64.2	24.7	10	0.8	0.3
Cumberland, Eng.	2.3455	91.55	1.10	7.35	52.5	28.3	12	6.0	1.2
Ceara, Brazil.....	2.3865	77.15	2.55	20.30	79.0	11.7	7.8	1.5	—

Regnault (Ann. Ch. Phys., II, i, 202) found:

LOCALITIES.	C.	H.	ASH.
Canada (I)................................	86.8	0.5	12.6 = 99.9
" (II)	76.35	0.70	23.40 = 100.45
" (III)................................	98.56	1.34	0.20 = 100.10

Hardness = 1–2. Specific gravity = 2.0891; of Ticonderoga, 2.229 (Kenngott); 2.14 (Wunsiedel, Fuchs). Color, black. Streak, black and shining. Lustre metallic, opaque. Sectile; soils the fingers. Infusible. Burns at a high temperature, without flame or smoke, leaving usually some oxide of iron. Not acted on by acids.

Graphite in some places is coal altered by heat. It is largely used in the arts for the manufacture of lead pencils and crucibles, also as a lubricator. It is found at Burrowdale, in Cumberland. Found in the United States in Massachusetts, Rhode Island, Connecticut, Vermont, New York, and elsewhere.

8. CHROMIUM.

The principal Chromium mineral is chromite ($\dot{\mathrm{Fe}}$, $\dot{\mathrm{Cr}}$, $\dot{\mathrm{Mg}}$) ($\dddot{\mathrm{Al}}$, $\dddot{\mathrm{Fe}}$, $\dddot{\mathrm{Cr}}$). This mineral, called also chromic iron, is the ore which furnishes the chromium in the arts. When pure, contains oxide of iron 32, and oxide of chromium 68 = 100 ($\dot{\mathrm{Fe}}\,\dddot{\mathrm{Cr}}$).

The following table* contains a number of analyses of chromic iron:

LOCALITIES.	$\dot{\mathrm{Fe}}$.	$\dot{\mathrm{Mg}}$.	$\dddot{\mathrm{Cr}}$.	$\dddot{\mathrm{Al}}$.	$\dot{\mathrm{Si}}$.
1. Chester County, Pa.	35.14	—	51.56	9.72	2.90 = 99.32
2. " " "	$\dddot{\mathrm{Fe}}$ 38.95	—	60.84	0.98	0.62, Ni 0.10
3. Baltimore (massive)......	18.97	9.96	44.91	13.85	0.83 = 98.35
4. " (crystallized)....	20.18	7.45	60.04	11.85	— = 99.45

Hardness = 5.5. Specific gravity, 4.321, crystals (Thomson); 4.498, a variety from Styria; 4.568, Texas, Pennsylvania. Lustre is semi-metallic. Fracture uneven. Color, brownish-black. Streak, brown. Opaque. Sometimes slightly magnetic. Chromic iron is one of the spinels of iron, a sort of magnetite, and cannot be distinguished from magnetite with certainty except by its chemical properties.

Chromic iron is not fusible before the blowpipe; in R. F. becomes slightly rounded on the edges, as also magnetic. With borax and salt of phosphorus when cool give chrome-green color; the green color is heightened by fusion on charcoal with metallic tin. It is not attacked by acids, but decomposed by fusion with bisulphate of potash and soda.

Occurs in serpentine, forming veins, or imbedded masses. It assists in giving the variegated color to verde-antique marble.

---

* Analysis No. 1, Seybert (Am. J. Sci., iv, 321); No. 2, Starr (Am. J. Sci., II, xiv); No. 3, Abich; No. 4, Abich (Pogg., xxiii, 335).

It is found in large quantities in veins or masses in serpentine, at Baltimore, Md. Found in crystals abundantly in Pennsylvania. Found massive in New Jersey, Vermont, Massachusetts, and California.

The ore obtained in England is procured mostly from Baltimore, Drontheim, and Shetland Isles; it amounts to 2000 tons annually.

9. COBALT.

The principal Cobalt minerals are:

NAME.	HARDNESS.	SP. GR.	FORMULA.	COMPOSITION.
Linnæite.....	5.5	4.8—5	$2CoS + CoS_2$	Co = 58; S = 42
Bieberite.....	—?—	1.924	$(\dot{Co}, \dot{Mg})\dddot{S} + 7\dot{H}$	$\dot{Co} = 25.5$; $\dddot{S} = 28.4$; $\dot{H} = 46.1$
Smaltite......	5.5—6	6.4—7.2	$(Co, Fe, Ni)As_2$	Co=9.4; As=72.1; Ni=9.5; Fe=9
Cobaltite.....	5.5	6—6.3	$Co(S, As)_2$	Co = 35.5; As = 45.2; S = 19.3
Erythrite.....	1.5—2.5	2.948	$\dot{Co}\overset{\cdot\cdot\cdot\cdot\cdot}{As} + 8\dot{H}$	$\dot{Co}=37.55$; $\overset{\cdot\cdot\cdot\cdot\cdot}{As}=38.43$; $\dot{H}=34.02$
Remingtonite.	—?—	—?—	—?—	—?—
Earthy Cobalt.	2—2.5	3.15—3.29	$(\dot{Co}, \dot{Ca})\ddot{Mn}_2 + 4\dot{H}$	Sometimes 32% Co

SMALTITE.

The composition of smaltite when pure is Co = 9.4; As = 72.1; Ni = 9.5; Fe = 9.0 $(Co, Fe, Ni)As_2$. The following are a few analyses:

LOCALITIES.	AS.	CO.	NI.	FE.	CU.	S.	BI.
1. Schneeberg	70.37	13.95	1.79	11.71	1.39	0.66	0.01 = 99.88
2. Chatham, Conn......	70.11	3.82	9.44	11.85	—	4.78	— = 100
3. Richelsdorf, Conn...	60.42	10.80	25.87	0.80	—	2.11	— = 100

Analysis No. 1 was made by Hoffmann (Pogg., xxv, 485); No. 2 by Genth; No. 3 by Rammelsberg.

Hardness = 5.5–6. Specific gravity, 4.4–7.2. Color generally a silver or tin white, sometimes iridescent or grayish from tarnish. Streak grayish-black. Lustre metallic. Brittle. Fracture granular and uneven.

On charcoal it gives off arsenic, and fuses to a globule. In a closed tube gives a sublimate of metallic arsenic; in an open tube a white sublimate of arsenious acid, and sometimes traces of sulphurous acid. With the fluxes it affords the reactions for Co, Fe, and Ni. It is not attacked by the non-oxidizing acids.

Occurs with silver and copper at Freiberg and particularly at Schneeberg, in Saxony. It has been found at Chatham, Conn.; also in crystals at Mine La Motte, Missouri. It is used for making smalt; hence its name.

COBALTITE.

Cobaltite has the following composition when pure: Cobalt = 35.5; arsenic = 45.2; sulphur = 19.3 [$CoS_2 + CoAs_2$ or $Co(S, As)_2$]. The cobalt, though, is sometimes replaced largely by iron, and sparingly by copper.

LOCALITIES.	S.	As.	Co.	Fe.
1. Skutterud	20.08	43.46	33.10	3.23 = 99.87
2. "	20.25	42.97	32.07	3.42, quartz 1.63 = 100.34
3. Siegen plumose.....	19.08	43.14	9.62	24.99, Sb 1.04, Cu 2.36, gangue 0.52=100.75

Analysis No. 1 was made by Stromeyer (Schw. J., xix, 336).
" No. 2 " " Ebinghaus (Ramm., 4th Suppl., 116).
" No. 3 " " Heidingsfeld (Ramm., 5th Suppl.)

Hardness = 5.5. Specific gravity = 6–6.3. Color silver white, often a little rosy and also grayish, if much iron is present. Streak grayish-black. Lustre metallic. Fracture uneven and lamellar. Brittle.

Not altered in a closed tube, but in an open tube gives sulphurous fumes, and a crystalline sublimate of arsenious acid. On charcoal, affords fumes of sulphur and arsenic, and fuses to a magnetic globule. With the fluxes gives the reactions for Ni, Co, Fe. It is soluble in warm nitric acid, separating arsenious acid and sulphur.

Found at Hokansbö and Tunaberg, in Sweden, in splendid large crystals. Also at Skutterud, in Norway. The most productive mines are those of Vena, in Sweden, where it occurs in mica slate; these mines were first opened in 1809. This species and smaltite afford the greater part of the smalt of commerce. Sometimes the black oxide of cobalt, a kind of bog ore and very impure, is sometimes sufficiently abundant to be valuable.

10. COPPER.

The principal Copper minerals are:

NAME.	HARDNESS.	SP. GR.	FORMULA.	COMPOSITION.
Native Copper	2.5	8.838	Cu	$Cu = 100$
Cuprite.......	3.5–4	5.85—6.15	$\dot{\mathrm{Ȼu}}$	$\dot{Cu} = 88.8$; $O = 11.2$
Chalcocite....	2.5—3	5.5—5.8	$\mathrm{Ȼu}\,S$	$Cu = 79.8$; $S = 20.2$
Bornite......	3	4.4—5.5	$(Cu\,Fe)\,S$	For $(\frac{4}{5}Cu + \frac{1}{5}Fe)\,S =$ $Cu = 70.18$; $Fe = 7.76$; $S = 22.11$
Chalcopyrite..	3,5—4	4.1—4.3	$\mathrm{Ȼu}\,S + Fe\,S + Fe\,S_2$	$Cu = 34.6$; $Fe = 30.5$; $S = 34.9$
Tennantite...	3.5—4	4.37—4.53	$4\,(\mathrm{Ȼu},Fe)\,S + As_2S_3$	$Cu = 47.7$; $Fe = 9.75$; $As = 12.46$; $S = 30.25$
Tetrahedrite..	3—4.5	4.5—5.11	$4\,(Cu,Fe,Zn,Hg,Ag)\,S$ $(Sb, As)_2S_3$	$Cu = 19.25$; $Fe = 2—7$; $Zn = 1—7$; $Ag = 0—31$; $As = 0—11$; $Sb = 11—28$; $S = 19—26$
Chalcanthite..	2.5	2.13	$\dot{Cu}\,\dddot{S} + 5\,\dot{H}$	$\dot{Cu} = 31.8$; $\dddot{S} = 32.1$; $\dot{H} = 36.1$
Brochantite...	3.5—4	3.78—3.87	$2\dot{Cu}_3\,\dddot{S} + \dot{Cu}\,\dot{H} + 4\dot{H}$	$\dot{Cu} = 69$: $\dddot{S} = 19.9$; $\dot{H} = 11.1$
Atacamite....	3—3.5	4—4.3	$Cu\,Cl\,\dot{H} + 3\dot{Cu}\,\dot{H}$	$\dot{Cu} = 53.6$; $CuCl = 30.2$; $\dot{H} = 16.2$
Libethenite...	4	3.6—3.8	$\dot{Cu}_4\,\overset{\cdot\cdot\cdot\cdot\cdot}{P} + \dot{H}$	$\dot{Cu} = 66.5$; $\overset{\cdot\cdot\cdot\cdot\cdot}{P} = 29.7$; $\dot{H} = 3.8$
Olevenite.....	3	4.1—4.4	$\dot{Cu}_4\,(\overset{\cdot\cdot\cdot\cdot\cdot}{As}, \overset{\cdot\cdot\cdot\cdot\cdot}{P}) + \dot{H}$	$\dot{Cu} = 57.4$; $\overset{\cdot\cdot\cdot\cdot\cdot}{As} = 35.7$; $\overset{\cdot\cdot\cdot\cdot\cdot}{P} = 3.7$; $\dot{H} = 3.2$
Liroconite....	2—2.5	2.882— 2.985	$\dot{Cu}\,(\overset{\cdot\cdot\cdot\cdot\cdot}{As}, \overset{\cdot\cdot\cdot\cdot\cdot}{P})$ $+ (\frac{1}{3}\dot{Cu}_3 + \frac{1}{3}\dddot{Al})$ $\dot{H}_3 + 9\dot{H}$	$\dot{Cu} = 36.38$; $\overset{\cdot\cdot\cdot\cdot\cdot}{As} = 23.05$. $\overset{\cdot\cdot\cdot\cdot\cdot}{P} = 3.73$; $\dddot{Al} = 10.85$; $\dot{H} = 25.01$
Malachite.....	3.5—4	3.7—4.01	$\dot{Cu}_2\,\ddot{C} + \dot{H}$	$\dot{Cu} = 71.9$; $\ddot{C} = 19.9$; $\dot{H} = 8.2$
Azurite.......	3.5—4.25	3.5—3.831	$2\dot{Cu}\,\ddot{C} + \dot{Cu}\,\dot{H}$	$\dot{Cu} = 69.2$; $\ddot{C} = 25.6$; $\dot{H} = 5.2$

NATIVE COPPER.

When perfectly pure, native copper consists of copper, 100 per cent., but it often contains some silver and bismuth. Hautefeuille states that a Lake Superior specimen gave copper 69.280, silver 5.543, mercury 0.0119, gangue 25.248; while F. A. Abel found in a specimen of same, which had a thick vein of native silver running through it, 0.002 per cent. of silver, with a trace of lead, and in another 0.56 silver (J. Ch. Soc., II, i, 89). Abel obtained for a Uralian, from the Kirghiz District, 0.034 silver, 0.11 bismuth, a trace of lead, and 1.28 of arsenic. Color, copper red. Streak, metallic, shining; ductile and malleable. Fracture is hackly. Lustre metallic.

Fuses easily; on cooling becomes covered with a coating of black oxide. Dissolves readily in acids.

Copper occurs native in beds and veins, and is most abundant in the vicinity of dikes and igneous rocks. Sometimes found in loose masses in the soil.

Found in fine crystals at Turinsk in the Urals. Brazil, Chili, Bolivia and Peru afford native copper. Found also in China and Japan. Found in Massachusetts, Connecticut and New Jersey. The largest deposits in the world are found, though, at Kewenaw Point, Lake Superior, where it occurs in veins that intersect the trap and sandstone. The largest mass of copper ever found was at the Minnesota mine; it was 45 feet in length, 22 feet at the greatest width, and the thickest part was eight feet. It contained over 90 per cent. of copper, and weighed about 420 tons. Found also in small quantities in California and Colorado, and in large drift masses in Russian America.

CUPRITE.

The composition of Cuprite, when pure, is copper 88.8; oxygen 11.2 ($\dot{\text{Ȼ}}\text{u}$). It sometimes affords traces of selenium. Von Bibra found the tile ore of Algodon Bay, Bolivia, to contain chlorine, and to be a mixture of atacamite, cuprite, hematite, and other earthy materials; he obtained from one, atacomite 31.32, cuprite 10.85, sesquioxide of iron 20.50, gangue 34.42, water, antimony and loss 2.87 (J. pr. Ch., xcvi, 203).

Color is dark blood-red, sometimes almost black. Streak dark cochineal-red. Subtransparent, subtranslucent. Fracture conchoidal, uneven. Brittle. Lustre adamantine or submetallic to earthy.

In oxidizing flame, it is infusible, and gives a black scoria. In the reducing flame, it gives a button of metallic copper, which is malleable and ductile. Soluble in HCl and HNO_3. Unaltered in the closed tube.

Abundant in Chili, Peru and Bolivia. Crystals in this region simply cubes (D. Forbes). When found in large quantities, this mineral is valuable as an ore of copper. Found at Sommerville, N. J., Cornwall, Pa., and Lake Superior.

CHALCOCITE.

Composition, when pure, copper 79.8, sulphur 20.2 (CuS). It generally contains iron, and sometimes silica and silver.

LOCALITIES.	S.	CU.	FE.	Ṡi.
1. Siegen	19.00	79.50	0.75	1.00 = 100.25
2. Montagone, Tuscany	21.90	71.31	6.49	— = 99.70
3. Bristol, Conn	20.26	79.42	0.33	Ag 0.11 = 100.12

Analysis No. 1 is by Ullmann (Syst. tab. Uebeis, 248).
" No. 2 (Ramm., 5th Suppl., 151, and Min. Ch., 997).
" No. 3 (Private contribution to Dana's Mineralogy).

Hardness = 2.5–3. Sp. Gr. = 5.5–5.8; 5.7522 (Thompson). It crystallizes as a right rhombic prism 119° 35′. Color and streak dark-blue, almost black. Lustre metallic. Streak sometimes shining. Ductile, easily cut with knife into curved shavings.

Yields nothing volatile in closed tube. Melts in flame of candle, giving off sulphurous fumes. Melts to globule of copper on charcoal. Soluble in hot nitric acid.

Splendid crystals are found at Cornwall. Found massive in Siberia, Tuscany, Mexico, Peru, Bolivia and Chili. Found massive at Bristol, Conn.; also in New York, New Jersey, Virginia, and other States.

BORNITE.

The formula for Bornite is (Cu,Fe)S, with the proportion of copper and iron varying. The following are some analyses:

LOCALITIES.	S.	CU.	FE.
1. St. Pancrace................	22.8	59.2	13.0, gangue 5.0 = 100
2. Delarne (massive)	25.80	56.10	17.86, $\ddot{\mathrm{Si}}$ = 0.13 = 99.89
3. Jeurteland, Sweden.........	24.49	59.71	11.12, Mn trace, $\ddot{\mathrm{Si}}$ = 3.83 = 99.15
4. Ramos, Mexico.......... ...	23.46	62.17	11.79, Ag = 2.58 = 100

Analysis No. 1 by Berthier (Ann. de M., III, vii, 540, 556).
" No. 2 by Plattner (Pogg., xlvii, 351).
" No. 3 by D. Forbes (Ed. N. Phil. J., I, 278).
" No. 4 by C. Bergemann (Jahrb. Min., 1857, 354).

Hardness = 3. Specific gravity = 4.4–5.5. Specific gravity of Analysis No. 3, 4.432. Color is reddish-brown, or a black violet-blue, with a great variation in colors, owing to tarnish. Streak pale grayish-black, or blackish bronze-yellow, slightly shining. Lustre metallic. Fracture small conchoidal, uneven. Brittle.

Gives in a closed tube a faint sublimate of sulphur. In the oxidizing flame it is roasted with sulphurous odor; in the reducing flame a half-melted globule, which is attracted by the magnet. Soluble in nitric acid with separation of sulphur.

It is generally found compact, and owing to its variation of colors, easily detected. It is a valuable ore of copper. Crystalline varieties are found at Cornwall, and mostly near Redruth. It is the principal copper ore at some Chilian mines, especially those of Tamayo and Sapos; also common in Peru, Bolivia and Mexico. At the copper mines of Bristol, Conn., it is abundant, and often in fine crystals. It occurs also in Massachusetts, New Jersey, Pennsylvania, and elsewhere.

CHALCOPYRITE.

The composition of Chalcopyrite, when pure, is copper 34.6, sulphur 34.9, iron 30.5 $(CuS+FeS+FeS_2) = 2(\frac{1}{2}Cu+\frac{1}{2}Fe)S+FeS_2$. Some analyses give other proportions; but probably from mixture of pyrite.

Localities.	S.	Cu.	Fe.	Quartz.
1. Sayn	35.87	34.40	30.47	0.27 = 100.01
2. Jemtel'd, Sweden	33.88	32.65	37.77	Mn trace, S̈i 0.32 = 99.62
3. Phenixville	36.10	32.85	29.93	Pb 0.35 = 99.23

Analysis No. 1 by H. Rose (Gibb, lxxii, 185).
" No. 2 by D. Forbes (Ed. N. Phil. J., I, 278).
" No. 3 by J. L. Smith (Am. J. Sci., II, xx, 249).

Hardness = 3.5–4. Specific gravity = 4.1–4.3. Color is brass-yellow, with metallic lustre. It is subject to tarnish, and is often iridescent. Streak is greenish-black, a little shining. Opaque. Fracture conchoidal, uneven.

Decrepitates in a closed tube, and gives a sulphur sublimate. On charcoal, before the blowpipe it melts, gives off sulphurous acid, and yields a metallic globule. Dissolves in nitric acid, with separation of sulphur.

Chalcopyrite is a very valuable ore of copper. At the Cornwall mines, it is the principal ore of copper, and 10,000 to 12,000 tons of pure copper are smelted annually from 150,000 to 160,000 tons of ore. There are large beds of this ore at Fahlun, in Sweden; it occurs also at Rammelsburg, in the Harz. Found in fine crystals at Cerro Blanco, in Chili. It is found in Maine, New Hampshire, Vermont, Massachusetts, Connecticut, New York, Pennsylvania, Virginia, North Carolina, Tennessee, and California. The ore is extensively mined at Bruce mine on Lake Huron.

TETRAHEDRITE.

The composition of Tetrahedrite is copper 19–25, iron 2–7, zinc, 1–7, silver 0–31, arsenic 0–11, antimony 11–28, sulphur 19–26 $[4(\text{Ꞓu}, \mathrm{Fe}, \mathrm{Zn}, \mathrm{Hg}, \mathrm{Ag})\mathrm{S}(\mathrm{SbAs})_2\mathrm{S}_3]$.

LOCALITIES.	S.	SB.	AS.	CU.	FE.	ZN.	AG.
1. Rammelsberg (massive)	25.82	23.78	—	37.95	2.24	2.52	0.67 = 97.98
2. Arkansas..............	26.71	26.50	1.02	36.40	1.89	4.20	2.30 = 99.02
3. Freiberg........... ...	21.17	24.63	—	14.81	5.98	0.99	31.29 = 98.87
4. Poratsch, Hungary.....	23.00	31.56	—	39.04	7.38	—	0.12, Hg 0.52 = 100.62
5. " "	24.37	25.48	trace	30.58	1.46	—	0.09, Hg 16.69 = 98.67
6. Kotterbach............	22.53	19.34	2.94	35.84	0.87	0.69	— Hg 17.27, Pb 0.21, Bi 0.81 = 100
7. Moschellandsberg......	21.90	23.45	0.31	32.19	1.41	0.10	0.10, Hg 17.32, Co 0.23, Bi 1.57, gangue 1.39 = 99.87

Analysis No. 1 by (B. H. Ztg., 1853, No. 2); Analysis No. 2 by J. L. Smith (Ann. J. Sci., II, xliii, 67); Analysis No. 3 by H. Rose (Pogg., xv, 576); Analyses No. 4 and No. 5 are by Hauer (Jahrb. g. Reichs, 1852, 98; J. pr. Ch., lx, 55); Analysis No. 6 by G. v. Rath (Pogg., xcvi, 322); Analysis No. 7 by Oellacher (Jahrb. Min., 1865, 594).

Hardness = 3–4.5. Specific gravity = 4.5–5.11. Color is a blackish-gray, which is more or less dark. Streak generally same as color; sometimes inclined to brown and cherry-red. Opaque. Lustre metallic. Rather brittle.

In the oxidizing flame, on charcoal, it is roasted, giving a slight odor of arsenic and fumes of antimony, and in the reducing flame, gives a brittle globule of copper. Decomposed by nitric acid, with separation of antimonious and arsenious acids.

It is found in masses with or without gangue. The Cornish mines, near St. Aust., have afforded large tetrahedral crystals with rough and dull surfaces. More brilliant crystals occur in Cornwall. The ore containing mercury occurs in Schmöllnitz, Hungary. Tetrahedrite is found in Mexico, Chili, Arkansas, California, and Arizona.

MALACHITE.

Composition of Malachite, when pure, is protoxide of copper 71.9; carbonic acid 19.9; water 8.2 $(\dot{\mathrm{C}}\mathrm{u}_2\ddot{\mathrm{C}}+\dot{\mathrm{H}} = \dot{\mathrm{C}}\mathrm{u}\ddot{\mathrm{C}}+\dot{\mathrm{C}}\mathrm{uH})$.

LOCALITIES.	$\ddot{C}$.	$\dot{C}u$.	$\dot{H}$.
1. Turjiusk, Ural	18.0	70.5	11.5 = 100
2. Chessy.........................	21.25	70.10	8.75 = 100.10
3. Phenixville	19.09	71.46	9.02, $\dddot{Fe}$ 0.12 = 99.69

Analysis No. 1 by Kaproth (Beitr., ii, 287, 1797).
" No. 2 by Vauquelin (Ann. du Mus., xx, 1).
" No. 3 by J. L. Smith (Am. J. Sci., II, xx, 249).

Hardness = 3.5–4. Specific gravity = 3.7–4.01. Color is green, and may be of different degrees of intensity. Streak paler than color. Translucent, opaque. Lustre of crystals. Adamantine, inclining to vitreous; of fibrous varieties more or less silky; often dull and earthy. Fracture subconchoidal, uneven. It crystallizes an inclined rhombic prism of 104° 28′.

In a closed tube blackens and gives off water. It melts at 2, coloring the flame green, and gives a scoriaceous mass. On charcoal with the reducing flame gives a globule of metallic copper. Soluble in acids with effervescence.

Green malachite accompanies other ores of copper. It is usually found in concretionary masses, which have a fibrous fracture, rarely conchoidal. Their lustre is silky and velvety.

Occurs abundantly in the Urals; at Chessy, in France; in the old mine at Sandlodge, in Shetland; in the Tyrol; in Cornwall and Cumberland, England; also in handsome masses at Bembe, on west coast of Africa; also in Cuba, Chili, and Australia. It is found in the United States at Cheshire, Conn. In New Jersey, Pennsylvania, Maryland, Wisconsin and California. Malachite is a valuable ore of copper, when found in large quantities. It admits of a high polish, and when in large masses is cut into tables, vases, etc. It is often employed for veneering large articles, such as tables, doors, etc. A mass weighing forty tons was found in Siberia.

AZURITE.

Composition of Azurite, when pure, is oxide of copper 69.2, carbonic acid 25.6, water 5.2 $(2\dot{C}u\ddot{C}+\dot{C}u\dot{H})$. Hardness =

3.5–4.25. Specific gravity = 3.5–3.83. Color is azure-blue, which is more or less dark. Streak is lighter than color. Lustre vitreous, almost adamantine. Transparent, subtranslucent. Fracture conchoidal. Brittle. It crystallizes as an inclined rhombic prism of 99° 32′.

In closed tube blackens and gives off water. In the reducing flame, on charcoal, a globule of metallic copper is produced. Soluble in acids when heated, with effervescence.

It is sometimes found in concretionary masses in mamelons, which are sometimes so close together as to become joined. Found in splendid crystallizations at Chessy, near Lyons, whence it derived the name Chessy copper. It is found in Siberia; in Cornwall, Devonshire, and Derbyshire in England. Found in Pennsylvania, New York, New Jersey, Wisconsin, and California.

When found in large quantities, it becomes a valuable ore of copper. When ground to an impalpable powder, it forms a bright paint with a blue tint; but it is not used much as a pigment, as it is liable to turn green.

II. GOLD.

The principal Gold minerals are:

NAME.	HARDNESS.	SP. GR.	FORMULA.	COMPOSITION.
Native Gold..........	2.5—3	15.6—19.5	Pure, Au.	Pure, 100.
Gold Amalgam.......	—	—	$(Au, Ag)_2Hg_3$	Gold 38.39; Mercury 57.40; Silver, 5.0.
Sylvanite.............	1.5—2	5.732; 8.28 (Petz).	$(Ag, Au)\ Te_3$	Au 28.5; Te 55.8; Ag 15.7 when (Ag : Au = 1 : 1).
Nagyagite............	1—1.5	6.85—7.2	(Te, S, Pb, Au, Ag, Cu)	Te 32.2; S 3.0; Pb 54.0; Au 9.0; Ag 0.5; Cu 1.3.
Petzite...............	2.5	8.72—8.83 (Petz)	AuTe + 4½AgTe (Petz).	Te 34.98; Ag 46.76; Au 18.26; Fe, Pb, S, *Tr*.
		9—9.4 (Kilstel)	AuTe + 3AgTe (Genth).	Te 32.23; Ag 42.14; Au 25.63.
Calaverite............	—	—	$AuTe_4$	Te 55.53; Au 44.47.
Palladium (Porpezite).	—	—	Au Pd (Ag)	Au 85.98; Pd 9.85; Ag 4.17.
Rhodium Gold........	—	15.5—16.8	Au Rd (Ag)	Au 38.89; Ag 5; Rd 34-43%

NATIVE GOLD.

The composition of native gold, when pure, is gold, but it sometimes contains traces of copper, iron, palladium, and rhodium.

Localities.	Sp. Gr.	Au.	Ag.	Fe.	Cu.
1. Wicklow County, Ireland..	16.324	92.33	6.17	0.78	— = 99.27
2. Boruschka (N. Tagilsk)....	18.66	94.41	5.23	0.04	0.39 = 100
3. Bolivia, Tipuani...........	16.07	91.96	7.47	Trace.	— gangue 0.57 = 100
4. New Grenada, Santa Rosa.	14.15	64.93	35.07	—	— = 100
5. Australia..................	—	95.48	3.59	—	— quartz 0.10 = 99.17
6. "	—	99.28	0.44	0.20	0.07, Bi 0.01 = 100
7. Tasmania, Fingal	—	90.89	8.02	—	*Tr.*, Sn, Pb, Co 1.0=99.91

Hardness ∓ 2.5–3. Specific gravity = 15.6–19.5; 19.30–19.34 when quite pure (G. Rose). Color and streak different shades of gold-yellow, sometimes inclining to silver-white. Lustre metallic. Very ductile and malleable. Fuses easily, but gives no reaction with fluxes. Not soluble in any acid except aqua-regia.

Gold is widely distributed over the globe, and occurs in rocks of various ages, from the Eozoic to the cretaceous or tertiary. In Europe it is most abundant in Hungary at Konigsberg, Schemnitz and Felsobanya, and in Transylvania. Occurs in the sands of the Rhine, the Reuss, the Aar, the Rhone, and the Danube. On the Alps, in Spain, in many streams of Cornwall, in Scotland, Ireland and Sweden.

The large fragments found in sand are called nuggets, which are of considerable size.

The following table gives the weight of the principal ones:

Name.	Weight.	Name.	Weight.
Welcome Nugget............	184 lbs. 8 oz.	Miask, Urals................	27 lbs.
Ballarat, Australia (value,		" "	16 "
$41,823).		Paraguay....	50 "
Blanch Barkley Nugget.......	146 lbs.	Cabarrus County, N. C.......	87 "
Miask, Urals................	96 "	California..................	27 "
" "	27 "	"	17 "

The whole amount of gold in the auriferous sands of the Rhine has been estimated at $30,000,000, but it is mostly covered by soil under cultivation. In the Urals, they are principally alluvial washings, and these washings seldom yield less than 65 grains of gold for 4000 pounds of soil, and rarely more than 120. The mines in the Ural became, after 1819, the most productive in the world, until the discovery of the California mines.

Gold is found in China, Japan, Africa, and South America. It is found in the Rocky Mountains, Mexico, Sierra Nevada, and California. In the Eastern States, it is found principally in Virginia, North and South Carolina, and Georgia.

12. IRIDIUM.

The principal ore of Iridium is Iridosmine.

IRIDOSMINE.

Composition of Iridosmine is iridium and osmium in different proportions. Some rhodium, platinum, rutherium and other metals are usually present.

LOCALITIES.	IR.	RD.	PT.	RU.	OS.	CU.	FE.
1. New Grenada..........	70.40	12.30	0.10	—	17.20	—	— = 100
2. Russia (Sp. Gr. 18.9)...	43.28	5.78	0.63	8.49	40.11	0.78	0.99 = 100

Hardness = 6–7. Specific gravity = 19.3–21.12.

Color tin-white or steel-gray. Lustre metallic. Opaque. Malleable with difficulty.

At a very high temperature gives off fumes of osmium. With nitre gives the reaction for osmium.

It is found with platinum in the province of Choco, in South America; in the Ural Mountains; in Australia. It is rather abundant in the auriferous beach-sands of Northern

California. Also traces in the gold washings on the Rivières du Loup and des Plantes, Canada.

Iridium is used for the points of gold pens.

13. IRON.

The principal Iron minerals are:

NAME.	HARDNESS.	SP. GR.	FORMULA.	COMPOSITION.
Native Iron.....	4.5	7.3—7.8	(When pure) Fe.	Fe 100.
Meteorites......			Fe + Co + Ni	Ni from 1—20 per cent.
Magnetite	5.5—6.5	4.9—5.2	$\dot{\mathrm{Fe}}, \dddot{\mathrm{Fe}}$	Fe 72.4; O 27.6.
Franklinite.......	5.5—6.5	5.069	$(\dot{\mathrm{Fe}}, \dot{\mathrm{Mn}}, \dot{\mathrm{Zn}})(\dddot{\mathrm{Fe}}, \dddot{\mathrm{Mn}})$	$\dddot{\mathrm{Fe}}$ 66; $\dddot{\mathrm{Mn}}$ 16; $\dot{\mathrm{Zn}}$ 17.
Hematite.........	5.5—6.5	4.5—5.3	$\dddot{\mathrm{Fe}}$	Fe 70; O 30.
Golthite..........	5—5.5	4—4.4	$\dddot{\mathrm{Fe}}\dot{\mathrm{H}}$	$\dddot{\mathrm{Fe}}$ 8.99; $\dot{\mathrm{H}}$ 10.1.
Limonite.........	5—5.5	3.6—4	$\dddot{\mathrm{Fe}}_2\dot{\mathrm{H}}_3$	Fe_2O_3 86.6; $\dot{\mathrm{H}}$ 14.4.
Pyrrhotite........	3.5—4.5	4.4—4.68	Fe_7S_8	Fe 60.5; S 39.5.
Pyrite	6—6.5	4.83—5.2	FeS_2	Fe 46.7; S 53.3.
Marcasite.........	6—6.5	4.678—4.847	FeS_2	Fe 46.7; S 53.3.
Melanterite.......	2	1.832	$\dot{\mathrm{Fe}}\dddot{\mathrm{S}} + 7\dot{\mathrm{H}}$	Fe 25.9; S 28.8; H 45.3.
Copiapite.........	1.5	2.14	$\dddot{\mathrm{Fe}}_2\dddot{\mathrm{S}}_5 + 18\dot{\mathrm{H}}$	Fe_2O_3 34.2; $\dddot{\mathrm{S}}$ 42.7; $\dot{\mathrm{H}}$ 23.1.
Vivianite.........	1.5—2	2.58—2.68	$\dot{\mathrm{Fe}}_3\overset{\cdot\cdot\cdot}{\overset{\cdot\cdot}{\mathrm{P}}} + 8\dot{\mathrm{H}}$	FeO 43: $\overset{\cdot\cdot\cdot}{\overset{\cdot\cdot}{\mathrm{P}}}$ 28.3; $\dot{\mathrm{H}}$ 28.7.
Leucopyrite	5—5.5	6.8—8.71	$FeAs_2$	Fe 27.2; As 72.8.
Arsenopyrite.....	5.5—6	6—6.4	$Fe(As, S)_2$	Fe 34.4; As 46; S 19.6.
Scorodite	3.5—4	3.1—3.3	$\dddot{\mathrm{Fe}}\,\overset{\cdot\cdot\cdot}{\overset{\cdot\cdot}{\mathrm{As}}} + 4\,H$	Fe_2O_3 34.7; $\overset{\cdot\cdot\cdot}{\overset{\cdot\cdot}{\mathrm{As}}}$ 49.8; H 15.5.
Pharmacosiderite.	—	—	$3\dddot{\mathrm{Fe}}\,\overset{\cdot\cdot\cdot}{\overset{\cdot\cdot}{\mathrm{As}}} + \dddot{\mathrm{Fe}}\,H_3 + 12\dot{\mathrm{H}}$	——
Arseniosiderite...	1—2	3.52—3.88	$\dot{\mathrm{Ca}}_3\overset{\cdot\cdot\cdot}{\overset{\cdot\cdot}{\mathrm{As}}} + 4\dddot{\mathrm{Fe}}_2\overset{\cdot\cdot\cdot}{\overset{\cdot\cdot}{\mathrm{As}}} + 15\dot{\mathrm{H}}$	Fe_2O_3 42.1; $\overset{\cdot\cdot\cdot}{\overset{\cdot\cdot}{\mathrm{As}}}$ 37,9; $\dot{\mathrm{Ca}}$ 11.1; H 8.9.
Siderite...........	3.5—4.5	3.7—3.9	$\dot{\mathrm{Fe}}\ddot{\mathrm{C}}$	FeO 62.1; $\ddot{\mathrm{C}}$ 37.9.
Menaccanite......	5.6	4.5—5	$(Ti, Fe, Mn, Mg)_2O_3$	$\overset{\cdot\cdot}{\ddot{\mathrm{Fe}}}$ 1.2-82.47; $\dot{\mathrm{Fe}}$ 1.5-50.17.
Chromite.........	5.5	4.321—4.498	$(\dot{\mathrm{Fe}}, \dot{\mathrm{Cr}}, \dot{\mathrm{Mg}})(\dddot{\mathrm{Al}}, \dddot{\mathrm{Fe}}, \dddot{\mathrm{Cr}})$	For $\dot{\mathrm{Fe}}\dddot{\mathrm{Cr}}$, Fe 32; $\dddot{\mathrm{Cr}}$ 68.
Columbite........	6	5.4—6.5	$(\dot{\mathrm{Fe}}, \dot{\mathrm{Mn}})(\overset{\cdot\cdot\cdot}{\overset{\cdot\cdot}{\mathrm{Ca}}}, \overset{\cdot\cdot\cdot}{\overset{\cdot\cdot}{\mathrm{Ta}}})$	For $\dot{\mathrm{Fe}}\overset{\cdot\cdot\cdot}{\overset{\cdot\cdot}{\mathrm{Cb}}}$, $\dot{\mathrm{Fe}}$ 21.17; $\overset{\cdot\cdot\cdot}{\overset{\cdot\cdot}{\mathrm{Cb}}}$ 78.83.
Wolframite.......	5—5.5	7.1—7.55	$2\dot{\mathrm{Fe}}\dddot{\mathrm{W}} + 3\dot{\mathrm{Mn}}\dddot{\mathrm{W}}$, or $4\dot{\mathrm{Fe}}\dddot{\mathrm{W}} + \dot{\mathrm{Mn}}\dddot{\mathrm{W}}$	$\dot{\mathrm{Fe}}$ 9.55; $\dddot{\mathrm{W}}$ 75.33; $\dot{\mathrm{Mn}}$ 15.12 $\dot{\mathrm{Fe}}$ 5.6; $\dddot{\mathrm{W}}$ 76.2; $\dot{\mathrm{Mn}}$ 17.94.

NATIVE IRON.

Native iron contains various quantities of other substances than iron, principally nickel, associated with small proportions of cobalt. The quantity of nickel may vary from 1 to 20%. Pure metallic iron has been reported to be found in certain pyrites mines. Proust analyzed several specimens and pronounced them to be pure. The metal in a pure state has also been found in a mine in Dauphiné, Auvergne, and Brazil, but such iron is very rare. It is found native as grains, disseminated through volcanic rocks, at the Giant's Causeway and in Auvergne. It is easy to prove its presence by dipping the rocks into a solution of cupric sulphate, when the rock becomes coated with copper.

Iron is usually found native, however, as meteorites. Meteorites may be of two kinds:

First. Entirely composed of metallic iron, associated with chromium, nickel, and sometimes with cobalt, manganese, and sulphur, and sometimes contain bituminous substances. In the last case the masses are spongy, the cavities being filled with chrysolite, or a substance analogous to it.

When a meteorite is polished and treated with acid, they show the traces of crystallization. The following are some of the principal meteorites:

The Gibbs Meteorite, in Yale College, weighs 1,635 lbs.
The Tuckson Meteorite, in Smithsonian Institute, weighs 1,400 lbs.
(1.) South America Meteorite weighs 32,000 lbs.
(2.) " " " " 14,000 lbs.
The Pallas Meteorite contains crystals of chrysolite, found in Siberia; weighs 1,600 lbs.

Second. Other meteorites, on the other hand, are of a stony character, and contain the iron scattered through them in bunches. The exterior of these meteorites is generally scorified and covered over with a coating.

MAGNETITE.

The composition of Magnetite, when pure, is iron 72.4, oxygen 27.6 ($\dot{\mathrm{Fe}}\,\dddot{\mathrm{Fe}}$); or ferric oxide ($Fe_2O_3$) 68.97, ferrous oxide ($FeO$) 31.03. The iron is sometimes replaced in part by titanium, magnesium, lime, silicic oxide, alumina, nickel, copper, and manganese.

	$\dddot{\mathrm{Fe}}$.	$\dot{\mathrm{Fe}}$.	$\ddot{\mathrm{Ti}}$.	$\dot{\mathrm{Mn}}$.	$\dot{\mathrm{Cu}}$.	$\dot{\mathrm{Ni}}$.	$\dot{\mathrm{Mg}}$.	$\dot{\mathrm{Ca}}$.	$\ddot{\mathrm{Si}}$.	$\dddot{\mathrm{Al}}$.	$\dddot{\mathrm{Cr}}$.
1. Meiches.......	21.75	51 29	24.95	1.75	—	—	—	—	—	—	—
2. Ytterby.......	68.54	30.18	2.03	—	—	—	—	—	—	—	—
3. Ochreous......	66.20	13.87	—	17.00	0.09	—	—	—	—	—	Sand.
4. Landau	69.27	29.48	—	—	—	—	0.49	0.05	0.28	0.03	—
5. "	66 90	11.97	—	—	—	—	0.17	0.38	0.18	0.22	—
6. Nickeliferous..	68.92	29.32	*Tr.*	*Tr.*	—	1.76	—	—	—	—	*Tr.*

Analysis No. 1 by A. Knop (Ann. Chem. Pharm., cxxiii, 348).
" No. 2 by J. A. Michaelson (J. p. Ch., xc, 107).
" No. 3 by F. A. Genth (Ann. Chem. Pharm., lxvi, 277).
" Nos. 4 and 5, by Schwalbe (Zs. nat. Ver. Halle, xx, 198).
" No. 6 by Petersen (Jahrb. Min., 1867, 836).

Hardness = 5.5–6.5. Specific gravity = 4.9–5.2; 5.168–5.180, crystals (Kenngott), and 5.27 after long heating. Color is black and streak is black. On its natural faces it has a semi-metallic lustre. Generally opaque, but in very thin dendrites is sometimes transparent. Fracture subconchoidal, shining. Brittle. Strongly magnetic, sometimes possessing polarity.

It is fusible with difficulty. In oxidizing flame loses its influence on the magnet. It is insoluble in nitric acid, but is dissolved in hot hydrochloric acid.

Magnetite is mostly confined to crystalline rocks, and is most abundant in metamorphic rocks, though found also in grains in eruptive rocks. It sometimes happens that the grains are covered with a superficial coating of oxide on the surface, which makes them iridescent. Such ore is called *short-ore* by the miner. The granular varieties, by the action of the elements, often becomes a fine black sand. Such sand is the only ore of iron in New Zealand, and it is found on the sea-shore, where the constant action of the water has washed out the impurities and made it quite pure.

The beds of ore at Arendal, and nearly all the celebrated iron mines of Sweden, consist of massive magnetite; Dannemora and Täberg, in Smaoland, are entirely formed of it. Still larger mountains of it exist at Kurunavara and Gelwara, in Lapland. Octahedral crystals are found at Fahlun, in Sweden; dodecahedral crystals occur at Normark, in Wermland. The most powerful native magnets are found in Siberia and in the Harz; they are also obtained on the island of Elba.

In North America, it constitutes vast beds. It occurs in New York in several counties; in Maine, in an epidotic rock; at Marshall's Island, masses are strongly magnetic. Also in Vermont, Connecticut, New Jersey, Pennsylvania, Maryland, and in California, Sierra Co., abundant, massive, and in crystals.

"No ore of iron is more generally diffused than the magnetic, and none superior for the manufacture of iron. It is easily distinguished by its being attracted readily by the magnet, and also by means of the black color of its streak or powder, which is some shade of red or brown in hematite and limonite. The ore, when pulverized, may be separated from earthy impurities by means of a magnet, and machines for this purpose are in use."

FRANKLINITE.

Composition, when pure, is ferric oxide 66, manganic oxide 16, zincic oxide 17 $(\dot{\mathrm{Fe}}, \dot{\mathrm{Mn}}, \dot{\mathrm{Zn}})(\dddot{\bar{\mathrm{Fe}}}, \dddot{\bar{\mathrm{Mn}}})$.

The following are a few analyses:

LOCALITIES.	$\dddot{\bar{\mathrm{Fe}}}$.	$\dddot{\bar{\mathrm{Mn}}}$.	$\dot{\mathrm{Zn}}$.	$\dot{\mathrm{Si}}$.	$\dddot{\bar{\mathrm{Al}}}$.
1. New Jersey	66.88	18.17	10.81	0.40	0.73 = 98.99
2. " "	64.51	13.51	25.30	—	— = 103.52
3. " "	66.12	11.99	21.77	0.28	— = 100

Analysis No. 1 by Abich (Pogg., xxiii, 342).
" No. 2 by Rammelsberg (Pogg., cvii, 312).
" No. 3 by Steffens (B. H. Ztg., xix, 463).

Hardness = 5.5–6.5. Specific gravity = 5.069 (Thompson), 5.091 (Haidinger). Color is black. Streak dark reddish-brown. Very slightly magnetic. Lustre metallic. Opaque. Fracture conchoidal. Brittle.

Infusible. With borax in oxidizing flame gives a reddish-amethystine bead (manganese), and in reducing flame changes to bottle-green (iron). On charcoal with borax gives the reactions for zinc and iron. Soluble in hydrochloric acid with slight evolution of chlorine.

It is found in cubic crystals near Elibach, in Nassau; in amorphous masses at Altenberg, near Aix-la-Chapelle.

It is only found in large quantities at Hamburg, New Jersey, near the Franklin Furnace; it is there found with red oxide of zinc and garnet, in granular limestone; also at Sterling Hill, in the same region, where it is associated with willemite in a large vein, in which cavities occasionally contain crystals from one to four inches in diameter.

Franklinite is used as an ore of iron and zinc.

HEMATITE.

Composition, when pure, is iron 70, and oxygen 30 ($\dddot{\mathrm{Fe}}$). Some hematite contains titanium. Crystals from Krageröe afforded Rammelsberg (Pogg., civ, 528).

$$\dddot{\mathrm{Fe}}\ 93.63 - \ddot{\mathrm{Ti}}\ 3.55,\ \dot{\mathrm{Fe}}\ 3.26 = 100.44 = \dot{\mathrm{Fe}}\ddot{\mathrm{Ti}} + 13\dddot{\mathrm{Fe}} \text{ or}$$

$$(\mathrm{FeTi})_2\mathrm{O}_3 + 13\dddot{\mathrm{Fe}}.$$

The varieties depend on texture or state of aggregation, and in some cases the presence of impurities.

Var. 1. *Specular.* Lustre metallic, and crystals often splendent.

(*b.*) When the structure is foliated or micaceous, the ore is called *micaceous* hematite.

Var. 2. Compact, columnar, or fibrous. The masses often long, radiating; lustre submetallic to metallic; color brownish-red to iron-black. Sometimes called red-hematite.

Var. 3. *Red Ochreous.* Red and earthy. *Reddle* and *red chalk* are red ochre, mixed with more or less clay.

Var. 4. *Clay Iron-stone; Argillaceous Hematite.* Hard brownish-black to reddish-brown, heavy stone; often in part deep red; of submetallic to unmetallic lustre; and affording, like all the preceding, a red streak.

(*b.*) When reddish in color and jasper-like in texture, often called *jaspery-clay* iron-stone.

(*c.*) When oolitic in structure (consisting of minute flattened concretions), it is called *lenticular iron-ore.*

Hardness = 5.5–6.5. Specific gravity = 4.5–5.3, of some compact varieties as low as 4.2. Color dark, steel-gray or iron-black; in very thin particles, blood-red by transmitted light; when earthy, red. Streak blood-red or brownish-red. In thin scales, it is transparent and of a blood-red color. Sometimes slightly magnetic, and occasionally even magnetipolar.

It is infusible, but when exposed for a long time to the reducing flame, it gives a magnetic globule. Dissolves with difficulty in hydrochloric acid, more especially if it contains titanium. This ore is found in rocks of all ages. The specular variety is mostly confined to crystalline or metamorphic rocks, but is also a result of igneous action about some volcanoes, as at Vesuvius.

The beds that occur in metamorphic rocks are sometimes of very great thickness. In North America it is widely distributed; occurs in beds in vast thickness in rock of the Eozoic age, as in the Marquette region in northern Michigan, and in Missouri at the Pilot Knob and the Iron Mountain; the former, 650 feet high, consisting mainly of an Eozoic quartz rock, and having specular iron in the upper part, the iron ore in heavy beds interlaminated with quartz; the latter 200 feet high, and consisting at surface of massive hematite in loose blocks, many ten to twenty tons in weight; in Arizona and New Mexico. Besides these regions of enormous beds, there are numerous others of workable value, either crystallized or argillaceous, in New York, Massachusetts, New Hampshire, North Carolina and South Carolina; a micaceous variety is schistose rocks, containing the so-called *specular schist* or *itabirite.*

"This ore affords a considerable portion of the iron manufactured in different countries. The varieties, especially the specular, require a greater degree of heat to smelt than other ores, but the iron obtained is of good quality. Pulverized red hematite is employed in polishing metals, and also as a coloring material. The species is readily distinguished from magnetite by its red streak, and from turgite by its greater hardness and its not decrepitating before the blowpipe."

LIMONITE.

Composition, when pure: ferric oxide 85.6, water 14.4 $(\ddot{\mathrm{F}}\mathrm{e}_2\dot{\mathrm{H}}_2)$. In the bog ores and ochres, sand, clay, phosphates, oxides of manganese, and humic or other acids of organic origin, are very common impurities.

The following are a few analyses of Limonite:

LOCALITIES.	$\ddot{\mathrm{Fe}}$.	$\dddot{\mathrm{Mn}}$.	$\dot{\mathrm{H}}$.	$\ddot{\mathrm{Si}}$.	$\ddot{\mathrm{P}}$.	$\dddot{\mathrm{Al}}$.	$\dot{\mathrm{Co}}$.	$\dot{\mathrm{Ca}}$.
1. Horhausen.... ...	82.27	—	13.26	4.50	—	—	—	— = 100.03
2. Salisbury, Conn...	81.13	0.60	13.81	3.68	*Tr.*	0.93	*Tr.*	*Tr.*, $\dddot{\mathrm{S}}$ *Tr.* = 100.15
3. Dist. of Kandern (pisolitic)......	71.71	—	8.23	13.00	—	6.71	—	0.60 = 100.25
4. Dist. of Kandern (pisolitic)......	68.70	—	11.53	11.80	—	7.47	—	— = 99.50
5. Buffalo, Mo.	84.30	—	11.62	2.88	—	0.64	—	— S 0.12 = 100.06

Analysis No. 1 by Schönberg (J. pr. Ch., xix, 107).
" No. 2 by C. S. Rodman.
" Nos. 3 and 4 by Schenck (Ann. Ch. Pharm., xc, 123).
" No. 5 by Litton (Rep. G. Mo., 1855).

Hardness = 5–5.5. Specific gravity = 3.6–4. Color generally different shades of brown, sometimes nearly black in the botryoidal varieties; when earthy, brownish-yellow, ochre-yellow. Streak yellowish-brown. Lustre silky, often submetallic, sometimes dull and earthy.

The varieties are

1. *Compact.* Submetallic to silky in lustre.

2. *Ochreous* or earthy, brownish-yellow to ochre-yellow; often impure from the presence of clay, sand, etc.

3. *Bog Ore.* The ore from marshy places, generally loose or porous in texture, often petrifying leaves, wood, nuts, etc.

4. *Brown Clay Iron-stone*, in compact masses, often in concretionary nodules, having a brownish-yellow streak, and thus distinguished from the clay iron-stone of the species hematite and siderite; it is sometimes (*a*) *pisolitic*, or an aggregation of concretions of the size of small peas (Bohnerz, Germany); or (*b*) *oolitic*.

Gives off water and becomes red when heated. Soluble in acids.

Limonite is in all cases the result of alteration of other ores, through exposure to moisture, air, and carbonic or organic acids; and is derived largely from the change of pyrite, siderite, magnetite and various other species. It is therefore found in secondary or more recent deposits.

Extensive beds exist at Salisbury and Kent, Conn.; also in Beekman, Fishkill, Dover, and Amenia, N. Y.; also at Lenox, Mass.; in Vermont at Bennington, Monkton, Pittsford, Putney and Ripton.

"Limonite is one of the most important ores of iron. The pig iron from the purer varieties, obtained by smelting with charcoal, is of superior quality. That yielded by bog ore is what is termed *cold-short*, owing to the phosphorus present, and cannot therefore be employed in the manufacture of wire, or even of sheet iron, but is valuable for casting. The hard or compact nodular varieties are employed in polishing metallic buttons, etc."

PYRITE.

The composition of Pyrite, when pure, is iron 46.7; sulphur 53.3 (FeS_2). There are several varieties of pyrite.

VAR. 1. *Ordinary.* (*a*) Indistinct crystals; (*b*) nodular, or concretionary, often radiating within; (*c*) stalactitic; (*d*) amorphous.

VAR. 2. *Nickeliferous.* Schnabel found 0.168 of nickel in a kind from a silver mine near Eckerhagen. A pyrite from the Kearney ore-bed, Gouverneur, N. Y., is similar; it is a pale bronze in color, and radiated botryoidal. Hardness = 5.5. Specific gravity = 4.863. (Am. J. Sci., II, xv, 444.)

VAR. 3. *Cobaltiferous.* Specimens from Cornwall, Lebanon County, Pa., afforded J. M. Blake 2 per cent. of cobalt.

VAR. 4. *Cupriferous.* A variety from Cornwall, Lebanon County, Pa., gave J. C. Booth 2.39 per cent. of copper, affording the formula, $(Fe, Cu) S_2$. (Dana's Min., 1854, 55.)

VAR. 5. *Stanniferous; Ballesterosite,* Schulz and Paillette (Bull. G. Fr., II, vii, 16.) A kind in cubes, containing tin and zinc, occurring in argillite, from Galicia.

VAR. 6. *Auriferous.* Containing native gold. The pyrite of most gold regions is auriferous.

VAR. 7. *Argentiferous* from Hungary.

VAR. 8. *Thalliferous.* The pyrite of the Rammelsberg mine, near Goslar, Prussia, is especially rich in thallium.

The following are a few analyses:

LOCALITIES.	S.	FE.	NI.	CO.	CU.	$\ddot{\text{Si}}$	$\dddot{\text{Al}}$	$\dot{\text{H}}$
1. Inverary	49.32	45.73	1.99	1.24	1.18	—	—	— insoluble 0.06
2. Cornwall	53.37	44.47	—	—	2.39	—	—	—
3. Chessy and St. Bel	46.5	39.3	—	—	—	10.2	8.8	0.2
4. Allier	52.7	44.2	—	—	—	2.5	—	0.2

Analysis No. 1 by D. Forbes (Phil. Mag., IV, xxxv, 178).
" No. 2 by Booth (Dana's Min., 1854, 55).
" Nos. 3 and 4 by C. Mène (C. R., lxiv, 870).

Hardness = 6–6.5. Specific gravity = 4.83–5.2; 5.185, polished crystals, Zepharovich. Color on its natural faces and on its fracture is brass yellow, with a very decided metallic lustre, and is quite uniform. This color caused it to be much sought after at one time as an object of ornament. It was then known to jewelers as marcasite. Streak is greenish or brownish black. Opaque. Fracture conchoidal, uneven. Brittle. It strikes fire with steel without giving out any odor. It can be fused in the flame of a candle. Heated in a tube, sulphur sublimes. In the reducing flame a residue is obtained which attracts the magnet. It is insoluble in hydrochloric acid, but dissolves in nitric acid with evolution of H_2S. Pyrite occurs abundantly in rocks of all ages, from the oldest crystalline to the most recent alluvial deposits. It usually occurs in small cubes, more or less modified; also in irregular spheroidal nodules and in veins, in clay, slate, argillaceous sandstones, the coal formation, etc. Very large cubes are found in the Cornish mines. Large octahedral crystals are found at Persberg, in Sweden. Magnificent crystals come from Peru. Found as crystal in Maine at Conia, Peru, etc., and massive at Bingham, Brooksville. Found also in New Hampshire, at Unity, massive. It is also found in Massachusetts, Vermont, New York, Pennsylvania, Wisconsin, Illinois, North Carolina, Virginia, and Canada.

SIDERITE.

The composition of Siderite, when pure, is ferrous oxide 62.1 and carbonic oxide 37.9 ($\dot{\text{Fe}}\ddot{\text{C}}$). Part of the iron oxide is often replaced by manganese, and often by magnesia and lime. The principal varieties are:

(1) ORDINARY. (*a*) *Crystallized.* (*b*) *Concretionary = Spherosiderite;* in globular concretions, either solid or concentric, scaly, with usually a fibrous structure. (*c*) *Granular* to *compact massive.* (*d*) *Oolitic,* like oolite limestone in structure. (*e*) *Earthy,* or stony, impure from a mixture with clay or sand, constituting a large part of the clay iron-stone of the coal formation and other stratified deposits.

(2) In this variety the bases replace part of the iron.

The following are a few analyses:

LOCALITIES.	$\ddot{\text{C}}$.	$\dot{\text{Fe}}$.	$\dot{\text{Mn}}$.	$\dot{\text{Mg}}$.	$\dot{\text{Ca}}$.	$\dot{\text{H}}$.	$\dddot{\text{Fe}}$.
1. Durham	35.90	54.57	1.15	—	0.59	2.63	—
2. Bieber (white).....	38.41	53.06	4.20	2.26	1.12	—	— gangue 0.48
3. Salzburg...........	40.31	43.86	2.57	10.46	0.40	—	4.07
4. L. Laach...........	38.16	60.00	—	—	1.84	—	—
		$\dot{\text{Fe}}\ddot{\text{C}}$.	$\dot{\text{Mn}}\ddot{\text{C}}$.	$\dot{\text{Mg}}\ddot{\text{C}}$.	$\dot{\text{Ca}}\ddot{\text{C}}$.		
5. Erzberg, Styria....	—	79.87	0.16	10.88	11.91	—	—

Analysis No. 1 by Thompson (Min., i, 445).
" No. 2 by Glasson (Ann. Ch. Pharm., lxii, 89).
" No. 3 by Sommer (Jahrb. Min., 1866, 455).
" No. 4 by Bischof (Rammelsburg, Min. Chemie, 222).
" No. 5 by Sauder (Ramm. Min. Ch., 217).

Hardness = 3.5–4.5. Specific gravity = 3.7–3.9. Color is white when just taken from the mine and when quite pure, but it soon becomes altered in the air, and takes a grayish color, which sometimes becomes brown, brownish-red, or green. Streak is white. Translucent to subtranslucent. Lustre vitreous, more or less pearly. Fracture uneven. Brittle.

On charcoal it blackens and fuses at 4.5. Heated in a closed tube gives off carbonous and carbonic oxide, blackens, and gives a magnetic globule. In the oxidizing flame the iron becomes ferric oxide, in the reducing flame it becomes magnetic. Dissolves in acid in the cold slowly with effervescence, but rapidly and with brisk effervescence with hot acid.

Siderite occurs in many of the rock strata, in gneiss, mica slate, clay slate, and as a clay iron-stone in connection with the coal formation and many other stratified deposits. It is often associated with metallic ores. Siderite is one of the most important ores of iron.

In Styria and Carinthia this ore forms extensive tracts in gneiss. Clay iron-stone occurs in beds near Glasgow. It is found in veins at New Milford, Conn., Plymouth, New Hampshire, and Sterling, Mass.; also in New York, Ohio and Pennsylvania.

14. LEAD.

The principal Lead minerals are:

MINERAL.	HARDNESS.	SP. GR.	FORMULA.	COMPOSITION.
Native lead.....	1.5	11.445	Pb.	Pb = 100.
Minium........	2.3	4.6	$\ddot{Pb} + 2\dot{Pb}$.	Pb = 90.66; O = 9.34.
Galenite........	2.5—2.75	7.25—7.77	PbS	Pb = 86.6; S = 13.4.
Bournonite.....	2.5—3	5.7—5.91	$3(Cu,Pb)S+Sb_2S_3$	Pb=42.4; Sb=25; Cu=12.9; S = 19.7.
Anglesite.	2.75—3	6.12—6.39	$\dot{Pb}\dddot{S}$	Pb = 73.6; $\dddot{S}$ = 26.4.
Clausthalite	2.5—3	7.6—8.8	PbSe.	Pb = 72.4; Se = 27.6.
Pyromorphite..	3.5—4.5	6.5—7.1	$3\dot{Pb}_3\overset{\cdot\cdot\cdot\cdot\cdot}{P}+PbCl$.	$\dot{Pb}$ = 74.1; $\overset{\cdot\cdot\cdot\cdot\cdot}{P}$ = 15.7; Cl = 2.6; Pb = 7.6.
Minretite.......	3.5	7—7.25	$3\dot{Pb}_3\overset{\cdot\cdot\cdot\cdot\cdot}{As} + PbCl$.	$\dot{Pb}\overset{\cdot\cdot\cdot\cdot\cdot}{As}$ = 90.60; PbCl = 9.34.
Cerussite.......	3—3.5	6.465—6.48	$\dot{Pb}\ddot{C}$.	$\dot{Pb}$ = 83.5; $\ddot{C}$ = 16.5.
Crocoite........	2.5—3	5.9—6.1	$\dot{Pb}\dddot{Cr}$.	$\dot{Pb}$ = 68.9; $\dddot{Cr}$ = 31.1.
Stolzite.........	2.75—3	7.87—8.13	$\dot{Pb}\dddot{W}$.	$\dot{Pb}$ = 49; $\dddot{W}$ = 51.
Wulfenite......	2.75—3	6.05—7.01	$\dot{Pb}\dddot{Mo}$.	$\dot{Pb}$ = 61.5; $\dddot{Mo}$ = 38.5.

GALENITE.

The composition of Galenite, when pure, is lead 86.6; sulphur 13.4 (PbS). It sometimes contains selenium, zinc, cadmium, antimony, copper as sulphides, besides, also, sometimes native silver and gold, and even platinum.

The following are a few analyses:

LOCALITIES.	S.	PB.	SB.	FE.	CU.	ZN.	AG.
1. Bottino......	12.840	80.700	3.307	1.377	0.440	0.024	0.325
2. Argentina....	15.62	72.90	5.77	1.77	1.11	1.33	0.72

Analyses No. 1 and 2 are by E. Bechi (Am. J. Sci., II, xiv, 60).

Hardness = 2.5–2.75. Specific gravity = 7.25–7.7. Color is grayish-blue. Streak lead-gray. In its fresh fracture it has a metallic lustre, which is quite bright, but becomes dull on exposure. Fracture flat, subconchoidal, or even. Frangible.

In an open tube it gives off sulphurous oxide. On charcoal, decrepitates, and then in oxidizing flame is roasted, giving off sulphurous odor and lead fumes, which coat the coal at a short distance from the assay with a yellow ring. After being roasted, gives a globule of metallic lead, which is malleable. It is soluble in nitric acid, with evolution of H_2S.

Occurs in beds and veins, both in crystalline and uncrystalline rocks. At Freiberg, it occurs in veins in gneiss; in Spain, in granite.

Extensive deposits of this ore exist in Missouri, Illinois, Iowa, and Wisconsin. The productive lead region is bounded on the west, north, and east by the Mississippi, Wisconsin, and Rock rivers. Occurs also in New York, Maine, New Hampshire, Massachusetts, Virginia, Tennessee, etc.

Galenite is the only important ore of lead.

CERUSSITE.

The composition of Cerussite, when pure, is oxide of lead 83.5, carbonic oxide 16.5 ($\dot{P}b\ddot{C}$).

The following are a few analyses:

LOCALITIES.	$\ddot{C}$.	$\dot{P}$B.	FE.	CA.
1. Leadhills	16.0	82.00	—	—
2. Zellerfeld	16.0	81.20	0.50	0.90

Analysis No. 1 by Westruub, and No. 2 by Klaproth (Beitr., iii, 167).

Hardness = 3–3.5. Specific gravity = 6.465–6.480. Colors are white, grayish-white, and does not interfere with an adamantine lustre. Streak is uncolored. Transparent to subtranslucent. Fracture conchoidal. Very brittle.

Decrepitates when heated in a small tube, loses carbonic acid, turns first yellow, and at a higher temperature dark red, but becomes again yellow on cooling. After decrepitation on charcoal, it becomes reduced to a metallic globule. Soluble, with effervescence, in nitric acid.

It is found in beautiful crystals at Johanngeorgenstadt; in the Harz; in England and Ireland.

Found in Massachusetts, Pennsylvania, North Carolina, and Wisconsin.

15. LITHIUM.

The principal Lithium mineral is lepidolite, or lithia mica. Its composition varies.

LOCALITIES.	$\ddot{\text{Si}}$.	$\dddot{\bar{\text{Al}}}$.	$\dddot{\bar{\text{Fe}}}$.	$\dddot{\bar{\text{Mn}}}$.	$\dot{\text{Mg}}$.	$\dot{\text{Na}}$.	$\dot{\text{Li}}$.	$\dot{\text{K}}$.	$\dot{\text{H}}$.	Cl.	F.	Ca.	$\ddot{\ddot{\text{P}}}$.
1. Rozena..	49.06	33.61	—	1.40	0.41	—	3.59	4.18	4.24	0.11	3.40	—	—
2. Cornwall	51.70	26.76	—	1.29	0.24	1.15	1.27	10.29	—	—	7.12	0.40	0.16
3. Zinnwald	46.23	14.14	17.97	$\dot{\text{M}}$. 4.57	—	—	4.21	4.90	0.83	—	3.10	—	—

Analysis No. 1 by Gmelin; No. 2 by Rammelsburg (5th Suppl., 120); No. 3 by Gmelin.

The formula for lepidolite is $[(\dot{\text{K}}, \dot{\text{Li}})_3 (\dddot{\bar{\text{Al}}}, \dddot{\bar{\text{Fe}}})_2] \ddot{\text{Si}}_3 + 2\ddot{\text{Si}}$.

Hardness = 2.5–4. Specific gravity = 2.84–3. Crystallizes as a right rhombic prism of 120°. Color, rose-red, violet, gray, lilac, grayish-white, white, or yellow. It is to these brilliant colors, which resemble the wings of certain lepidoptera, that it owes its name. Lustre pearly. Translucent. Streak is colorless.

In closed tube gives off water and reaction for fluorine. Before the blowpipe fuses with intumescence to a grayish glass, coloring the flame red. Attacked by acids, but not completely decomposed. Gelatinizes, after fusion, with hydrochloric acid.

It is found near Otö, in Sweden, grayish-white; in Zunnwald, in Bohemia, lilac or reddish; violet at Rozena, in Moravia; brown in St. Michael's Mount, in Cornwall.

Found in the United States at Paris and Hebron, Me.; and granular near Middletown, Conn.

16. MAGNESIUM.

The principal Magnesium minerals are:

MINERAL.	HARDNESS.	SP. GR.	FORMULA.	COMPOSITION.
Brucite	2.5	2.35—2.46	$\dot{Mg}\dot{H}$	$\dot{Mg}$ 68.97; $\dot{H}$ 31.13.
Epsomite	2.25	1.685—1.751	$\dot{Mg}\dddot{S}+7\dot{H}$	—
Boracite	7 (only 4 when massive)	2.918—2.974	$\dot{Mg}_3\dddot{B}_4+\frac{1}{3}MgCl$	$\dot{Mg}$ 26.8; $\dddot{B}$ 62.6; MgCl 10.6.
Magnesite	3.5—4.5	3—3.08	$\dot{Mg}\ddot{C}$	$\dot{Mg}$ 47.6; $\ddot{C}$ 54.4.
Spinel	8	3.5—4.9	$\dot{Mg}\dddot{Al}$	$\dot{Mg}$ 28; $\dddot{Fe}$ 72.

MAGNESITE.

The composition of Magnesite, when pure, is magnesia 47.6, carbonic acid 52.4 ($\dot{Mg}\ddot{C}$). Ferrous oxide often replaces some magnesia.

The following are a few analyses:

	$\ddot{C}$.	$\dot{Fe}$.	$\dot{Mn}$.	$\dot{Mg}$.	$\dot{Ca}$.	$\dot{H}$.	$\dddot{Al}$.	
1. Snarum (crystallized)....	51.45	0.79	—	47.29	—	0.47	—	
2. " "	50.79	2.26	—	45.36	—	0.26	1.12	
3. Salzburg "	49.67	$\dddot{Al}$ 3.62	0.28	44.58	0.65	—	—	insol. 0.58
4. Frankenstein (compact)..	50.22	—	0.21	48.36	—	1.39	—	
5. " " ..	52.10	—	—	47.90	—	—	—	
FERRIFEROUS MAGNESITE.								
6. Semmering (white)......	50.45	3.19	—	42.49	2.18	—	—	C 1.29
7. Hall (black)..............	50.92	5.00	1.51	42.71	—	—	—	C 0.11
8. St. Gothard (yellow).....	50.32	6.54	0.56	41.80	—	—	—	

Analysis No. 1 by Marchand and Scheerer (J. pr. Ch., i, 395).
" No. 2 by Münster (Pogg., lxv, 292).
" No. 3 by Sommer (Jahrb. Min., 1866, 456).
" No. 4 by Stromeyer (Kastn. Arch., iv, 432, Unt.).
" No. 5 by Rammelsberg (Handw., 397).
" No. 6 by Hauer (Jahrb. G. Reichs, iii, 154, 1852).
" No. 7 by Stromeyer (Schw. J., li).
" No. 8 by Stromeyer (l. c.).

Hardness = 3.5–4.5. Specific gravity = 3–3.08 crystallized; 2.8 earthy; 3–3.2 when ferriferous.

Color is white, yellow, or brown. Lustre vitreous; fibrous varieties sometimes silky. Transparent, opaque. Fracture flat conchoidal. The primitive form is a rhombohedron of 107° 29′.

Heated in a tube, it gives off water and acts like dolomite. When reduced to powder, it is easily dissolved by warm hydrochloric acid, with effervescence, more easily than dolomite. It is infusible, but glows intensely (Mg).

First discovered by Mitchell, at Hrubschütz, in Moravia; found in Silesia, Norway, Styria, etc. In the United States it is found at Bolton, Mass.; at Barehills, near Baltimore, Md.; in Pennsylvania and California.

Magnesite is much used for making Epsom salts.

SPINEL.

The composition of Spinel, when pure, is magnesia 28, alumina 72 ($\dot{\text{Mg}}\dddot{\text{Al}}$). The magnesia may be replaced by lime, iron, manganese, or zinc, separately or in combination. Alumina generally takes the part of a base; in spinel, however, it plays the part of an acid. Spinel is not really a mineral species, but is rather the name of a family of minerals, which are similar in composition and crystalline form.

The varieties of spinel are:

VAR. 1. *Ruby*, or *Magnesia Spinel.* Clear red or reddish. Transparent to translucent, sometimes subtranslucent. Specific gravity = 3.53–3.58. Composition $\dot{\text{Mg}}\dddot{\text{Al}}$, with little or no $\dot{\text{Fe}}$, and sometimes oxide of chromium as a source of the red color. Varieties are called (*a*) spinel-ruby, deep red; (*b*) balas-ruby, rose-red; (*c*), rubicelle, yellow or orange-red; (*d*) almandine, violet.

VAR. 2. *Ceylonite*, or *Iron-magnesia Spinel.* Color is dark-green, brown to black, mostly opaque, or nearly so. Specific gravity = 3.5–3.6. Composition, $(\dot{\text{Mg}}, \dot{\text{Fe}})\,\dddot{\text{Al}}$ or $(\dot{\text{Mg}}, \dot{\text{Fe}})\,(\dddot{\text{Al}}, \ddot{\text{F}})$.

VAR. 3. *Magnesia-lime Spinel.* Color green.

VAR. 4. *Chlorospinel*, or *Magnesia-iron Spinel.* Color grass-green, owing to the presence of copper. Specific gravity = 3.591–3.594. Composition $\dot{\mathrm{M}}\mathrm{g}\,(\dddot{\mathrm{Al}}, \dddot{\mathrm{Fe}})$, the iron being in the state of ferric oxide.

VAR. 5. *Picotite.* Color black. Contains over 7 per cent. of oxide of chromium, and has the formula $(\dot{\mathrm{M}}\mathrm{g}, \dot{\mathrm{F}}\mathrm{e})\,(\dddot{\mathrm{Al}}, \dddot{\mathrm{Fe}}, \dddot{\mathrm{Cr}})$. Lustre brilliant. Specific gravity = 4.08.

The following are a few analyses:

LOCALITIES.	$\dddot{\mathrm{Al}}$.	$\dddot{\mathrm{Fe}}$.	$\dot{\mathrm{Fe}}$.	$\dot{\mathrm{Mg}}$.	$\dot{\mathrm{Ca}}$.	$\ddot{\mathrm{Si}}$.	$\dddot{\mathrm{Cr}}$.
1. Ceylon (red)	69.01	—	0.71	26.21	—	2.02	1.10
2. Aker (blue)	68.94	—	3.49	25.72	—	2.25	—
3. Franklin, N. J. (green)	73.31	—	—	13.63	7.42	5.62	—
4. Ceylon (Ceylonite)	57.20	—	20.51	18.24	—	3.15	—
5. Ural (Pleonaste)	65.27	—	13.97	17.58	—	2.50	—
6. " (Chlorospinel)	64.13	8.70	—	26.77	0.27	—	— Cu 0.27
7. L. Lhery (Picotite)	55.34	—	24.60	10.18	—	1.98	7.90

Analyses No. 1 and 2 by Abich (Pogg., xxiii, 305).
" No. 3 by Thompson (Min., i, 214).
" No. 4 by C. Gmelin (Jahresb., iv, 156).
" No. 5 by Abich (l. c.).
" No. 6 by Rose (Pogg., i, 652).
" No. 7 by Damour (Bull. G. Soc., II, xix, 413).

Hardness = 8. Specific gravity = 3.5–4.1; 3.523, Hardinger; 3.575, red spinel. Color red of various shades, passing into blue, green, yellow, brown, and black; occasionally almost white. Streak is white. Transparent, nearly opaque. Fracture conchoidal.

Infusible, but changes color. Soluble in borax and salt of phosphorus. Soluble with difficulty in concentrated sulphuric acid. Decomposes by fusion with hydrosodic or potassic sulphate. It occurs in pebbles of beautiful colors at Ceylon, in Siam, and other eastern countries. Pleonaste is found at Candy, in Ceylon. A pale-blue and pearl-blue variety is found at Aker, in Sweden. Small black splendent crystals in the ancient ejected masses of Mount Somma.

It is found from Amity, N. Y., to Andover, N. J., in a granular limestone. It is also found in Massachusetts and Canada West.

The varieties used in the arts are usually brought to this country separated from their gangues. They come especially from Ceylon and Birmah. These spinels are used by jewelers, and are called balas-ruby; they are much less esteemed than the oriental ruby.

17. MANGANESE.

The principal Manganese minerals are:

MINERAL.	HARDNESS.	SP. GR.	FORMULA.	COMPOSITION.
Braunite........	6—6.5	4.75—4.82	$\dot{\mathrm{Mn}}$, $\ddot{\mathrm{Mn}}$, or $\dddot{\mathrm{Mn}}$	Mn 86.95; O 9.85; Ba 2.25; $\dot{\mathrm{H}}$ 0.95.
Hausmannite ..	5—5.5	4.722	$\dot{\mathrm{Mn}}_2\ddot{\mathrm{Mn}}$.	Mn 72.1; O 27.9.
Pyrolusite......	2—2.5	4.82	$\ddot{\mathrm{Mn}}$.	Mn 63.3; O 36.7.
Manganite	4	4.2—4.1	$\dddot{\mathrm{Mn}}\dot{\mathrm{H}}$.	Mn 62.5; O 27.3; $\dot{\mathrm{H}}$ 10.2.
Psilomelane....	5.6	3.7—4.7	$(\dot{\mathrm{Ba}},\dot{\mathrm{Mn}})\ddot{\mathrm{Mn}} + \dddot{\mathrm{Mn}} + n\dot{\mathrm{H}}\dot{\mathrm{Mn}}$.	$\dddot{\mathrm{Mn}}$ and $\dot{\mathrm{Mn}}$ 81.8; O 9.5; K 4.5; $\dot{\mathrm{H}}$ 4.2.
Wad...........	0.5—6	3—4.26	$\dot{\mathrm{R}}\dddot{\mathrm{Mn}} + \dot{\mathrm{H}}.\dot{\mathrm{R}} = \dot{\mathrm{K}}, \dot{\mathrm{Ba}}, \dot{\mathrm{Co}}, \dot{\mathrm{Mn}}$.	$\dot{\mathrm{Mn}}\dddot{\mathrm{Mn}}$ 79,12; O 8.82; $\dot{\mathrm{Ba}}$ 1.4; $\dot{\mathrm{H}}$ 10.66.
Alabandite.....	3.5—4	3.95—4.04	MnS.	Mn 63.3; S 36.7.
Triplite	4.55	3.44—3.8	$\dot{\mathrm{R}}^3\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}} + \mathrm{R}_4\mathrm{F}$.	$\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$ 32.8; $\dot{\mathrm{Fe}}$ 31.9; $\dot{\mathrm{Mn}}$ 32.6; $\dot{\mathrm{Ca}}$ 3.2. $\dot{\mathrm{R}}$=Fe and Mn; R=Ca, Mg, Fe.
Rhodochrosite .	3.5—4.5	3.4—3.7	$\dot{\mathrm{Mn}}\ddot{\mathrm{C}}$.	$\dot{\mathrm{Mn}}$ 61.4; $\ddot{\mathrm{C}}$ 38.6.

"DISTINCTION BETWEEN THE OXIDES OF MANGANESE.—The oxides of manganese are very difficult to distinguish with the blowpipe, as they all give the same violet bead with fluxes. *Manganite* is distinguished by giving off water, from braunite, hausmannite, and pyrolusite. *Wad* is distinguished especially by its lightness; for all the others, the best distinctions are taken from the color of their streaks.

Hausmannite.—Acute octahedra with plane faces; traces of cleavage; streak brownish-red.

Braunite.—Octahedra, curved faces without cleavage; granular with a bluish-black color; streak brown.

Pyrolusite.—Tender; stains paper black.

Manganite.—Black, with no bluish color; fracture granular; streak brown; hardness greater than the others; gives off water.

Wad.—Light, soils the fingers chocolate brown, and gives off water.

The only remaining oxide is *Psilomelane*, which has no very distinct characters. It is generally necessary to make a chemical test for $\dot{B}a$, by treating with HCl and then with $\dddot{S}$. Its hardness is generally greater than that of the other oxides."

PYROLUSITE.

The composition, when pure, is manganese 63.3; oxygen 36.7 ($\ddot{M}n$).

	$\dot{M}n\dddot{M}n$.	O.	$\dot{B}a$.	$\ddot{S}i$.	$\dot{H}$.	$\dddot{\bar{F}e}$.	$\dot{C}a$.	$\dddot{\bar{A}l}$.
1. Elgersberg	84.05	11.78	0.53	0.51	1.12	—	—	—
2. Ilmenan....... ...	87.0	11.6	1.2	0.8	5.8	1.8	0.3	0.3

Analysis No. 1, by Turner (Edinb. Trans., 1828).
" No. 2, by Scheffler (Arch. Pharm., xxxv, 260).

Hardness = 2–5.5. Specific gravity = 4.82 (Turner). Color iron-black or dark steel-gray. Lustre metallic. Opaque. Its fracture is irregular and unequal. Streak black. Crystallizes as a right rhombic prism of 93° 40′.

Pyrolusite is infusible, not even giving off water. With fluxes gives the reactions for manganese. Hydrochloric acid dissolves it with evolution of chlorine. When it contains rhodonite, gelatinous silica is deposited.

This ore is extensively worked at Elgersberg, near Ilmenan, and other places in Thuringia; at Norderehrensdorf, near Mährish; Träban, in Moravia, which place affords many hundred tons of ore; at Plateau, in Bohemia, and elsewhere.

Occurs in the United States with psilomelane; abundantly in Vermont, at Brandon, Irasburg, Bennington, etc., both crystallized and massive; in Conway, Mass., in a vein of quartz; at Plainfield and West Stockbridge, Mass.; at Winchester, N. H.; at Salisbury and Kent, Conn., forming velvet-like coating on limonite. Found also in California, New Brunswick, and Nova Scotia.

Pyrolusite and manganite are the most important ores of manganese. Pyrolusite is used extensively in glass works, for making bleaching powders and also for the manufacture of oxygen.

MANGANITE.

Composition of Manganite, when pure, is sesquioxide of manganese 89.8 (=Mn 62.5, O 27.3), water 10.2 ($\dddot{\overline{\mathrm{Mn}}}\dot{\mathrm{H}}$).

	MN.	O.	H.	$\dddot{\mathrm{Fe}}$, $\dot{\mathrm{Ba}}$ AND LOSS.
1. Ilefeld.................	62.86	27.64	9.50	—
2. Cheverie..............	86.81	—	10.00	Gangue 1.14—2.05

Analysis No. 1, by Gmelin (Ib., xlii, 208).
" No. 2, by How (Phil. Mag., IV, xxxi, 166).

Hardness = 4; Specific gravity = 4.2–4.4. Color dark-brown or iron-black. Streak reddish-brown to nearly black, darker than limonite. Lustre semi-metallic. Opaque; minute splinters, sometimes brown by transmitted light. Fracture uneven. Crystallizes as a right rhombic prism of 99° 40′, with an easy cleavage parallel to the brachypinacoid, and another more difficult, parallel to the prism. It is usually well crystallized. In a tube it gives off water when heated, and is then infusible; this distinguishes it from the other oxides. With fluxes gives the reaction for manganese. In acids, even before calcination, it is dissolved and gives off chlorine.

Manganite occurs at Ilefeld, in the Harz; Undennes, in Sweden; Christiansand, in Norway; and Cornwall, etc. It is found also in Nova Scotia and New Brunswick.

WAD.

The composition of Wad varies as follows:

LOCALITIES.	$\dot{\mathrm{Mn}}$.	$\dddot{\mathrm{Mn}}$.	O.	$\dddot{\mathrm{Fe}}$.	$\dot{\mathrm{Ba}}$.	$\dot{\mathrm{Cu}}$.	$\dot{\mathrm{H}}$.
1. Devonshire.........	79.12		8.82	—	1.4	—	10.66
2. Vicdessos...........	69.8	—	11.17	—	—	—	12.4 $\dddot{\mathrm{Al}}$ 7.0
3. Hillsdale, N. Y......	68.50		—	16.75	—	—	11.50, insol. 3.25.
4. Skidberg...........	66.16		—	2.70	15.84	—	$\dot{\mathrm{Co}}$ 12.07, $\ddot{\mathrm{Si}}$ 0.92, $\dddot{\mathrm{Al}}$ 0.75, $\dot{\mathrm{Ca}}$ 0.59, $\dot{\mathrm{Mg}}$ 0.28, $\dot{\mathrm{K}}$ 0.28.

Analysis No. 1 by Turner (Edinb. J. Sci., N. S., ii, 218).
" No. 2 by Berthier (Ann. Ch. Phys., li, 19).
" No. 3 by Beck (Rep. Min. N. Y., 55).
" No. 4 by Bahr (J. pr. Ch., liii, 308; fr. Oefv. Ak. Stockh., 240, 1850).

Hardness = 0.5–6. Specific gravity = 3–4.26. Color is dull-bluish, or brownish-black, or reddish-brown. It is often very light and soils the fingers.

In a closed tube, wad when heated yields water. Loses oxygen by ignition. Gives the reaction for manganese. Yields chlorine with hydrochloric acid. The varieties containing cobalt and copper react for these metals.

When wad contains cobalt, it is called asbolite or earthy cobalt.

When wad contains copper, it is called lampadite or cupreous manganese.

Wad, or bog-manganese, is found abundant in Columbia and Dutchess counties, N. Y.; at Austerlitz, Canaan Centre, and elsewhere occurs as marsh deposits. Also found in New Hampshire.

This ore, when abundant, is valuable.

18. MERCURY.

The following are the principal Mercury minerals:

MINERAL.	HARDNESS.	SP. GR.	FORMULA.	COMPOSITION.
Native Mercury.....	—	13.568	Hg	100
Cinnabar...........	2–2.5	8.998	HgS	Hg 86.2; S 13.8.
Calomel...........	1–2	6.482	Hg_2Cl	Hg 84.9; Cl 15.1.

CINNABAR.

The composition of Cinnabar, when pure, is mercury 86.2, and sulphur 13.8 (HgS or Hg_3S_3).

LOCALITIES.	S.	HG.
1. Neumarktel...............	14.25	85.00 = 99.25
2. Japan.....................	17.5	78.4, $\overset{\cdots}{\mathrm{Fe}}$ 1.7, $\overset{\cdots}{\mathrm{Al}}$ 0.7, $\dot{\mathrm{Ca}}$ 1.3, $\overset{\cdots}{\mathrm{Mn}}$ 0.2.
3. California.................	11.36	69.36, Fe 1.23, $\dot{\mathrm{Ca}}$ 1.40, $\overset{\cdots}{\mathrm{Al}}$ 0.61, $\dot{\mathrm{Mg}}$. 0.49, $\ddot{\mathrm{Si}}$ 14.30.

Analysis No. 1 by Klaproth (Beitr., iv, 14).
" No. 2 by John (John's Ch. Unt., i, 252).
" No. 3 by A. Bealey (J. Ch. Soc., iv).

Hardness = 2–2.5. Specific gravity = 8.998. Color is cochineal-red, inclining to violet. Streak characteristic vermilion-red. When it is impure, the color is often black, but the streak is always red. It absorbs light easily, which often makes it opaque. It is the most refrangent of all known bodies. Sectile. Polarization circular. Ordinary refraction, 2.854; extraordinary, 3.201 (Descl.).

On charcoal it volatilizes without residue. In a tube gives a red sublimate. It is not attacked by acids, and is the only sulphide which is not acted on by aqua-regia.

The Idria mines are in the carboniferous formation; those of New Almaden, California, in partially cretaceous or tertiary beds. It is found in Japan, China, Chili, Peru, etc.

Cinnabar is the principal ore of mercury, from which it is obtained by sublimation. It is sometimes ground and used as a pigment, called vermilion.

19. NICKEL.

The principal Nickel minerals are:

MINERAL.	HARDNESS.	SP. GR.	FORMULA.	COMPOSITION.
Millerite......	3—3.5	4.6—5.65	NiS	Ni 64.9; S 35.1.
Niccolite.....	5—5.5	7.33—7.671	$NiAs$	Ni 44.1; As 55.9.
Ulmannite....	5.5—5	6.2—6.51	$NiS + Ni\,(Sb,As)_2$	Ni 27.7; Sb 57.2; S 15.1.
Annabergite..	—	—	$\dot{Ni}_3\overset{\cdot\cdot\cdot\cdot\cdot}{As} + 8\dot{H}$	Ni 37.2; $\overset{\cdot\cdot\cdot\cdot\cdot}{As}$ 38.6; $\dot{H}$ 24.2.
Zaratite......	3—3.25	2.57—2.693	$\dot{Ni}\ddot{C} + 2\dot{Ni}\dot{H} + 4\dot{H}$	$\dot{Ni}$ 59.4; $\ddot{C}$ 11.7; $\dot{H}$ 28.9.

Chloanthite, or the niccoliferous smaltite, is sometimes very valuable for nickel, as the cobalt is nearly absent in some specimens.

MILLERITE.

The composition of Millerite, when pure, is nickel 64.9, sulphur 35.1 (NiS).

LOCALITIES.	S.	NI.	CO.	FE.	CU.
1. Saalfeld..................	35.79	61.34	—	—	1.14 = 100
2. Gap Mine, Pa............	35.14	63.08	0.58	0.40	0.87, gangue 0.28 = 100.35.

Analysis No. 1 by Rammelsberg (1st Suppl., 67).
" No. 2 by Genth (Ann. J. Sci., II, xxxiii, 195).

Hardness = 3–3.5. Specific gravity = 4.6–5.65; 5.65 fr. Saalfeld Rammelsberg; 4.601 fr. Joachimethal Kenngott. Color brass yellow, and often with an iridescent tarnish. Streak bright. Lustre metallic. Brittle.

In an open tube gives, when heated, sulphurous fumes. Fuses to a globule on charcoal before the blowpipe; gives a magnetic globule in the reducing flame. With fluxes most varieties show traces of copper, cobalt, and iron.

It is found in cavities at Bohemia, Przibram, Hummelfahrt mine near Freiberg, Saxony, Cornwall, etc. It is found at the Sterling mine, Antwerp, N. S.; also at the Gap mine, Lancaster Co., Pa.

NICCOLITE.

The composition of Niccolite, when pure, is nickel 44.1; arsenic 55.9 ($NiAs$ or Ni_3As_3).

	As.	Ni.	Fe.	Pb.	Co.	Sb.	S.	Cu.
No. 1.........	54.73	44.21	0.34	0.32	—	—	0.40	—
No. 2.........	54.05	43.50	0.45	—	0.32	0.05	2.18	— gangue 0.20.
No. 3.	52.71	45.37	—	—	—	—	0.48	1.44

Analysis No. 1, by Stromeyer (Gel. Anz. Gött., 1817, 204).
" No. 2, by Ebelmen (Ann. d. M., IV, xi, 55).
" No. 3, by Schnabel (Rammelsberg, 4th Suppl., 128).

Hardness = 5–5.5. Specific gravity = 7.33–7.671. Color is a light copper-red, which is very characteristic. The intensity of the color is, however, variable, and is subject to tarnish; those specimens containing antimony are much darker, while those containing arsenic are paler. Streak is pale brownish-black. Lustre metallic. Opaque. Fracture uneven. Brittle.

On charcoal it gives off a garlic odor with white vapors, if it contains arsenic; when antimony is alone present, there is only a coating of antimony without any odor. With fluxes gives reactions for iron, cobalt, and nickel. Soluble in nitro-hydrochloric acid.

It is found in the Saxon mines of Annaberg, Schneeberg, etc.; found also in Styria, Allemont, Cornwall sometimes; Scotland, Chili, and Argentine provinces. It is also found at Chatham, Conn., in gneiss associated with smaltite.

Niccolite is a very important ore of nickel.

20. PHOSPHORUS.

The principal Phosphorus mineral, or minerals containing phosphorus, are:

MINERAL.	HARDNESS.	SP. GR.	FORMULA.	COMPOSITION.
Schreibersite.......	6.5	7.01—7.22	P, Fe, Ni, C.	One sample yielded P 7.26; Fe 87.20; Ni 4.24. C undetermined.
Cryptolite..........	....	4.6 Cryptolite. 4.78 Phosphocerite.	$\overset{\cdot}{\mathrm{Ce}}_3$ $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$ (the Ce replaced in part by Di).	One analysis gave $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$ 27.87; $\overset{\cdot}{\mathrm{Ce}}$, $\overset{\cdot}{\mathrm{Di}}$ 73.70; $\overset{\cdot}{\mathrm{Fe}}$ 1.51 (Cryp.); $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$ 29.66; $\overset{\cdot}{\mathrm{Ce}}$, $\overset{\cdot}{\mathrm{Di}}$ 67.38; $\overset{\cdot\cdot\cdot}{\bar{\mathrm{F}}\mathrm{e}}$ 2.95 (Phosphocerite).
Apatite............	5. (Sometimes 4.5)	2.92—3.25	$\overset{\cdot}{\mathrm{Ca}}_3$ $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$ + $\frac{1}{3}$Ca (Cl, Fl).	$\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$ 40.92; $\overset{\cdot}{\mathrm{Ca}}$ 48.43=89.35; Cl 6.81; Ca 3.84 or $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$ 42.26; $\overset{\cdot}{\mathrm{Ca}}$ 50=92.26; $\overset{\cdot}{\mathrm{Ca}}$ $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$; F 3.77; Ca 3.97.
Pseudomalachite...	4.5—5	4—4.4	$\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$, $\overset{\cdot}{\mathrm{Cu}}$, $\dot{\mathrm{H}}$. Analyses vary much.	$\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$ 24.55; $\overset{\cdot}{\mathrm{Cu}}$ 67.25; $\dot{\mathrm{H}}$ 8.20. Analysis of one sample.
Borickite...........	3.5	2.696—2.707	$(\overset{\cdot\cdot\cdot}{\bar{\mathrm{F}}\mathrm{e}}, \overset{\cdot}{\mathrm{Ca}}_3)_5$ $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}_2$+15$\dot{\mathrm{H}}$.	$\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$ 20.49; $\overset{\cdot\cdot\cdot}{\bar{\mathrm{F}}\mathrm{e}}$ 52.29; $\overset{\cdot}{\mathrm{Ca}}$ 8.16; $\dot{\mathrm{H}}$ 19.06.
Callainite...........	3.5—4	2.5—2.52	$\overset{\cdot\cdot\cdot}{\bar{\mathrm{A}}\mathrm{l}}$ $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$+5$\dot{\mathrm{H}}$	$\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$ 42.39; $\overset{\cdot\cdot\cdot}{\bar{\mathrm{A}}\mathrm{l}}$ 30.75; $\dot{\mathrm{H}}$ 26.86.
Phosphorgummite or Gummite	2.5—3	3.9—4.20	$(\overset{\cdot\cdot\cdot}{\bar{\mathrm{U}}}, \overset{\cdot\cdot\cdot}{\bar{\mathrm{F}}\mathrm{e}})$ H_2+ Impurities.	$\overset{\cdot\cdot\cdot}{\bar{\mathrm{U}}}$ 72.0; $\overset{\cdot\cdot\cdot}{\bar{\mathrm{M}}\mathrm{n}}$ 0.05; $\overset{\cdot}{\mathrm{Ca}}$ 6.00; Si 4.26; $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$ 2.30; $\dot{\mathrm{H}}$ 14.75; F, As, *tr*.
Pyromorphite......	3.5—4.5	6.5—7.1	3$\overset{\cdot}{\mathrm{Pb}}_3$ $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$+ Pb Cl.	$\overset{\cdot}{\mathrm{Pb}}$ 74.1; $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$ 15.7; Cl 2.6; Pb 7.6.

APATITE.

The composition of Apatite is phosphate of lime with chloride or fluoride of lime or both; $\overset{\cdot}{\mathrm{Ca}}_3\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}+\frac{1}{3}\mathrm{Ca(Cl,F)}$; or $[\frac{9}{10}\overset{\cdot}{\mathrm{Ca}}+\frac{1}{10}\mathrm{Ca(Cl,F)}]_{10}\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}_3$ = for *chlorapatite*. Phosphoric acid 40.92, lime 48.43 (= 89.35 $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}},\overset{\cdot}{\mathrm{Ca}}$), chlorine 6.81, calcium 3.84 (= 10.65 Cl,Ca); and for *fluorapatite*, $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$ 42.26, $\overset{\cdot}{\mathrm{Ca}}$ 50.00 (= 92.26 $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}},\overset{\cdot}{\mathrm{Ca}}$), F 3.77, Ca 3.97 (= 7.74 F,Ca); and the analysis should give for the former $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$ 40.92, $\overset{\cdot}{\mathrm{Ca}}$ 53.81; Cl 6.81; for the latter, $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$ 42.26, $\overset{\cdot}{\mathrm{Ca}}$ 55.56, F 3.77 (Rammelsberg).

The following analyses are by G. Rose (Pogg., ix, 185):

	1. SNARUM. NORWAY.	2. MURCIA, SPAIN.	3. ARENDAL, NORWAY.	4. GREINER. TYROL.
Phosphate of Lime............	91.13	92.066	92.189	92.16
Chloride of Calcium....	4.28	0.885	0.801	0.15
Fluoride of Calcium............	4.59	7.049	7.01	7.69
Specific Gravity...........	3.174	3.235	3.194	3.175

The following are a few other analyses:

	$\overset{\cdot\cdot\cdot\cdot\cdot}{\text{P}}$.	$\overset{\cdots}{\bar{\text{Fe}}}$.	$\dot{\text{M}}\text{G}$.	$\dot{\text{C}}\text{A}$.	CL.	F.	$\dot{\text{H}}$.
1. Snarum..........	41.54	1.79	—	53.46	2.66	Not deter.	—
2. Kragröe, *white*...	41.25	0.29	—	53.84	4.10	"	0.42, $\overset{\cdots}{\bar{\text{Al}}}$ 0.38; alk. 0.17; insol. 0.82.
3. " *red*.....	41.81	1.05	—	54.59	1.08	"	0.83, alk. 0.30; insol. 1.10.
4. Pargas, *blue*......	40.76	0.81	—	54.74	*Tr.*	"	— $\overset{\cdot\cdot\cdot\cdot\cdot}{\text{P}}$, $\overset{\cdots}{\bar{\text{Fe}}}$, $\overset{\cdots}{\bar{\text{Al}}}$ 0.99.
5. Miask, *yellow*....	42.08	0.17	—	55.17	*Tr.*	"	0.16
6. Staffel......	34.48	6.42	0.16	45.79	—	3.45	2.45, $\overset{\cdots}{\bar{\text{Al}}}$ 1.08; $\ddot{\text{Si}}$ 4.83; $\ddot{\text{C}}$ 1.51; $\dot{\text{Na}}$ 0.42; $\dot{\text{K}}$ 0.58.

Analysis No. 1, by Weber (Pogg., lxxxiv, 306).
" No. 2 and 3, by Völcker (J. pr. Ch., lxxv, 384).
" No. 4, by Arppe (An. Finska Min., 4).
" No. 5, by Rath (Pogg., xcvi, 331).
" No. 6, by Foster (Ib., 1866, 716).

Hardness = 4.5–5. Specific gravity = 2.92–3.25. Apatite is generally found in large crystals, which are yellow, green, blue, or violet. The colors are never very bright. It may also be white, red, flesh-red, and brown. Lustre vitreous, inclining to subresinous. Streak is white. Transparent, opaque. In the white varieties, there is sometimes a bluish opalescence in the direction of the vertical axis. Cross fracture conchoidal and uneven. Brittle.

Apatite fuses with difficulty on the edges at 4.5, coloring the flame red ($\dot{\text{C}}\text{a}$). When moistened with sulphuric acid and heated, colors the flame pale bluish-green ($\overset{\cdot\cdot\cdot\cdot\cdot}{\text{P}}$). It is soluble in hydrochloric and nitric acids, without residue, when CaFl is absent. It is sometimes phosphorescent in the dark, especially in powder.

It is found in Sweden, Norway, Switzerland, Bavaria, Bohemia, and in Cornwall.

In the United States it is found in Maine, New Hampshire, Massachusetts, New York, New Jersey, Pennsylvania, Maryland, and Delaware. Also found in Canada.

A compact variety, resembling impure limestone, has been found near Charleston, S. C. It is used in making fertilizers.

PYROMORPHITE.

The composition of Pyromorphite is phosphoric acid 15.7, oxide of lead 74.1, chlorine 2.6, lead 7.6 = phosphate of lead 89.8, chloride of lead 10.2 = 100. $[3\dot{\mathrm{P}}\mathrm{b}_3\,\overset{\cdot\cdot\cdot}{\ddot{\mathrm{P}}} + \mathrm{PbCl}$, or $(\frac{9}{10}\,\dot{\mathrm{P}}\mathrm{b} + \frac{1}{10}\,\mathrm{PbCl})_{10}\,\overset{\cdot\cdot\cdot}{\ddot{\mathrm{P}}}]$. Part of the lead is often replaced by lime, part of the chloride of lead replaced by fluoride of calcium, and arsenic acid part of the phosphoric acid.

The following are a few analyses:

LOCALITIES.	$\dot{\mathrm{P}}\mathrm{b}_3\overset{\cdot\cdot\cdot}{\ddot{\mathrm{P}}}$.	PbCl.	CaF.	$\dot{\mathrm{C}}\mathrm{a}_3\overset{\cdot\cdot\cdot}{\ddot{\mathrm{P}}}$.
1. Bleistadt (brown crystallized)	87,88	10.23	0.07	0.86, $\dot{\mathrm{F}}\mathrm{e}_2\ddot{\mathrm{P}}$ 0.77.
2. Krausberg (green).....................	89.16	10.47	—	—
3. Beresovsk (yellowish-green)...........	89.18	9.94	—	— $\dddot{\mathrm{F}}\mathrm{e}$, $\dddot{\mathrm{C}}\mathrm{r}$ 0.59, $\dddot{\mathrm{V}}$ *tr.*
4. Leadhills (orange-red)..................	90.09	9.91	—	—
Polysphœrite (with much phosphate of lime).				
5. Freiberg (brown)......................	77.02	10.84	1.09	11.05
CONTAINING ARSENIC ACID.	$\overset{\cdot\cdot\cdot}{\ddot{\mathrm{P}}}$.	$\overset{\cdot\cdot\cdot}{\ddot{\mathrm{A}}}\mathrm{s}$.	$\dot{\mathrm{P}}\mathrm{b}$.	PbCl.
6. Zschopau (white).......................	[15.17]	2.30	72.44	10.09
7. Badenweiler (wax-yellow)..............	16.11	0.66	77.46	— $\dot{\mathrm{C}}\mathrm{a}$ 2.40, Cl 2.64.
8. " (dark-orange).	15.88	0.69	77.45	— Ca 2.45, Cl undet.

Analysis No. 1 by Lerch (Ann. Ch. Pharm., xlv, 328).
" No. 2 by Sandberger (J. pr. Ch., xlvii, 462).
" No. 3 by Struve (Koksch. Min. Russl., iii, 42).
" No. 4 by Wöhler (Pogg., iv, 161).
" No. 5 by Kersten (Schw. J., lxi, 1; Pogg., xxvi, 489).
" No. 6 by Wöhler (Pogg., iv, 161).
" Nos. 7 and 8 by Seidel (Jahrb. Min., 1864, 222).

Hardness = 3.5–4. Specific gravity = 6.5–7.1, mostly when without lime; 5–6.5, when containing lime. The colors are very variable, green, yellow, brown, or white, and are depend-ent upon the composition. Streak white, sometimes yellowish. Lustre resinous. Subtransparent, subtranslucent. Fracture subconchoidal, uneven. Brittle.

Pyromorphite occurs principally in veins, and accompanies other ores of lead.

It is found in Brittany, Saxony, Bohemia, at Sonnenwerbel near Freiberg, and in Siberia. It is found green and brown at Cornwall, gray at Devon, green and yellow at Derbyshire, golden-yellow at Cumberland, red and orange formerly in Scotland, clove-brown and yellowish-green at Wicklow.

In the United States it has been found at the Perkionen lead mine near Philadelphia, and very fine at Phenixville; also in Maine, New York, Massachusetts, and Bristol, Conn. Good crystallizations of bright green and gray colors have been found in Davidson County, N. C. It is a valuable ore of lead.

21. PLATINUM.

The principal Platinum minerals are:

MINERAL.	HARDNESS.	SP. GR.	FORMULA.	COMPOSITION.
Platinum (Platina).	4—4.5	16—19	Pt + Fe, Ir, Os, etc.	Ores of Pt usually contain Pt 90%, insol. 10%, Ir ½%, Ru 2%.
Platiniridium......	6—7	22.6—23	Pt, Ir + Pd, Rh, Cu, etc.	Pt 19.64—55.44

PLATINUM.

The composition of Platinum, or Platina, is platinum combined with iron, iridium, osmium, and other metals.

The following are a few analyses:

LOCALITIES.	PT.	AU.	FE.	IR.	RH.	PD.	CU.	H.	OS.	SAND.
1. Ural.......	80.87	—	10.92	0.06	4.44	1.30	2.30	0.11	—	—
2. Choco, S. A.	86.16	—	8.03	1.09	2.16	0.35	0.40	1.91	—	0.97, Mn 0.10.
3. California .	79.85	0.55	4.45	4.20	0.65	1.95	0.75	4.95	0.05*	2.60
4. " ..	76.50	1.20	6.10	0.85	1.95	1.30	1.25	7.55	1.25*	1.50, Pb (?) 0.55.
5. " ..	63.30	0.30	6.40	0.70	1.80	0.10	4.25	[22.55]	—	— Hg 0.60.

* The loss, with some osmium.

Analysis No. 1 by Osann (Pogg., viii, 505; xi, 411: xiii, 283; xiv, 329; xv, 158).
" No. 2 by Svanberg (Institut., ii, 294).
" Nos. 3 and 4 by St. C. Deville and Debray (Ann. Ch. Phys., III, lvi, 449).
" No. 5 by Kromayer (Arch. Pharm., II, cx, 14; Jahresb., 1862, 707).

Hardness=4–4.5. Specific gravity = 16–19, 17.862, 17.759, two masses (G. Rose); 17.200, a smaller; 17.108, small grains (Breith); 17.608, a mass (Breith); 17.60, large mass from Nischne Tagilsk, Sokoloff. Color and streak are whitish steel-gray; shining. Lustre metallic. Opaque. Ductile. Fracture hackly. Occasionally magneti-polar. When crystallized, it is found in cubes and octahedra. Platinum was found in pebbles and small grains in the alluvial deposits of the River Pinto, in South America. It was first discovered in 1822, in Russia; it occurs at Nischne Tagilsk and Goroblagodat in the Ural in alluvial deposits. Russia affords annually about 800 cwt. of platinum, which is nearly ten times the amount from Brazil, St. Domingo and Borneo, which last place furnishes 600 to 800 lbs. annually. It is also found in the sands of the Rhine; in Ireland, in Honduras, in traces with gold in Rutherford Co., N. C.; at St. Francois Beauc, etc., Canada East.

The prominent masses of Platinum are:

	Weight.	
Mass brought by Humboldt from S. A. (Berlin Museum)..	1.088	grains.
" " from Coudoto (Madrid Museum)...........	11.641	"
" " " Ural (weighed $10\frac{9}{16}$ Russian pounds)..	11.57	lbs. Troy.
" in Demidoff Cabinet, the largest yet obtained.......	21	"

22. POTASSIUM.

The principal Potassium minerals are:

MINERAL.	HARDNESS.	SP. GR.	FORMULA.	COMPOSITION.
Kalinite........	2—2.5	1.75	$\dot{K}\dddot{S} + \dddot{Al}\dddot{S}_3 + 24\dot{H}$.	$\dot{K}\dddot{S}$ 18.4; $\dddot{Al}\dddot{S}$ 36.2; $\dot{H}$ 45.5.
Sylvite..........	2	1.9—2	KCl.	K 52.5; Cl 47.5.
Carnallite.......			$KCl + 2MgCl + 12\dot{H}$.	KCl 26.88; MgCl 34.20; $\dot{H}$ 38.92.
Nitre...	2	1.937	$\dot{K}\overset{\cdot\cdot\cdot\cdot\cdot}{N}$.	$\dot{K}$ 46.6; $\overset{\cdot\cdot\cdot\cdot\cdot}{N}$ 53.4.
Taylorite.......	2		$(\frac{5}{6}KO + \frac{1}{6}NH_4O)SO_3$.	KO 47; NH_4O 5.2; SO_3 47.8.
Aphthilalite....	3—3.5	1.731	$\dot{K}\dddot{S}$.	$\dot{K}$ 54.1; $\dddot{S}$ 45.9.

NITRE.

The composition of nitre, when pure, is potash 46.6; nitric acid 53.4 ($\dot{K}\ddot{N}$). Klaproth obtained for an African specimen (Beitr., i, 317) nitrate of potash 42.55, sulphate of lime 25.54, chloride of calcium 0.20, carbonate of lime 30.40.

A nitre crust from the vicinity of Constantine, Algeria, afforded $\dot{K}\ddot{N}$ 86.00, $\dot{Ca}\ddot{N}$ and $\dot{Mg}\ddot{N}$ 3.00, NaCl 6.00, $\dot{H}$ 3.50, insol., etc., 1.50 (Boussingault). Hardness = 2. Specific gravity = 1.937. Crystallizes as a right rhombic prism 118° 50′. It is usually white and transparent, or at least translucent. Streak white. Lustre vitreous. Taste saline and cooling.

Nitre deflagrates on charcoal, coloring the flame violet ($\dot{K}$). Soluble in its weight of cold and half its weight of warm water. It is not altered by exposure.

Nitre is found generally in minute needle-form crystals and crusts on the surface of the earth, on walls, rocks, etc. It forms abundantly in certain soils in Spain, Egypt and Persia, especially during hot weather succeeding rains. It is found in Madison Co., Kentucky; it is found scattered through the loose earth covering the bottom of a large cave; also in other caverns in the Mississippi valley; also in Tennessee. Nitre is the saltpetre of commerce.

23. SILICON.

The principal Silicon minerals:

MINERAL.	HARDNESS.	SP. GR.	FORMULA.	COMPOSITION.
Quartz........	7	2.5—2.8	$\ddot{Si}$.	Si 46.67; O 53.33.
Opal..........	5.5—6.5	1.9—2.3	$\ddot{Si} + x\dot{H}$.	$\dot{H} = 3 - 21\%$.
Wallastonite..	4.5—5	2.78—2.9	$\dot{Ca}\ddot{Si}$.	$\dot{Ca}$ 48.3; $\ddot{S}$ 51.7.
Pyroxene.....	5—6	3.23—3.5	$\dot{R}\ddot{Si}$ ($\dot{R}$ may be $\dot{Ca}$, $\dot{Mg}$, $\dot{Fe}$, $\dot{Mn}$, $\dot{Zn}$, $\dot{Na}$ and $\dot{K}$.	——
Malacolite.....	—	3.2—3.38	$(\dot{Ca}\dot{Mg})\ddot{Si}$.	$\dot{Ca}$ 25.8; $\dot{Mg}$ 18.5; $\dot{Si}$ 55.7.
Sahlite........	—	3.25—3.4	$(\dot{Ca}\dot{Mg}\dot{Fe})\ddot{Si}$.	$\dot{Ca}$ 24.9; $\dot{Mg}$ 18.4; $\dot{Si}$ 53.7.

THE PRINCIPAL SILICON MINERALS—(*Continued.*)

MINERAL.	HARDNESS.	SP. GR.	FORMULA.	COMPOSITION.
Hedenbergite..	—	3.5—3.58	$(\frac{1}{2}\dot{Ca} + \frac{1}{2}\dot{Fe})\ddot{Si}$.	$\dot{Fe}$ 27.01 ; $\dot{Ca}$ 22.95 ; $\ddot{Si}$ 47.78.
Augite..	—	3.25—3.5	$(\dot{Ca}\dot{Mg}\dot{Fe})(\ddot{Si}\dddot{Al}\frac{1}{3})$.	$\ddot{Si}$ 44.4—51.79 ; $\dot{Ca}$ 14—24 ; $\dot{Mg}$ 8.75—21.11 ; $\dot{Fe}$ 4.24—18.03 ; $\dddot{Al}$ 3.38—8.63.
Rhodomite ...	5.5—6.5	3.4—3.68	$\dot{Mn}\ddot{Si}$.	$\dot{Mn}$ 54.1 ; $\ddot{Si}$ 45.9.
Spodamene...	6.5—7	3.13—3.19	$(\dot{Li}_3 + \dddot{Al})\ddot{Si}_3$.	$\dot{Li}$ 6.4 ; $\dddot{Al}$ 29.4 ; $\ddot{Si}$ 64.2.
Petalite.......	6—6.5	2.39—2.5	$[(\dot{Li}\dot{Na})_3+\dddot{Al}]\ddot{Si}_3+8\ddot{Si}$.	$\dot{Li}$ 33 ; $\dot{Na}$ 1.2 ; $\dddot{Al}$ 17.8 ; $\ddot{Si}$ 77.7.
Amphibole ...	5—6.5	2.9—3.4	$\dot{R}\ddot{Si}$ ($\dot{R}$ may be $\dot{Na}$, $\dot{K}$, $\dot{Ca}$, $\dot{Mg}$, $\dot{Fe}$, and $\dot{Mn}$).	——
Tremolite	5—6.5	2.9—3.1	$(\dot{Ca}\dot{Mg})\ddot{Si}$.	$\dot{Ca}$ 12—15 ; $\dot{Mg}$ 24—26 ; $\ddot{Si}$ 57—59.
Hornblende ..	—	3.05—3.47	Three varieties, depending on the quantity of iron.	$\dot{Ca}$ 10—14 ; $\dot{Mg}$ 5—23 ; $\dddot{Al}$ 5—15 ; $\dot{Fe}$ 3—29 ; $\ddot{Si}$ 40—55.
Actinolite.....	—	3—3.2	$(\dot{Ca}\dot{Mg}\dot{Fe})\ddot{Si}$.	$\ddot{Si}$ 55—59 ; $\dot{Mg}$ 9—24 ; $\dot{Ca}$ 9—21 ; $\dot{Fe}$ 3—11.
Beryl	7.5—8	2.68—2.76	$(\frac{1}{2}\dot{Be}_3 + \frac{1}{2}\dddot{Al})\ddot{Si}_2$.	$\dot{Be}$ 14.1 ; $\dddot{Al}$ 19.1 ; $\ddot{Si}$ 66.8.
Chrysolite....	6—7	3.33—3.5	$(\dot{Mg}\dot{Fe})_2\ddot{Si}$.	$\dot{Mg}$ 50.28 ; $\dot{Fe}$ 9.36 ; $\ddot{Si}$ 40.75.
Willemite.....	5.5	3.89—4.18	$\dot{Zn}_2\ddot{Si}$.	$\dot{Zn}$ 72.9 ; $\ddot{Si}$ 27.1.
Phenacite.....	7.5—8	2.96—3	$\dot{Be}_2\ddot{Si}$.	$\dot{Be}$ 45.8 ; $\ddot{Si}$ 54.2.
Garnet........	6.5—7.5	3.15—4.31	$(\dot{R}_3)_2\ddot{Si}_3 + \dot{R}_2\ddot{Si}_3$.	——
Pyrope........	—	3.7—3.76	$[\frac{1}{2}(\dot{Mg}\dot{Ca}\dot{Fe}\dot{Mn})_3 + \frac{1}{2}\dddot{Al}]_2\ddot{Si}_3$.	$\dot{Mg}$ 13.43 ; $\dddot{Al}$ 22.47 ; $\dot{Ca}$ 6.53 ; $\dot{Fe}$ 9.29 ; $\dot{Mn}$ 6.27 ; $\ddot{Si}$ 42.45.
Groxularite ..	—	3.4—3.7	$(\frac{1}{2}\dot{Ca}_3,\frac{1}{2}\dddot{Al})_2\ddot{Si}_3$.	$\dot{Ca}$ 37.2 ; $\dddot{Al}$ 22.7 ; $\ddot{Si}$ 40.1.
Almandite....	—	—	$(\frac{1}{2}\dot{Fe}_3 + \frac{1}{2}\dddot{Al})_2\ddot{Si}_3$.	$\dot{Fe}$ 43.3 ; $\dddot{Al}$ 20.5 ; $\ddot{Si}$ 36.1.
Spessartite....	—	3.7—4.4	$[\frac{1}{2}(\dot{Mn}\dot{Fe})_3 + \frac{1}{2}\dddot{Al}]_2\ddot{Si}_3$.	$\dot{Mn}$ 30.96 ; $\dot{Fe}$ 14.93 ; $\dddot{Al}$ 18.06 ; $\ddot{Si}$ 35.33.
Ouvarovite....	7.5	3.41—3.52	$(\frac{1}{2}\dot{Ca}_3+\frac{1}{2}\dddot{Cr})_2\ddot{Si}_3$.	——
Zircon........	7.5	4.05—4.75	$\ddot{Zr}\ddot{Si}$.	$\ddot{Zr}$ 67 ; $\ddot{S}$ 33.
Versuvianite .	6.5	3.49—3.45	$[\frac{2}{3}(\dot{Ca}\dot{Mg}\dot{Fe})_3 + \frac{1}{3}(\dddot{Al}\dddot{Fe})]_2\ddot{Si}_3$.	Ca 27—38 ; $\dot{Mg}$ 0—10 ; $\dot{Fe}$ 0—16; $\dddot{Al}$ 10—26; $\ddot{Si}$ 35—39.

THE PRINCIPAL SILICON MINERALS—(*Continued.*)

MINERAL.	HARDNESS.	SP. GR.	FORMULA.	COMPOSITION.
Epidote.......	6—7	3.25—3.5	$(\frac{1}{3}\dot{\mathrm{Ca}}_3+\frac{2}{3}(\dddot{\mathrm{Fe}}\dddot{\mathrm{Al}})_2\ddot{\mathrm{Si}}_3$.	$\dot{\mathrm{Ca}}$ 16—30; $\dddot{\mathrm{Al}}$ 14—28; $\dddot{\mathrm{Fe}}$ 7—17; $\ddot{\mathrm{Si}}$ 36—37.
Iolite.........	7—7.5	2.56—2.67	$2\,(\mathrm{MgFe})\ddot{\mathrm{Si}}+\mathrm{Al}_2\ddot{\mathrm{Si}}_3$.	$\dot{\mathrm{Mg}}$ 8.8; $\dot{\mathrm{Fe}}$ 7.9; $\dddot{\mathrm{Al}}$ 33.9; $\ddot{\mathrm{Si}}$ 49.4.
Biotite...	2.5—3	2.7—3.1	$[\frac{1}{2}(\dot{\mathrm{K}}\,\dot{\mathrm{Mg}}\,\dot{\mathrm{Fe}})_3+\frac{1}{2}(\dddot{\mathrm{Al}}\dddot{\mathrm{Fe}})]_2\ddot{\mathrm{Si}}_3$.	$\dot{\mathrm{Mg}}$ 4—25; $\dot{\mathrm{Fe}}$ 0—20; $\dddot{\mathrm{Al}}$ 11—21; $\dddot{\mathrm{Fe}}$ 4—25; $\ddot{\mathrm{Si}}$ 36—44.
Muscovite.....	2—2.5	2.75—3.1	$[\dot{\mathrm{K}}_3(\dddot{\mathrm{Al}}\dddot{\mathrm{Fe}})]_2\ddot{\mathrm{Si}}_3+1\frac{1}{2}\ddot{\mathrm{Si}}$.	$\dot{\mathrm{K}}$ 5—12; $\dddot{\mathrm{Al}}$ 31—39; $\dddot{\mathrm{Fe}}$ 1—8; $\ddot{\mathrm{Si}}$ 43—50.
Lepidolite	2.5—4	2.84—3	$[(\dot{\mathrm{K}}\mathrm{Li})_3(\dddot{\mathrm{Al}}\dddot{\mathrm{Fe}})]_2\ddot{\mathrm{Si}}_3+2\ddot{\mathrm{Si}}$.	$\dot{\mathrm{K}}$ 4—14; $\dot{\mathrm{Li}}$ 1—5; $\dddot{\mathrm{Al}}$ 14—38; $\dddot{\mathrm{Fe}}$ 0—11; $\ddot{\mathrm{Si}}$ 49—54.
Wernerite	5—6	2.63—2.8	$[\frac{1}{3}(\dot{\mathrm{Ca}}\dot{\mathrm{Na}})_3+\frac{2}{3}\dddot{\mathrm{Al}}]_2\ddot{\mathrm{Si}}_3+\ddot{\mathrm{Si}}$.	$\dot{\mathrm{Na}}$ 5; $\dot{\mathrm{Ca}}$ 18.1; $\dddot{\mathrm{Al}}$ 28.5; $\ddot{\mathrm{Si}}$ 48.4.
Nephelite.....	5.5—6	2.5—2.65	$(\dot{\mathrm{Na}}_3\mathrm{K}_3)_2\ddot{\mathrm{Si}}_3+3\dddot{\mathrm{Al}}_2\ddot{\mathrm{Si}}_3+3\ddot{\mathrm{Si}}$.	$\dot{\mathrm{Na}}$ 16.9; $\dot{\mathrm{K}}$ 5.2; $\dddot{\mathrm{Al}}$ 33.7; $\ddot{\mathrm{Si}}$ 44.2.
Lapis-Lazuli..	5—5.5	2.38—2.45	$\dot{\mathrm{Na}}$, $\dot{\mathrm{Ca}}$, $\dddot{\mathrm{Al}}$, $\dddot{\mathrm{Fe}}$, $\ddot{\mathrm{Si}}$, $\dddot{\mathrm{S}}$, S.	$\dot{\mathrm{Na}}$ 0—12; $\dot{\mathrm{Ca}}$ 1—23; $\dddot{\mathrm{Al}}$ 11—43; $\dddot{\mathrm{Fe}}$ 0—4; $\ddot{\mathrm{Si}}$ 40—66; $\ddot{\mathrm{S}}$ 0—5; S 0—4.
Haüynite....	5.5—6	2.4—2.5	$(\frac{1}{4}\dot{\mathrm{Na}}_3+\frac{3}{4}\dddot{\mathrm{Al}})_2\ddot{\mathrm{Si}}_3+\dot{\mathrm{Ca}}\dddot{\mathrm{S}}$.	$\dot{\mathrm{Na}}$ 16.5; $\dddot{\mathrm{Al}}$ 27.4; $\ddot{\mathrm{Si}}$ 32; $\dot{\mathrm{Ca}}$ 9.9; S 14.2.
Leucite.......	5.5—6	2.44—2.56	$\dot{\mathrm{K}}\ddot{\mathrm{Si}}+\dddot{\mathrm{Al}}\ddot{\mathrm{Si}}_3$.	$\dot{\mathrm{K}}$ 21.5; $\dddot{\mathrm{Al}}$ 23.5; $\ddot{\mathrm{Si}}$ 55.
Anorthite.....	6—7	2.66—2.78	$(\frac{1}{4}\dot{\mathrm{Ca}}_3+\frac{3}{4}\dddot{\mathrm{Al}})_2\ddot{\mathrm{Si}}_2$.	$\dot{\mathrm{Ca}}$ 20; $\dddot{\mathrm{Al}}$ 36.9; $\ddot{\mathrm{Si}}$ 43.1.
Labradorite...	6	2.67—2.76	$(\dot{\mathrm{Na}},\dot{\mathrm{Ca}})\ddot{\mathrm{Si}}+\dddot{\mathrm{Al}}\ddot{\mathrm{Si}}_2$.	$\dot{\mathrm{Na}}$ 4.5; $\dot{\mathrm{Ca}}$ 12.3; $\dddot{\mathrm{Al}}$ 30.3; $\ddot{\mathrm{Si}}$ 52.9.
Oligoclase....	6—7	2.56—2.72	$\frac{1}{4}(\dot{\mathrm{Na}},\dot{\mathrm{Ca}})_3+\frac{3}{4}\dddot{\mathrm{Al}})\ddot{\mathrm{Si}}_2+3\frac{1}{2}\ddot{\mathrm{Si}}$.	$\dot{\mathrm{Na}}$ 2—12; $\dot{\mathrm{Ca}}$ 0.5—5; $\dddot{\mathrm{Al}}$ 19.24; $\ddot{\mathrm{Si}}$ 59—64.
Albite	6—7	2.59—2.65	$(\frac{1}{4}\dot{\mathrm{Na}}_3+\frac{3}{4}\dddot{\mathrm{Al}})_2\ddot{\mathrm{Si}}_2+6\ddot{\mathrm{Si}}$.	$\dot{\mathrm{Na}}$ 11.8; $\dddot{\mathrm{Al}}$ 19.6; $\ddot{\mathrm{Si}}$ 68.6.
Orthoclase....	6—6.5	2.44—2.62	$(\frac{1}{4}\dot{\mathrm{K}}_3+\frac{3}{4}\dddot{\mathrm{Al}})_2\ddot{\mathrm{Si}}_2+6\ddot{\mathrm{Si}}$.	$\dot{\mathrm{K}}$ 16.9; $\dddot{\mathrm{Al}}$ 18.8; $\ddot{\mathrm{Si}}$ 64.6.
Chrondrodite.	6—6.5	3.118—3.24	$\mathrm{Mg}_2\ddot{\mathrm{Si}}_2$.	One sample gave $\dot{\mathrm{Mg}}$ 54.5; $\dot{\mathrm{Fe}}$ 6.75; $\ddot{\mathrm{Si}}$ 33.19; Fe 5.56.
Tourmaline ..	7—7.5	2.94—3.3	$[(\dot{\mathrm{Na}},\dot{\mathrm{K}},\dot{\mathrm{Ca}},\dot{\mathrm{Mg}},\dot{\mathrm{Fe}})_3(\dddot{\mathrm{Fe}},\dddot{\mathrm{Al}},\dddot{\mathrm{B}})]_2\ddot{\mathrm{Si}}_2$.	$\dot{\mathrm{Na}}$ 0—5; $\dot{\mathrm{K}}$ 0—4; $\dot{\mathrm{Ca}}$ 0—2. $\dot{\mathrm{Mg}}$ 0—15; $\dot{\mathrm{Fe}}$ 0—17; $\dddot{\mathrm{Fe}}$ 0—11; $\dddot{\mathrm{Al}}$ 30—44; $\dddot{\mathrm{B}}$ 4—11; $\ddot{\mathrm{Si}}$ 35—40.

THE PRINCIPAL SILICON MINERALS—(*Continued*).

MINERAL.	HARDNESS.	SP. GR.	FORMULA.	COMPOSITION.
Andalusite....	7.5 (for transparent). 3.1—3.2 (for opaque)	3.05—3.35	$\dddot{\mathrm{Al}}\ddot{\mathrm{Si}}$.	$\dddot{\mathrm{Al}}$ 63.2; $\ddot{\mathrm{Si}}$ 36.8.
Fibrolite......	6—7	3.2—3.3	$\dddot{\mathrm{Al}}\ddot{\mathrm{Si}}$.	$\dddot{\mathrm{Al}}$ 63.2; $\ddot{\mathrm{S}}$.36.8 ($\dddot{\mathrm{Al}}$ may be replaced by 2% $\dddot{\mathrm{Al}}$ or 0.8% $\dot{\mathrm{Mg}}$. $\dot{\mathrm{H}}$ may be present.)
Cyanite.......	5—7.25	3.45—3.7	$\dddot{\mathrm{Al}}\ddot{\mathrm{Si}}$.	$\dddot{\mathrm{Al}}$ 63.2: $\ddot{\mathrm{S}}$ 36.8.
Topaz	8	3.4—3.65	$\dddot{\mathrm{Al}}\ddot{\mathrm{Si}}(\mathrm{Fl})$.	Si 15.17; Al 29.58; O 34.67; Fl 20.58.
Euclase.......	7.5	3.098	$(\frac{1}{3}\dot{\mathrm{H}}_3 + \frac{2}{3}\dot{\mathrm{Be}}_3 + \frac{2}{3}\dddot{\mathrm{Al}})\ddot{\mathrm{Si}}$.	$\dot{\mathrm{Be}}$ 17.4; $\dddot{\mathrm{Al}}$ 35.3; $\ddot{\mathrm{Si}}$ 41.1; $\dot{\mathrm{H}}$ 6.2.
Datolite	5—5.5	2.8—3	$(\dot{\mathrm{Ca}}_2,\dot{\mathrm{H}}_2,\dddot{\mathrm{B}})\ddot{\mathrm{Si}}$.	$\dot{\mathrm{Ca}}$ 35.0; $\dot{\mathrm{H}}$ 5.6; $\dddot{\mathrm{B}}$ 21.9; $\ddot{\mathrm{Si}}$ 37.5.
Titanite	5—5.5	3.4—3.56	$(\dot{\mathrm{Ca}},\dot{\mathrm{Ti}})\ddot{\mathrm{Si}}$.	Ca 21—28; Ti 33—43; $\ddot{\mathrm{Si}}$ 30.35.
Staurolite.....	7—7.5	3.4—3.8	$[\frac{1}{3}(\frac{1}{3}\dot{\mathrm{H}} + \frac{1}{3}\dot{\mathrm{Mg}} + \frac{1}{3}\dot{\mathrm{Fe}})_3\ \frac{2}{3}\dddot{\mathrm{Al}})_4\ddot{\mathrm{Si}}_3$.	H 1.7; $\dot{\mathrm{Mg}}$ 2.5; $\dot{\mathrm{Fe}}$ 15.8; $\dddot{\mathrm{Al}}$ 51.7; $\ddot{\mathrm{Si}}$ 28.3.
Pectolite......	5	2.68—2.78	$(\frac{1}{3}\dot{\mathrm{H}} + \frac{1}{3}\dot{\mathrm{Na}} + \frac{2}{3}\dot{\mathrm{Ca}})\ddot{\mathrm{Si}}$.	$\dot{\mathrm{H}}$ 2.7; $\dot{\mathrm{Na}}$ 9.3; $\dot{\mathrm{Ca}}$ 33.8; $\ddot{\mathrm{Si}}$ 54.2.
Laumontite...	3.5—4	2.25—2.36	$(\frac{1}{3}\dot{\mathrm{Ca}}_3 + \frac{2}{3}\dddot{\mathrm{Al}})\ddot{\mathrm{Si}}_2 + 3\dot{\mathrm{H}}$.	$\dot{\mathrm{Ca}}$ 11.9; $\dddot{\mathrm{Al}}$ 21.9; $\ddot{\mathrm{Si}}$ 50.9; $\dot{\mathrm{H}}$ 15.3.
Dioptose	5	3.278—3.48	$\dot{\mathrm{Cu}}\ddot{\mathrm{Si}} + \dot{\mathrm{H}}$.	Cu 50.4; $\ddot{\mathrm{Si}}$ 38.2; $\dot{\mathrm{H}}$ 11.4.
Chrysocolla...	2—4	2—2.38	$\dot{\mathrm{Cu}}\ddot{\mathrm{Si}} + 2\dot{\mathrm{H}}$.	$\dot{\mathrm{Cu}}$ 45.3; $\dot{\mathrm{H}}$ 20.5; $\ddot{\mathrm{Si}}$ 34.2.
Calamine......	4.5—5	3.16—3.9	$\dot{\mathrm{Zn}}_2\ddot{\mathrm{Si}} + \dot{\mathrm{H}}$.	Zn 67.5; $\dot{\mathrm{H}}$ 7.5; $\ddot{\mathrm{Si}}$ 25.
Prehnite......	6—6.5	2.8—2.95	$(\frac{1}{3}\dot{\mathrm{H}} + \frac{2}{3}\dot{\mathrm{Ca}} + \frac{2}{3}\dddot{\mathrm{Al}})_2\ddot{\mathrm{Si}}_3$.	Ca 27.1; $\dot{\mathrm{H}}$ 4.4; $\dddot{\mathrm{Al}}$ 24.9; $\ddot{\mathrm{Si}}$ 43.6.
Chlorastrolite.	5.5—6	3.18	$(\dot{\mathrm{Ca}}_3,\mathrm{Na}_3)_2\ddot{\mathrm{Si}}_2 + 2(\dddot{\mathrm{Al}},\dddot{\mathrm{Fe}})_2\ddot{\mathrm{Si}}_3 + 6\dot{\mathrm{H}}$.	$\dot{\mathrm{Na}}$ 5.2; $\dot{\mathrm{Ca}}$ 18.7; $\dddot{\mathrm{Fe}}$ 6.4; $\dddot{\mathrm{Al}}$ 24.6; $\ddot{\mathrm{Si}}$ 37.6; $\dot{\mathrm{H}}$ 7.5.
Apophyllite...	4.5—5	2.3—2.4	$[\frac{1}{3}\dot{\mathrm{H}} + \frac{2}{3}(\frac{1}{8}\dot{\mathrm{K}} + \frac{7}{8}\dot{\mathrm{Ca}})]_2\ddot{\mathrm{Si}} + \dot{\mathrm{H}}\ddot{\mathrm{Si}}$.	$\dot{\mathrm{H}}$ 16.7; $\dot{\mathrm{K}}$ 4.8; $\dot{\mathrm{Ca}}$ 23; $\ddot{\mathrm{Si}}$ 55.5.
Natrolite.	5—5.5	2.17—2.25	$\dot{\mathrm{Na}}\dddot{\mathrm{Al}},3\ddot{\mathrm{Si}},2\dot{\mathrm{H}}$.	$\dot{\mathrm{Na}}$ 16.3; $\dddot{\mathrm{Al}}$ 27; $\ddot{\mathrm{Si}}$ 47.2; $\dot{\mathrm{H}}$ 9.5.
Analcite	5—5.5	2.22—2.29	$\dot{\mathrm{Na}},\dddot{\mathrm{Al}},4\ddot{\mathrm{Si}},2\dot{\mathrm{H}}$.	$\dot{\mathrm{Na}}$ 14.1; $\dddot{\mathrm{Al}}$ 23.3; $\ddot{\mathrm{Si}}$ 54.4; $\dot{\mathrm{H}}$ 8.2.

THE PRINCIPAL SILICON MINERALS—(*Continued*).

MINERAL.	HARDNESS.	SP. GR.	FORMULA.	COMPOSITION.
Chabazite.....	4.5	2.0—2.19	$[\frac{2}{3}\dot{Ca} + \frac{1}{3}(\dot{Na},\dot{K})] \dddot{Al},4\ddot{Si},6\dot{H}$.	$\dot{Ca}$ 4—11; $\dot{Na}$ 0—4; $\dot{K}$ 0.17—2.58; $\dddot{Al}$ 17—21; $\ddot{Si}$ 45—52; $\dot{H}$ 19—22.
Harmotome...	4.5	2.44—2.45	$\dot{Ba},\dddot{Al},5\ddot{Si} + 5\dot{H}$.	$\dot{Ba}$ 23.7; $\dddot{Al}$ 15.9; $\ddot{Si}$ 46.5; $\dot{H}$ 13.9. When it contains $\dot{Ca}$ 7.4; $\dddot{Al}$ 20.5; $\ddot{Si}$ 47.9; $\dot{K}$ 6.3; $\dot{H}$ 17.9.
Stelbite	3.5—4	2.094—2.205	$\dot{Ca},\dddot{Al},6\ddot{Si},6\dot{H}$.	$\dot{Ca}$ 8.9; $\dddot{Al}$ 16.5; $\ddot{Si}$ 57.4; $\dot{H}$ 17.2.
Henlandite....	3.5—4	2.2	$\dot{Ca},\dddot{Al},6\ddot{Si},5\dot{H}$.	$\dot{Ca}$ 9.2; $\dddot{Al}$ 16.9; $\ddot{Si}$ 59.1; $\dot{H}$ 14.8.
Talc...........	1.15	2.565—2.8	$(\frac{4}{5}\dot{Mg} + \frac{1}{5}\dot{H})\ddot{Si}$.	$\dot{Mg}$ 33.5; $\ddot{Si}$ 62.8; $\dot{H}$ 3.7.
Sepiolite......	2—2.5	—	$\dot{Mg}_2\ddot{Si}_3 + 2\dot{H}$.	$\dot{Mg}$ 27.1; $\dot{H}$ 12.1; $\ddot{Si}$ 60.8.
Serpentine....	—	—	$(\frac{3}{4}\dot{Mg}+\frac{1}{4}\dot{H})_2\ddot{Si} + \frac{1}{2}\dot{H}$.	$\dot{Mg}$ 42.97; $\ddot{Si}$ 44.14; $\dot{H}$ 12.89.
Prochlorite....	1—2	2.78—2.96	$[\frac{4}{7}(\dot{Mg},\dot{Fe})_3 + \frac{3}{7}\dddot{Al}] \ddot{Si}\frac{4}{3}\dot{H}$.	$\dot{Mg}$ 15.3; $\dot{Fe}$ 27.5; $\dddot{Al}$ 19.7; $\ddot{Si}$ 26.8; $\dot{H}$ 11.7.

QUARTZ.

The composition of Quartz is pure silica or silicon 46.67, oxygen 53.33 (SiO_2). The many different varieties of quartz may be regarded as allotropic modifications. "Quartz may be massive; coarse or fine granular to flint-like or crypto-crystalline. Sometimes mamillary, stalactitic, and in concretionary forms."

Colorless when pure; often various shades of yellow, red, brown, green, blue, and black. Streak is white, with pure varieties; if impure, often the same as color, although paler. Transparent, opaque. Hardness = 7. Specific gravity = 2.5–2.8; 2.6413–2.641 (Bendant); 2.663 (Deville). It acquires vitreous electricity by friction, but loses it very quickly. Tough, brittle, friable. Polarization circular, there being a colored centre instead of a central cross, and the rings of color around enlarging as the analyzer is turned to the right in the right-handed crystals, or left in the left-handed; and colored spirals are seen, which rotate to the right or left, when the incident light and emergent light are polarized, one circularly and the other plane.

It is infusible before the blowpipe. With soda it unites, with effervescence; with salt of phosphorus no action takes place. It is not acted upon by any acid except hydrofluoric.

The varieties of quartz are quite numerous, and may be considered as follows:

"Crystallized Quartz.

"Concretionary Quartz, Agate, or Chalcedony.

"Jasper.

"Silex or Flint, which is more easily attacked by alkalies than the other varieties. It is never pure.

"Earthy Quartz, sometimes in the shape of flour, and in every way analogous to the silicic acid produced in the laboratories. It is often formed of the skeletons of infusoria.

"Quartzites and Sand."

With respect to Crystallized Quartz, the form is a rhombohedron of 94° 15′, but this primitive form is rarely found, and is always in very small crystals. The most general form is the combination of two rhombohedra, by which the prism is apparently terminated by a hexagonal pyramid. The rhombohedron with the hexagonal prism is a form sometimes found.

Quartz is found penetrated by various minerals, "as topaz, chrysoberyl, garnet, different species of hornblende and pyroxene groups, kyanite, zeolites, calcite and other carbonates, rutile, stibnite, hematite, göthite, magnetite, fluorite, gold, silver, anthracite, etc."

Concretionary Quartz, Agate, or Chalcedony is less pure than crystallized quartz. A gray chalcedony from Hungary gave, according to Redtenbaher (Ramm. Min. Ch., 1007), $\ddot{\mathrm{Si}}$ 98.87, $\dddot{\mathrm{\bar{F}e}}$ 0.53, $\dot{\mathrm{Ca}}\ddot{\mathrm{C}}$ 0.62 = 100.02. Heintz analyzed a carnelian, which was a clear red, and found the red color to be due to ferric oxide—$\dddot{\bar{\text{Fe}}}$ 0.050, $\dddot{\bar{\text{Al}}}$ 0.081, $\dot{\text{Mg}}$ 0.028, $\dot{\text{K}}$ 0.043, $\dot{\text{Na}}$ 0.075.

Klaproth analyzed a specimen of chrysoprase which was apple-green, and found in that of Silesia (Beitr, ii, 127), $\ddot{\text{Si}}$ 96.16, $\dddot{\bar{\text{Al}}}$ 0.08, $\dddot{\bar{\text{Fe}}}$ 0.08, $\dot{\text{Ni}}$ 1.0, $\dot{\text{Ca}}$ 0.83, $\dot{\text{H}}$ 1.85 = 100. The color was due to the presence of nickelous oxide.

Redtenbacher has analyzed a brown-banded agate with the following results: $\ddot{\text{Si}}$ 98.91, $\dddot{\bar{\text{Fe}}}$ 0.72, $\dot{\text{Ca}}\ddot{\text{C}}$ 0.31 = 99.94. Some agates which are remarkable for their colors are made use of in the arts, such as the blue variety called sapphirine. Besides the carnelian, which is clear red, and the chrysoprase, which is clear apple-green, mentioned above, the phrase, which is dark-green, and the sardine-stone, which is dark-brown, are much used in the arts. When agates are used for cameos, they must have parallel layers of different colors. These are often produced artificially. The zone or ribbon agate is much used in the arts. When the zones or strata are in parallel layers, and the colors in great contrast, this variety is called onyx.

JASPER is the name given to impure, opaque-colored quartz. The *red jasper* is colored by ferric oxide—the *brownish* or *ochre-yellow jasper* is colored by hydrated ferric oxide, which when heated loses water and becomes red. It may also be dark-green and brownish-green; grayish blue and blackish or brownish-black. Striped or ribbon jasper has the colors in broad stripes; *Egyptian jasper* in nodules, which are zoned in brown and yellowish colors. Jasper admits of a high polish, and is used for vases, boxes, etc. *Porcelain jasper* is nothing but baked clay, and differs from true jasper in being, before the blowpipe, fusible on the edges. *Red porphyry*, or its base, resembles jasper, but is also fusible on the edges, being usually an impure feldspar. Jasper is used extensively in the manufacture of Florentine mosaics.

In the variety of quartz called SILEX or FLINT, there is no trace of crystallization to be distinguished, not even under the microscope. The colors are not so bright as in chalcedony. Lustre is barely glistening. Subvitreous. It breaks with a deeply conchoidal fracture, and a sharp cutting edge. It contains more impurities than the agate. There is usually one per cent. or so of alumina and peroxide of iron, with one or two of water. The coloring matter of the common kinds is mostly carbonaceous matter.

EARTHY QUARTZ.—This variety is another distinct allotropic modification. It is sometimes called Flowers of Silica, and is almost entirely soluble in alkalies.

SAND is the name applied to quartz in a finely-divided state. Sand may be of different kinds; sometimes each grain is a complete crystal, sometimes it is rounded or concretionary, and sometimes it appears to have no form, but made up of fragments of crystals.

When the grains of sand are united by a cement, such as ferric oxide or lime, large and round fragments are formed called pudding-stones. If the fragments are angular, it is called breccia. When the cement is silicic acid, it forms a rock which is called QUARTZITE. At Fontainebleau, the sands contain sufficient lime to cause them to crystallize with the form of calcite, even when they contain as much as 80–85% of silicic acid. Quartz is found all over the United States.

Quartz crystals are sometimes found of enormous size. A group in the Museum of the University of Naples weighs nearly half a ton. A crystal belonging to Sig. Rafelli, of Milan, measures 3¼ ft. in length and 5½ in circumference, and its weight is estimated at 870 lbs. Another in Paris 3 feet in diameter and weighs 8 cwt. A group from Moose Mountain, N. H., at Dartmouth College, weighs 147½ lbs. and contains 48 crystals, four of them from 5 to 5½ inches in diameter, ten from 4 to 4¾ inches. A crystal from Waterbury, Vt., is 2 ft. long and 18 inches through, and weighs 175 lbs.

OPAL.

The composition of Opal is $\ddot{\mathrm{S}}\mathrm{i}$, the same as quartz, but it contains a varying quantity of water, from 3 to 21%.

The following are a few analyses of opal:

LOCALITIES.	$\ddot{\text{Si}}$.	$\dot{\text{H}}$.	$\dddot{\overline{\text{Al}}}$.	$\dddot{\overline{\text{Fe}}}$.	$\dot{\text{Ca}}$.	$\dot{\text{Na}}$.	$\dot{\text{K}}$.	$\dot{\text{Mg}}$.	$\dddot{\text{S}}$.
1. Czerwenitza (precious opal).....	90	10	—	—	—	—	—	—	—
2. Zimapan (fire opal)	92	7.75	—	0.25	—	—	—	—	—
3. Faröe (fire opal)....	88.73	7.97	0.99	—	0.49	0.84		1.48	—
4. Schiffenberg (semi-opal)..........	90.20	2.73	1.86	4.11	—	0.90	0.30	0.86	0.31
5. Oberkassel (wood opal)..........	93.01	4.12	0.12	0.37	—	—	—	—	—
6. Waltsch, Bohem. (hyalite).......	96.94	3.06	—	—	—	—	—	—	—
7. Iceland (geyserite)...............	91.56	5.76	1.04	0.18	0.33	0.16	0.19	0.47	0.31
8. Bilin (tripolite)..................	87.58	8.89	2.04		1.09	—	—	0.30	—
9. Luneberg (infusorial earth)......	87.86	8.43	0.13	0.73	0.75	—	—	—	Org. 2.28
10. Paris (Q. nectique—floatstone) ..	94.00	5.00	0.5		—	—	—	—	—

Analysis No. 1 by Klaproth (Beitr., ii, 151).
" " 2 " " (l. c., iv, 156).
" " 3 " Forchhammer (Pogg., xxxv, 331).
" " 4 " Wrightson (Ann. Ch. Pharm., liv, 358).
" " 5 " R. Brandes (Nogg. Geb. Rh. Westph., i, 338).
" " 6 " Damour (Bull. G. Fr., II, v, 163, 1848).
" " 7 " Bickell (Ann. Ch. Pharm., lxx, 290).
" " 8 " Baumann (Ramm. Min. Ch., 186).
" " 9 " Haustein and Schultz (Ann. Ch. Pharm., xcv, 292)
" " 10 " Bucholz (Leonk. Tasch., vi, 5, 8).

Opal may have the following colors: white, yellow, red, brown, green, and gray; the colors are generally pale. It often has a very bright play of colors. Streak is white. Lustre is vitreous, pearly, or resinous. Transparent, translucent, opaque. Its hardness is from 5.5 to 6.5. Specific gravity = 1.9–2.3. It is infusible before the blowpipe, but loses water and becomes opaque. In some varieties the transparency may be made to reappear by plunging it into water.

When the colors are very dark, they arise from foreign admixtures; in such cases, sulphuric acid will turn it black, owing to organic matter. Some yellow varieties, containing oxide of iron, turn red. It is soluble in alkalies.

In a vacuum it loses its water and becomes entirely opaque.

The variety known as precious opal is generally found disseminated in trachytic or porphyritic rocks. Such opals are greatly prized as objects of ornament. The play of colors of the opal seems to depend on the hydration of the silicic acid;

for if an opal is heated it loses fire, but often regains it to a less degree if plunged into water.

Precious opal occurs in porphyry at Czerwenitza, near Kashaw, in Hungary; also in Honduras. *Fire opal* occurs at Zimapan, in Mexico. *Common opal* is abundant at Telkebanya, in Hungary; in Moravia, Bohemia, Iceland, the Giant's Causeway, and the Hebrides. *Hyalite* occurs at Schemnitz, in Hungary. *Wood opal* forms large trees in the pumice conglomerate of Saiba; also in Hungary, Faröe, and Tasmania.

The *Luneberg earth* contains many species of infusoria, and is 10 to 18 feet thick.

In the United States, *hyalite* occurs sparingly in New York, rarely in North Carolina, and in Georgia and Florida. In Washington County, Georgia, good fire opals have been found.

BERYL.

The composition of Beryl is silica 66.8, alumina 19.1, glucina 14.1 $(\frac{1}{2}\dot{B}e_3 + \frac{1}{2}\dddot{Al})\ddot{S}i_3$.

There are two prominent groups of beryl depending on the color, the color varying as chromium or iron is present. When the color is bright emerald green, it is owing to the presence of chromium and is called *Emerald.* All other specimens are called *Beryl,* and owe their color to iron.

The following are a few analyses:

	$\ddot{S}i$.	$\dddot{Al}$.	$\dot{B}e$.	$\dddot{F}e$	$\dot{C}a$.	$\dot{M}g$.
1. Rosenbach, *Beryl*.....	65.51	20.71	11.46	1.33	0.23	0.12
2. Fossum "	67.00	19.64	12.56	0.53	0.18	—
3. Goshen, Mass., "	66.97	17.22	12.92	2.03	—	$\dddot{M}n$, *tr.*
4. Muso, *Emerald*.........	68.50	15.75	12.50	1.00	—	$\dddot{C}r$ 0.30, Ca 0.35.

Analysis No. 1, by Hofmeister (Ib., lxxxi, 1).
" No. 2, by Scheerer (Pogg., xlix, 533).
" No. 3, by Mallet (Am. J. Sci., II, xvii, 180).
" No. 4, by Klaproth (Beitr., iii, 215).

The colors of beryl are very variable; they are emerald green, pale green, passing into light blue, yellow and white.

Streak is white. Brittle. Lustre vitreous or resinous; the opaque varieties, however, have no lustre. Double refraction feeble; axis negative. Hardness = 7.5–8. Specific gravity = 2.63–2.76. At a high temperature before the blowpipe the edges become rounded. Fuses at 5.5 (Kobell).

The colored varieties become white when heated and lose in weight, which would seem to indicate that the color is due to organic matter. Glass with borax clear and colorless for beryl, a fine green for emerald. Unacted upon by acids.

Emeralds are found in clay-slate near Muso, New Grenada. A perfect hexagonal crystal from this locality, two inches long, is in the cabinet of the Duke of Devonshire. Emeralds of less beauty but of large size are found in Siberia, Mount Zalora, and in Upper Egypt. Transparent beryls are found in Siberia, Hindostan and Brazil. Beryls of gigantic size have been found in New Hampshire and in Massachusetts. One beryl from Grafton, N. H., weighs 2.900 pounds; it is 32 inches through in one direction and 22 in another. It is also found in Maine, Connecticut, and Pennsylvania.

GARNET.

Garnet is a unisilicate, of sesquioxide and protoxide bases, having the general formula $(\frac{1}{2}\dot{\mathrm{R}}_2+\frac{1}{2}\dddot{\bar{\mathrm{R}}})_2\mathrm{Si}_3$ or $(\dot{\mathrm{R}}_3)_2\ddot{\mathrm{Si}}_3+\dddot{\bar{\mathrm{R}}}_2\mathrm{Si}_3$. The following are the varieties (with the exception of the last) which blend together more or less completely, through varieties containing combinations of the protoxide bases and also of the sesquioxide bases:

A. Grossularite or *Lime-alumina garnet.*
B. Pyrope or *Magnesia-alumina garnet.*
C. Almandite or *Iron-alumina garnet.*
D. Spessartite or *Manganese-alumina garnet.*
E. Andradite or *Lime-iron garnet.*
F. Bredergite or *Lime-magnesia-iron garnet.*
G. Ouvarovite or *Lime-chrome garnet.*

The following are a few analyses of the different varieties:

	$\ddot{\text{Si}}$	$\dddot{\text{Al}}$	$\dddot{\text{Fe}}$	$\dot{\text{Fe}}$	$\dot{\text{Mn}}$	$\dot{\text{Mg}}$	$\dot{\text{Ca}}$	
1. Sludianka R., *Gross*........	40.99	14.90	10.94	—	—	0.98	32.94	
2. Wilni, *Grossularite*..........	38.25	19.35	7.33	—	0.50	2.40	31.75	
3. Pyrope.....................	41.35	22.35	—	9.94	2.59	15.00	5.29,	$\dot{\text{Cr}}$ 4.17
4. Fahlun, *Almandite*..........	39.66	19.66	—	39.68	1.80	—	—	
5. Haddam, Ct., *Spessartite*.....	35.83	18.06	—	14.63	30.96	—	—	
6. Westmoreland, *Andradite*...	37.55	—	31.35	—	4.70	—	26.74	
7. Sala, *Bredergite*............	36.73	2.78	25.83	—	—	12.44	21.79	
8. Bissersk, *Ouvarovite*........	37.11	5.88	2.44	22.54	—	1.10	30.84,	$\dot{\text{H}}$ 3.01

Analysis No. 1, by Ivanoff (Koksch. Min. Russl., iii, 79).
" No. 2, by Karsten (Karst. Arch. Min., iv, 388).
" No. 3, by Moberg (J. pr. Ch., xliii, 122).
" No. 4, by Hisinger (Schw. J., xxi, 258).
" No. 5, by H. Seybert (Am. J. Sci., vi, 155, 1823).
" No. 6, Hisinger (Jahresb., ii, 101).
" No. 7, Bredberg (Ak. H. Stockh., i. 63, 1823).
" No. 8, Kourouen (Vech. Min. Ges. St. Pet., 1841-55).

Color of garnet may be red, brown, yellow, white, apple-green, black; some of the red and green colors are often bright. Streak is white. Transparent, translucent, opaque. Fracture conchoidal or uneven. Garnet is generally found crystallized, but the crystals are very often distorted. Hardness = 6.5–7.5. Specific gravity = 3.15–4.3. It is brittle and sometimes friable; when granular, massive; very tough, when compact; cryptocrystalline.

In the reducing flame of the blowpipe most varieties fuse to a light-brown or black gloss, and often becomes magnetic, owing to the presence of iron. The dark-red varieties are easily fusible to a magnetic scoria, as they contain more iron. Some varieties are partially decomposed by acids; all except ouvarovite are after ignition decomposed by hydrochloric acid, and generally with separation of gelatinous silica. Decomposed on fusion with alkaline carbonates.

Common garnet is found in Sweden and Norway. *Almandite* or precious garnet is found in Ceylon, Peru, Brazil and Greenland. Other varieties are found in Bohemia, Saxony, Hungary, and in the Urals.

In the United States, in Maine, beautiful yellow crystals or cinnamon stones (with idocrase) are found. Garnets are also found in New Hampshire, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Delaware, and California; also found in Canada and New Mexico.

LAPIS LAZULI.

The composition of Lapis Lazuli is silicate of soda, lime and alumina, with a sulphide, probably, of iron and sodium.

The following are a few analyses:

	$\ddot{Si}$.	$\dddot{Al}$.	$\dddot{Fe}$.	$\dot{Ca}$.	$\dot{Na}$.	$\dot{H}$.	$\dddot{S}$.
1. Orient..........	46.0	14.5	3.0	17.5	—	2.0	4.0, $\ddot{C}$ 10.0.
2. Bucharei........	45.50	31.76	*Tr.*	3.52	9.09	0.12	5.89, Fe 0.86, Cl 0.42, S 0.95.
3. Andes..........	45.70	25.34	1.30	7.48	10.55	—	4.32, S 3.96, K 1.35.

Analysis No. 1, by Klaproth (Beitr. i, 189).
" No. 2, by Varrentrapp (Pogg., xlix, 515).
" No. 3, by Schultz.

Color of lapis lazuli is azure-blue, violet-blue, red, green, or colorless. Streak, same as color. Translucent, opaque. Fracture uneven. Hardness, 5–5.5. Specific gravity, 2.38–2.45.

When heated in a closed tube, gives off moisture; the variety from Chili glows with a beetle-green light, but the color of the mineral remains blue on cooling. Fuses easily at 3 with intumescence, and gives a bluish bead. In acids it is more or less easily attacked, and gelatinizes, evolving at the same time a little H_2S. The action of acids is frequently to decolorize it; sometimes it is not attacked by acids except after calcination.

It is usually found in syenite or crylallien limestone, associated often with pyrite and mica in scales.

It is found in Siberia, of a dark-blue color; also in Transylvania, Persia, China, Thibet, Tartary, and near the Rio Grande.

It is much used by jewelers, especially when it contains pyrite. It was formerly used to make ultramarine, but is now superseded by a cheap artificial preparation.

ORTHOCLASE.

The composition of orthoclase or feldspar is $(\frac{1}{4}\dot{K}_3 + \frac{3}{4}\dddot{Al})_2 \ddot{\bar{Si}}_3 + 6\ddot{Si}$, or else with half the excess of silica basic = silica, 64.6; alumina, 18.5; potash, 16.9, with soda sometimes replacing part of the potash. The orthoclase of Carlsbad contains rubidium.

There is a large number of varieties. The following are a few analyses:

LOCALITIES.	$\ddot{Si}$.	$\dddot{Al}$.	$\dddot{Fe}$.	$\dot{Mg}$.	$\dot{Ca}$.	$\dot{Na}$.	$\dot{K}$.	$\dot{Zn}$.
1. Lomnitz, Silesia....	66.75	17.50	1.75	—	1.25	—	12.0	—
2. Siberia............	65.32	17.89	0.30	0.09	0.10	—	2.81	13,05, $\dddot{Mn}$ 0.19, Ca *tr*.
3. Radeberg, Sax. (wh.)	65.24	20.40	—	0.84	—	—	0.27	12.85–0.52, Li 0.71
4. Schemnitz..........	64.00	18.00	0.53	0.31	0.78	—	0.79	15.43, $\dot{Pb}$ and $\dot{Ca}$ 0.32
5. Davidson Co., N. C..	65.30	20.20	Trace	Trace	0.05	0.78	4.85	—
6. Zircon—Syenite....	66.03	19.17	0.31	—	0.20	6.83	6.96	0.21
7. Ischia.	67.09	18.88	1.25	0.03	0.35	4.59	7.58	—
8. Lococlase...........	65.40	19.43	1.25	0.20	2.26	7.23	2.76	0.76
9. Lochwald...........	66.37	19.95	Trace	0.40	—	9.64	3.42	—

Analysis No. 1 by Rose (Scheerer's J., viii, 248).
" " 2 " Abich (Pogg., li, 528; B. H. Ztg. Jahrg., 19).
" " 3 " Jenzsch (Pogg., xcv, 304).
" " 4 " C. Bischof (Bischof, Lehrb. Geol., ii, 2171–2187).
" " 5 " F. A. Genth (Keller and Tied, iii, 486).
" " 6 " Scheerer (Pogg., cviii, 426).
" " 7 " G. Bischof (Lehrb. Geol., l. c.).
" " 8 " Smith and Brush (Am. J. Sci., II, xvi, 43).
" " 9 " F. Sandberger (Geol. Beschr. Baden, Carlsruhe, 181, 48).

The color of orthoclase is flesh-red, white-gray, greenish or bright-green. Streak colorless. Transparent, translucent, opaque. Fracture conchoidal, uneven. Lustre vitreous on cleavage; surface sometimes pearly. Hardness, 6–6.5. Specific gravity, 2.44–2.62; mostly, 2.5–2.6.

Before the blowpipe, the colored varieties whiten. In thin scales it is fusible between 4 and 5 to white glass. With borax it gives a transparent glass, and with salt of phosphorus a silica skeleton. It is not acted on by acids. Orthoclase is an essential constituent of many rocks. It is found in fine crystals at Carlsbad and Elbogen in Bohemia; also in Siberia, Norway, Silesia, and Cornwall, etc. In the United States, orthoclase is found in crystals in Maine, Connecticut, New York, North Carolina, etc. Massive orthoclase is abundant in the above places, as also in Mt. Desert, Me.; Rockport, Mass.; Norwich, Conn. Kaolin at Andover, Mass., and abundantly in New Milford, Kent, and Cornwall, Conn., etc. Under the influence of atmospheric agencies the silicates undergo a peculiar decomposition. When decomposition has taken place in a rock, the elements of which are well separated as large-grained granites and pegmarites, the quartz is unaltered and the mica is not decomposed; the feldspar or orthoclase only has undergone decomposition. The mica, however, undergoes certain changes, and takes on a silvery look, which it did not have in the unaltered rock.

The products of decomposition may be separated as follows:

1. Kaolins or porcelain clays, resulting from the decomposition of rocks in places.
2. Ordinary Clays, formed as sediments.
3. Clays, produced by chemical decomposition.

KAOLIN.

In the decomposition of orthoclase to form kaolin, it loses $1\dot{K} + \frac{8}{3}\ddot{Si}$. Part of the silica set free may go off with more or less of the potash, or may form opal, quartz, or siliceous sinter. Kaolin is generally a simple hydrous silicate of alumina, expressed by the formula $\ddot{Al}\,\ddot{Si}_2 + 2\dot{H}$ = silica 46.3, alumina 39.8, water 13.9. It is usually white, and somewhat plastic, not very coherent, earthy, and without argillaceous odor when breathed upon. It is easily separated from the accompanying undecomposed materials by crushing and washing. It is very much sought for, when free from iron, for the manufacture of porcelain. For this purpose, it is indispensable that all the mica should be washed out.

Brougniart analyzed a great number of kaolins used in the arts, and arrived at the following limits:

$\ddot{\mathrm{Si}}$ 23–46; metallic oxides 0.5–1; $\dddot{\mathrm{Al}}$ 21–43; $\dot{\mathrm{Ca}}$, $\dot{\mathrm{Mg}}$ 0–6; alkalies 0–05; $\dot{\mathrm{H}}$ 5–12: residue not argillaceous 0–3.

ORDINARY CLAYS.

"Clays seem to have been formed from the product of decomposition, carried off by water and deposited in beds in the stratified formations. They do not have any well-defined character. When dry, they rapidly absorb water, which they lose easily, and then contract and crack in every direction." Lustre is somewhat pearly or waxy, to dull. Color white, grayish, greenish, bluish, reddish. When taken from the earth, they are sometimes somewhat translucent on the edges, and have a soapy look and a slight lustre. When breathed upon, they give a peculiar odor, called argillaceous, like the smell of ground after a rain. Fracture is conchoidal. Hardly plastic. Hardness = 1–2. Specific gravity = 1.8–2.4.

The composition of clays is very variable, but they can all be arranged around two types, represented by the following compositions:

	I.	II.
$\ddot{\mathrm{Si}}$	45—50	60—66
$\dddot{\mathrm{Al}}$	34—38	18—25
$\dot{\mathrm{H}}$	9—15	9—15

These may be represented by the formulæ:

$$\dddot{\mathrm{Al}}\,\ddot{\mathrm{Si}}_5 + 4\dot{\mathrm{H}};\quad \ddot{\mathrm{Si}}\ 51.83,\ \dddot{\mathrm{Al}}\ 35.36,\ \dot{\mathrm{H}}\ 12.46,\ \text{and}$$

$$\dddot{\mathrm{Al}}\,\ddot{\mathrm{Si}}_5 + 3\dot{\mathrm{H}};\quad \ddot{\mathrm{Si}}\ 65.64,\ \dddot{\mathrm{Al}}\ 22.54,\ \dot{\mathrm{H}}\ \ 4.82.$$

"These clays are generally plastic enough to allow their use in moulding and for pottery. When they contain but little iron, they can be used for fire-brick. They absorb water rapidly, and have a very distinct argillaceous odor, and are only partially acted on by acids."

CHEMICAL CLAYS.

Under this head is considered the varieties known as fuller's earth or smectic clay.

Their composition is as follows:

LOCALITIES.	$\ddot{\text{Si}}$.	$\dddot{\text{Al}}$.	$\dddot{\text{Fe}}$.	$\dot{\text{Mg}}$.	$\dot{\text{Ca}}$.	$\dot{\text{H}}$.
1. Cilley (smectite)........	51.21	12.25	2.07	4.89	2.13	27.89
2. Riegate (fuller's earth)..	53.00	10.00	9.75	1.25	0.50	24.00, K *tr*, NaCl 0.10
3. Steindörfel (malthacite).	50.17	10.66	3.15	—	0.25	35.83

Analysis No. 1 by Jordan (Pogg., lxxvii, 591).
" " 2 " Klaproth (Beitr., iv, 338).
" " 3 " O. Meissner (l. c.).

Color is white, gray, and various shades of green to mountain green and olive green, or brownish. Softens in water. In the fracture their lustre is quite bright; they may even be translucent on the edges. They do not absorb water as easily as kaolin and ordinary clays, but they unite with fats, even when cold, and saponify. They are largely used for soap in the countries where they are found.

Before the blowpipe the malthacite is infusible; but the smectite and the Riegate fuller's earth, owing to the impurities present, fuse rather easily. They are decomposed by hydrochloric acid.

Malthacite is found at Steindorfel, in Lausitz; and Beraun, in Bohemia. Smectite is found in Cilley, in Lower Styria.

TOPAZ.

The composition of Topaz is silicon 15.17, aluminium 29.58, oxygen 34.67, fluorine 20.58 [$\dddot{\text{Al}}$ ($\frac{1}{2}SiO_2 + \frac{1}{2}SiF_2$)].

The following are a few analyses:

LOCALITIES.	$\ddot{\text{Si}}$.	$\dddot{\text{Al}}$.	F.
1. Auerbach, Saxony	34.24	57.45	14.99
2. Brazil (yellow)..	34.01	58.38	15.06
3. Finbo (pyrophysalite)................................	34.36	57.74	15.02
4. Trumbull, Conn...............	35.39	55.96	17.35
5. Altenberg (pycnite)......................	35.00	48.00	16.5

Analyses No. 1, 2, 3, by Berzelius (Schweig J., xvi, 428; Afhandl., iv, 286).
Analysis No. 4 by Forchhammer (J. pr. Ch., xxx, 400).
" " 5 " Bucholz (Schw. J., i, 385).

The color of topaz may be blue, green, yellow, orange-yellow, red, and colorless. The colors vary with the locality and crystalline form, and appear to be generally owing to organic substances. Streak colorless. Hardness = 8. Specific gravity = 3.4–3.65. Lustre vitreous. Pyro-electric. Transparent, subtranslucent. Crystallizes as a right rhombic prism of 124° 17′.

It is infusible before the blowpipe. The yellow varieties, when heated, take a pink or red color, and are then known as burnt topaz. Fused in the open air with salt of phosphorus gives the reaction for fluorine. Only partly attacked by sulphuric acid. Fine topazes come from the Urals, near Katharinenburg and Miask; in Nertschinsk, beyond L. Baikal, in the Adun-Tschilon Mountains, etc., one crystal from near the River Urulga, now in the imperial cabinet at St. Petersburg, being 11⅝ in. long, 6½ in. broad, weighing 22½ lbs. Av., and magnificent also in its perfect transparency and wine-yellow color. Found also in Kamschatka; Villa Rica, in Brazil; Aberdeenshire; Altenberg, Norway; Broddbo, Sweden. One crystal found at this last place weighed 80 pounds.

In the United States it is found at Trumbull, Middletown, and Willimantic, Conn.; also in North Carolina and Utah.

TALC.

Syn.—Steatite, soapstone, or potstone.

The composition of talc in some cases may be represented by the formula $(\frac{4}{5}\dot{\mathrm{M}}\mathrm{g} + \frac{1}{5}\dot{\mathrm{H}})$ = silica 62.8, magnesia 33.5, water 3.7. In other cases $(\frac{4}{5}\dot{\mathrm{M}}\mathrm{g} + \frac{1}{5}\dot{\mathrm{H}})\,\ddot{\mathrm{S}}\mathrm{i} + \frac{1}{10}\dot{\mathrm{H}}$ = silica 62.0, magnesia 33.1, water 4.9. The formula is commonly written, $\dot{\mathrm{M}}\mathrm{g}_6\ddot{\mathrm{S}}\mathrm{i}_5 + 2\dot{\mathrm{H}}$.

The following are a few analyses:

LOCALITIES.	$\ddot{\text{Si}}$.	$\dddot{\text{Al}}$.	$\dot{\text{Fe}}$.	$\dot{\text{Mg}}$.	$\dot{\text{H}}$.
1. Chamouni (foliated talc).......	62.58	—	1.98	35.40	0.04
2. China (agalmat)...............	63.29	0.53	2.27	31.93	0.78, $\dot{\text{Mn}}$ 0.28
3. Canton, N. Y. (Rensselaerite)..	59.75	—	3.40	32.90	2.65, $\dot{\text{Ca}}$ 1.00
4. Rhode Island (talc)............	61.75	—	1.70	31.68	3.33
5. Pottou, Canada (steatite)......	59.50	0.40	4.50	29.15	4.40, $\dot{\text{Ni}}$ *tr*.

Analysis No. 1 by Marignac (Bibl. Univ., 1844).
" " 2 " J. Schneider (J. pr. Ch., xliii, 316).
" " 3 " Beck (Min. N. Y., 297).
" " 4 " Delesse (Rev. Scientif., etc.).
" " 5 " T. S. Hunt (Rep. G. Can., 1857, 454).

The color of talc may be green, white, red, and gray. Streak white, or lighter than color. It is flexible, but not elastic, which allows of its being distinguished from mica. Its touch is unctuous and soapy, on account of the large quantity of magnesia it contains. Lustre is pearly. Sectile in a high degree. Hardness=1–1.5. Specific gravity=2.565–2.8. Crystallizes in a right rhombic prism of 120°.

Before the blowpipe it whitens, swells, and sometimes decrepitates a little, fusing with difficulty on the edges. With nitrate of cobalt it gives the reaction for magnesia. Not decomposed by acids. Rensselaerite is decomposed, though, by concentrated sulphuric acid.

Talc, or steatite, is a very common mineral, and constitutes beds in some regions. Apple-green talc occurs in the Greiner Mountain, in Saltzburg; in Saltzburg, Valais, Cornwall, Scotland, Ireland, and Shetland Islands, etc.

In the United States, it is found in Maine, New Hampshire, Massachusetts, Rhode Island, New York, Staten Island, New Jersey, Pennsylvania, and North Carolina, Also in Canada.

24. SILVER.

The principal Silver minerals are:

MINERAL.	HARDNESS.	SP. GR.	FORMULA.	COMPOSITION.
Native silver.....	2.4—3	10.1—11.1	Ag (when pure)	Ag 100.
Amalgam	3—3.5	10.5—14	$AgHg_2$	Ag 34.8; Hg 65.2.
Argentite........	2—2.5	7.196—7.365	AgS	Ag 87.1; S 12.9.
Proustite..........	2—2.5	5.422—5.56	$3AgS + As_2S_3$	Ag 65.4; S 19.4; As 15.2.
Pyrargyrite	2—2.5	5.7—5.9	$3AgS + Sb_2S_3$	Ag 59.8; Sb 22.5; S 17.7
Stephanite.......	2—2.5	6.269	$5AgS + Sb_2S_3$	Ag 68.5; S 16.2; Sb 15.3.
Polybasite	2—3	6.214	$9(Ag,Cu)S + (Sb,As)_2S_3$	Ag 64.7; Cu 9.8; S 14.8; Sb 9.7.
Cerargyrite.......	1—1.5	5.31—5.43	AgCl	Ag 75.3; Cl 24.7.
Bromyrite.........	2—3	5.8—6	AgBr	Ag 57.4; Br 42.6.
Embolite.........	1—1.5	5.31—5.81	Ag (Cl, Br)	Ag 69.28; Br 14.30; Cl 16.42
Iodyrite..........	1—1.5	5.5—5.71	AgI	Ag 46; I 54.

NATIVE SILVER.

The composition of Native Silver is silver, with some copper, gold, and sometimes platinum, antimony, bismuth, and mercury. The varieties are:

1. AURIFEROUS.—*Küstelite* contains 10–30 per cent. of silver. Color is white to pale brass-yellow.

The name küstelite was given to an ore in Nevada. Hardness = 2–2.5. Specific gravity = 11.32–13.10. Richter found in it silver, lead, and gold.

2. CUPRIFEROUS.—Contains sometimes 10 per cent. of copper.

4. ANTIMONIAL.—John found in silver from Johanngeorgenstadt (Chem. Unt., i, 285) 1 per cent. of antimony, and traces of copper and arsenic.

The color of native silver is white, but is subject to tarnish and to become grayish-black. Streak silver-white. Ductile, sectile. Lustre metallic. Hardness = 2.5–3. Specific gravity = 10.1–11.1; when pure, 10.5.

Native silver has all the characteristics of silver on charcoal; fuses easily to a metallic globule. In the oxidizing flame gives a brown coating. Soluble in nitric acid, and deposited again by metallic copper, or precipitated by hydrochloric acid as argentic chloride.

The mines of Konigsberg, in Norway, have furnished magnificent specimens of native silver. A mass weighing 60 lbs. was obtained from the Himmelsfurst mine, near Freiberg, which had a gravity of 10.840. It is also found in the Harz, Hungary, Dauphiny, and in some of the Cornish mines. Mexico and Peru have been the most productive countries in silver. A Mexican specimen from Batopilas weighed, when obtained, 400 lbs.; and one from Southern Peru (mine of Huantaya) weighed over 8 cwt.

In the United States, it is disseminated through the copper mines at Michigan. It has also been found in New York, New Jersey, California, Nevada, and Idaho. Also found in Canada.

ARGENTITE.

The composition of Argentite, often called vitreous silver and silver glance, is sulphur 12.9, silver 87.1 (AgS).

The following are a few analyses:

LOCALITIES.	S.	AG.
1. Joachimsthal	15	85
2. Himmelsfürst	14.7	85.3
3. Joachimsthal	14.46	77.58, Pb 3.68, Cu 1.53, Fe 2.02

Analyses No. 1 and 2 by Klaproth (Beitr., i, 158).
Analysis No. 3 by Lindaker (Vogl's Min. Joach., 78).

Color, deep iron-black, with very little lustre on the natural faces. The lustre is, however, bright on the fracture. Streak same as color, and shining. Opaque. Perfectly sectile. Hardness = 2–2.5. Specific gravity = 7.196–7.365.

Argentite melts when held in a flame, without the aid of a blowpipe. In the oxidizing flame it is roasted; in the reducing flame gives a metallic globule. Soluble in nitric acid.

It is found as amorphous masses disseminated in gangues, which are usually limestones. It is a very valuable ore of silver, and is found at Freiberg, Annaberg, Joachimsthal of the Erzgebirge; at Schemnitz and Kremnitz, in Hungary; in Norway, in the Urals, Cornwall, Bolivia, Peru, Chili, and Mexico.

Occurs in Nevada, at the Comstock lode, at different mines, along with stephanite, native gold, etc.; in the vein at Gold Hill; common in the ores of Reese River; probably the chief ore of silver in the Cortez district; in the Kearsarge district, silver sprout vein.

PYRARGYRITE.

The composition of Pyrargyrite is sulphur 17.7, antimony 22.5, silver 59.8 ($3AgS + Sb_2S_3$).

The following are a few analyses:

LOCALITIES.	S.	SB.	AG.
1. Mexico	18.0	21.8	60.2
2. Chili	17.45	23.16	59.01
3. Andreasberg	16.61	22.85	58.95, gangue 0.30.

Analysis No. 1 by Wöhler (Ann. d. Pharm., xxvii, 157).
" " 2 " F. Field (Q. I. Ch. Soc., xii, 12).
" " 3 " Bonsdorff (Ak. H. Stockh., 1821, 338).

The color of pyrargyrite is black or very dark red. Streak cochineal-red. Lustre metallic, adamantine. Translucent. Opaque. Fracture conchoidal. Hardness = 2–2.5. Specific gravity = 5.7–5.9.

In a closed tube, gives a red sublimate of sulphide of antimony; in an open tube, sulphurous fumes are evolved, and a white sublimate of oxide of antimony. On charcoal it fuses and coats the coal. Heated for some time in the oxidizing flame, or with soda in the reducing flame, a globule of silver is obtained. Decomposed by nitric acid, with separation of sulphur and antimonious acid.

It is found at Andreasberg, in the Harz; also in Saxony, Hungary, Norway, in Spain and in Cornwall. In Mexico, it is worked extensively as an ore of silver. It is also found in Nevada, at Washoe, in Daney Mine; and at Poorman lode, Idaho, in masses sometimes of several hundredweight, along with cyrargyrite. It is a valuable ore of silver.

STEPHANITE.

The composition of Stephanite is ($5AgS + Sb_2S_3$) sulphur 16.2, antimony 15.3, and silver 68.5.

The following are two analyses:

Localities.	S.	Sb.	Ag.	Fe.	Cu.
1. Schemnitz	16.42	14.68	68.54	—	0.34
2. Andreasberg	16.51	15.79	68.38	0.14	—

Analysis No. 1 by Rose (Pogg., xv, 474).
" " 2 " Kerl (B. H. Ztg., 1853, No. 2).

The color and streak of Stephanite is black. Lustre metallic. Fracture uneven. Hardness = 2–2.5. Specific gravity = 6.269 (Pryebram).

In a close tube, it decrepitates and fuses, and after long heating gives a faint sublimate of sulphide of antimony. On charcoal it decrepitates and fuses, giving the rose-colored coating of silver and antimony. After long treatment, a globule of silver is obtained.

It is found at Freiburg, Saxony, Bohemia, Hungary, in the Harz, Mexico, and Peru.

It is an abundant ore in Nevada, in the Comstock lode; it is also found in Idaho.

It is a valuable ore of silver.

CERARGYRITE.

The composition of Cerargyrite (called also Horn Silver) is chlorine 24.7, silver 75.3 ($AgCl$). The color is white, gray, grayish-green, or colorless when perfectly pure. Streak colorless and shining. Transparent, feebly translucent. Fracture somewhat conchoidal. Sectile. Lustre resinous, passing into adamantine. Hardness = 1–1.5. Specific gravity = 5.552; 5.31–5.43 (Domeyke).

In a closed tube fuses without decomposition. Fuses in a flame of a candle. On charcoal, gives a globule of silver. Insoluble in nitric acid, but soluble in ammonia.

The largest masses, particularly green, are found in Peru, Chili and Mexico. It is also found in Norway, Brittany, Nevada, California, Idaho and Arizona. It is mined as an ore in South America.

25. SODIUM.

The principal Sodium minerals are:

MINERAL.	HARDNESS.	SP. GR.	FORMULA.	COMPOSITION.
Soda Nitre....	2	1.937	$\dot{Na}\overset{\cdot\cdot\cdot\cdot\cdot}{N}$.	$\dot{Na}$ 36.5; $\overset{\cdot\cdot\cdot\cdot\cdot}{N}$ 63.5.
Thenardite....	2—3	2.5—2.7	$\dot{Na}\dddot{S}$.	$\dot{Na}$ 56.3; $\dddot{S}$ 43.7.
Mirabilite.....	1.5—2	1.481	$\dot{Na}\dddot{S} + 10\dot{H}$.	$\dot{Na}$ 19.3; $\dddot{S}$ 24.8; $\dot{H}$ 55.9.
Glauberite....	2.5—3	2.64—2.85	$(\frac{1}{2}\dot{Na} + \frac{1}{2}\dot{Ca})\dddot{S}$.	$\dddot{S}$ 57.5: $\dot{Ca}$ 20.1; $\dot{Na}$ 22.4.
Halite........	2.5	2.1—2.257	$NaCl$.	Na 39.3; Cl 60.7.
Borax.........	2.25	1.716	$\dot{Na}\dddot{B}_2 + 10\dot{H}$.	$\dot{Na}$ 16.2; $\dddot{B}$ 36.6; $\dot{H}$ 47.2.
Natron........	1—1.5	1.423	$\dot{Na}\ddot{C} + 10\dot{H}$.	$\dot{Na}$ 18.8: $\ddot{C}$ 26.7; $\dot{H}$ 54.5.

SODA NITRE.

The composition of Soda Nitre is nitric acid 63.5, soda 36.5 ($\dot{Na}\overset{\cdot\cdot\cdot\cdot\cdot}{N}$). Hochstetter obtained from the Chilian minerals (v. Leonh., 1846, 235) $\dot{Na}\overset{\cdot\cdot\cdot\cdot\cdot}{N}$ 94.291, $NaCl$ 1.990, $\dot{K}\dddot{S}$ 0.239, $\dot{K}\overset{\cdot\cdot\cdot\cdot\cdot}{N}$ 0.426, $\dot{Mg}\overset{\cdot\cdot\cdot\cdot\cdot}{N}$ 0.858, insoluble 0.203, $\dot{H}$ 1.993.

The color of soda nitre is white; also reddish-brown, gray, and lemon-yellow. Lustre vitreous. Fracture indistinctly conchoidal. Taste cooling. Crystals strongly double refracting. Transparent, translucent, or opaque.

Deflagrates on charcoal; colors the flame yellow. Dissolves in three parts of water at 60° F.

It is found in Peru in great abundance; also in Chili and India.

GLAUBERITE.

The composition of Glauberite is sulphate of soda 51.1, sulphate of lime 48.9 $(\frac{1}{2}\dot{N}a + \frac{1}{2}\dot{C}a)\dddot{S}$.

The following are a few analyses:—

	$\dddot{S}$.	$\dot{C}$a.	$\dot{N}$a.	Cl.	$\dddot{\bar{F}}$e.
1. Villa Rubia..............	56.5	20.2	23.3	—	—
2. Ischl	57.52	20.37	21.87	0.31	—
3. Turapaca..	57.22	20.68	21.82	—	0.14

Analysis No. 1, by Brougniart.
" No. 2, by v. Hauer (Ber. Ac. Wien).
" No. 3, by Hayes (J. Nat. H. Soc. Bost., iv, 498).

The color of glauberite is generally yellow, somewhat gray, but when $\dddot{\bar{F}}$e is present it is red. Streak is white. Fracture conchoidal; brittle. Taste slightly saline. Hardness = 2.5–3. Specific gravity 2.64–2.85.

Decrepitates and melts into a bead, which is transparent when hot, but opaline when cold. Water separates the sulphates by dissolving the sulphate of soda. It is soluble in hydrochloric acid.

Glauberite is found at Villa Rubia near Ocana in New Castle, also at Ausse in Upper Austria, and in Bavaria. Near Madrid a large mass of glauberite was found fourteen to fifteen miles thick and several leagues square.

HALITE.

The composition of Halite (common salt) is chlorine 60.7, sodium 39.3 (NaCl).

The following are a few analyses:

	NaCl.	MgCl.	$\dot{Ca}\dddot{S}$.	$\dot{Na}\dddot{S}$.	$\dot{Mg}\dddot{S}$.
1. Vic, white............	99.3	—	0.5	—	— Clay 0.2.
2. " gray	90.3	—	5.0	2.0	— " 1.9.
3. " red...............	99.8	—	—	—	— " 0.2.
4. " yellow...	96.70	0.23	1.21	—	0.66
5. " green........ ...	96.27	0.27	1.09	—	0.80

Analyses No. 1—5, by Berthier (Ann. d. M., x, 259).

The colors of halite are very variable. When pure it is colorless, but generally it is colored by some earthy or organic matter. It may be gray, red, violet, blue or green. The cause of these colors is not very well understood; they may be owing to traces of $\dot{N}i$, $\dot{C}o$, $\dot{C}u$, or organic matter. Streak is white. Lustre vitreous. Hardness = 2.5. Specific gravity 2.1–2.257; of pure crystals 2.135 (Hunt). Transparent, translucent. Fracture conchoidal. Rather brittle. It is soluble, and has its own peculiar saline taste.

When heated it at first decrepitates and then melts; when fused, colors the flame deep yellow.

Halite or common salt occurs in irregular beds in rocks of various ages. At Durham, Northumberland, and Leicestershire, England, salt springs rise from the carboniferous series; in the Alps, some salt works are supplied from oolitic rocks. In the United States, the brines of New York come from upper silurian; those of Ohio, Pennsylvania and Virginia mostly from Devonian and subcarboniferous beds. Salt also occurs as efflorescences over the dry prairies and shallow ponds or lakes of the Rocky Mountains and California. The principal mines of Europe are at Wieliczka, in Poland; at Hall, in the Tyrol; Stassfurt, in Prussian Saxony. Also in Bavaria, Salzberg, Transylvania, Upper Silesia, France, Valley of Cardona and elsewhere in Spain, forming hills 300 to 400 feet high. Also occurs, forming hills, near Lake Oromiah, the Caspian Lake, etc. It is also found in Algeria, Abyssinia, India, China and Russia. In the United States, it has been found in

Virginia, Oregon and Louisiana. Brine springs are very numerous in the Middle and Western States. These springs are worked at Salina and Syracuse, N. Y.; in the Kanawha Valley, Va.; Muskingum, Ohio; Michigan at Saginaw and elsewhere, and in Kentucky.

26. STRONTIUM.

The principal Strontium minerals are:

MINERAL.	HARDNESS.	SP. GR.	FORMULA.	COMPOSITION.
Celestite...............	3—3.5	3.92—3.975	$\dot{Sr}\dddot{S}$.	$\dot{Sr}$ 56.4; $\dddot{S}$ 43.6.
Strontianite............	3.5—4	3.605—3.713	$\dot{Sr}\ddot{C}$.	$\dot{Sr}$ 70.2; $\ddot{C}$ 29.8.

CELESTITE.

The composition of Celestite is sulphuric acid 43.6, strontia 56.4 ($\dot{Sr}\dddot{S}$).

The following are a few analyses:

LOCALITIES.	$\dddot{S}$.	$\dot{Sr}$.	$\dot{Ba}$.	$\dot{Ca}$.	$\dddot{F}$.
1. Frankstown, Pa	42	58	—	—	—
2. Süntel, Hanover.........	42.74	55.18	0.86	0.81	0.04, $\dot{Ca}\ddot{C}$ 0.02, $\dot{H}$ 0.05.
3. Dehrself.................	42.94	55.01	0.64	—	0.65, $\ddot{Si}$ 0.11, $\dot{H}$ 0.25.
4. Domburg.................	42.95	56.26	—	—	0.03, $\dddot{Al}$ 0.05, $\dot{Ca}\ddot{C}$ 0.10, $\dot{H}$, Bit., 0.15.

Analysis No. 1 by Klaproth.
" Nos. 2, 3, and 4 by Stromeyer (Unters., 206).

The color of celestite is white, often faint bluish, and inclining to pearly. Streak is white. Hardness = 3–3.5. Specific gravity = 3.92–3.975; 3.9593, crystals (Bendant); 3.973, fr. Tharaud (Breith); 3.96 fr. Kingston (Hunt). Its lustre is very bright, often pearly. Fracture is lamellar and sometimes conchoidal.

Decrepitates and fuses, coloring the flame red. Insoluble in acids.

It is found in Sicily, Spain, France, Hungary, Hanover, Austria, Yorkshire, and New Grenada. It is found about Lake Huron, particularly about Strontian Island; and at Kingston, Canada; also in Chaumont Bay, Schoharie, and Lockport, N. Y.

Celestite is used in the arts for making nitrate of strontia, which produces the red color in fireworks.

STRONTIANITE.

The composition of Strontianite is carbonic acid 29.8, and strontia 70.2 ($\dot{Sr}\ddot{C}$). The strontia is often replaced in a small degree by lime.

The following are a few analyses:

LOCALITIES.	$\ddot{C}$.	$\dot{Sr}$.	$\dot{Ca}$.	$\dddot{Fe}$.	$\dot{Mn}$.	$\dot{H}$.
1. Strontian...............	30.0	69.5	—	—	—	0.5
2. Bräunsdorf, Saxony.....	29.94	67.52	1.28	—	0.09	0.07
3. Strontian...............	30.66	65.53	3.52	0.01	—	—
4. "	30.81	65.60	3.47	0.07		0.07

Analysis No. 1 by Klaproth (Beitr., i. 270; ii, 84).
" " 2 " Stromeyer (Unters, i, 193).
" " 3 " Thomson (Min., i, 108).
" " 4 " Stromeyer (l. c.).

The color of strontianite may be gray, white, yellow, brownish, and pale green. Streak white. Hardness = 3.5–4. Specific gravity = 3.605–3.713. Lustre vitreous, inclining to resinous on uneven faces of fracture. Transparent, translucent. Fracture uneven. Brittle.

Before the blowpipe it swells, arboresces, and fuses on the thin edges, and colors the flame red. With soda, on charcoal, the pure mineral fuses to a clear glass, and is entirely absorbed by the coal. Soluble in hydrochloric acid.

It is found at Strontian, in Argyleshire, in Yorkshire, England; in Ireland, Harz, Saxony, and Saltzburg.

In the United States, it occurs at Schoharie, N. Y.; at Muscalonge Lake; Chaumont Bay; and Theresa, in Jefferson County, New York.

Strontianite is used for pyrotechnics.

27. SULPHUR.

The composition of Native Sulphur is pure sulphur, which is often contaminated with clay and bitumen.

When it is quite pure, it is of a yellow color, called sulphur-yellow, sometimes having a greenish tint. It is sometimes of a reddish color, which has been attributed to traces of selenium. Streak is sulphur-yellow, reddish, or greenish. Hardness = 1.5–2.5. Specific gravity = 2.072, of crystals from Spain. Lustre is resinous. Transparent, subtranslucent. Fracture conchoidal, more or less perfect. Sectile. Crystallizes as a right rhombic prism, 101° 40′.

Heated in a closed tube it fuses and volatilizes, leaving no residue, if it is pure. In an open tube, it burns with a blue flame, and gives off sulphurous fumes. Becomes strongly electrified by friction. Insoluble in water, and not acted on by acids.

The great repositories of sulphur are either beds of gypsum and the associated rocks, or the region of active or extinct volcanoes. It occurs in the valley of Noto, and Mazzaro in Sicily; at Conil, near Cadiz, in Spain; at Bex, in Switzerland. Also at Hanover, Egypt, Tuscany, and in the Chilian Andes.

Sulphur is found near the Sulphur Springs of New York, and in Virginia, in limited quantities; also in North Carolina and Nevada.

28. TIN.

The principal Tin minerals are:

MINERAL.	HARDNESS.	SP. GR.	FORMULA.	COMPOSITION.
Cassiterite......	6—7	6.4—7.1	$\ddot{Sn}$.	Sn 78.67, O 21.33.
Stannite........	4	4.3—4.522	$2(Cu,Fe,Zn)S + SnS_2$.	Sn 27.2, Cu 29.3, Fe, 6.5, Zn 7.5, S 29.6.

CASSITERITE.

The composition of Cassiterite is tin 78.67, oxygen 21.33 $(\ddot{\mathrm{S}}\mathrm{n})$.

The following are a few analyses:

LOCALITIES.	$\ddot{\mathrm{Sn}}$.	$\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{Ta}}$.	$\overset{\cdots}{\bar{\mathrm{F}}\mathrm{e}}$.	$\overset{\cdots}{\bar{\mathrm{M}}\mathrm{n}}$.	$\ddot{\mathrm{Si}}$.	$\overset{\cdots}{\bar{\mathrm{A}}\mathrm{l}}$.
1. Finbo	93.6	2.4	1.4	0.8	—	—
2. Wicklow, Ireland	95.26	—	2.41	—	0.84	—
3. Tipuani, Bolivia (*buh*)	91.81	—	1.02		6.48	0.78

Analysis No. 1 by Berzelius (Afh., iv, 164).
" " 2 " Mallet (J. G. Soc., Dubl., iv, 276).
" " 3 " Forbes (Phil. Mag., iv, xxx, 140).

Cassiterite is sometimes found colorless, in a few localities, but generally its color is of every gradation, intermediate between gray, white, and yellow. The color is generally in bands not equally diffused. Streak white, grayish, or brownish. Hardness = 6–7. Specific gravity = 6.4–7.1. Lustre is adamantine, and crystals usually splendent. Nearly transparent, opaque. Fracture subconchoidal, uneven. Brittle. It is infusible before the blowpipe. In the reducing flame it is with difficulty reduced; but if soda be added, the reduction is facilitated. With borax it melts easily, and becomes the base of an enamel. It is only slightly acted on by acids.

It occurs in remarkable crystals in Cornwall. It is found in Ireland, Bohemia, Saxony, Greenland, Sweden, and in Finland. In the East Indies it is found near Borneo, and in Australia.

In Bolivia, S. A., at Oruro tin mines; in Bolivia, and in Mexico.

In the United States, found sparingly at Paris, Maine; in Massachusetts, New Hampshire, Virginia, and California.

29. ZINC.

The principal Zinc minerals are:

MINERAL.	HARDNESS.	SP. GR.	FORMULA.	COMPOSITION.
Zincite	4—4.5	5.43—5.7	$\dot{Zn}$	Zn 80 26, O 19.74.
Sphalerite	3.5—4	3.9—4.2	ZnS	Zn 67.0, S 33.0.
Goslarite	2—2.5	2.036	$\dot{Zn}\dddot{S}+7\dot{H}$	Zn 28.2, $\dddot{S}$ 27.9, H 43.9.
Smithsonite	5	4—4.5	$\dot{Zn}\ddot{C}$	$\dot{Zn}$ 64.8, $\ddot{C}$ 35.2.
Hydrozincite	2—2.5	3.58—3.8	$\dot{Zn}\ddot{C}+2\dot{Zn}\dot{H}$	Zn 75,3, $\ddot{C}$ 13.6, $\dot{H}$ 11.1.

ZINCITE.

The composition of Zincite is oxygen 19.74, zinc 80.26 ($\dot{Zn}$). The following are a few analyses:

VARIETIES.	$\dot{Zn}$.	$\dot{Mn}$.	$\dddot{Mn}$.	$\dddot{Fe}$.
1. Red	92	—	8	
2. "	88	12		—
3. "	93.48	5.50	—	0.36, scales Fe 0.44.
4. Yellow	99.47	—	0.68	— ign. 0.23.

Analysis No. 1 by Bruce.
" " 2 " Berthier (Ann. d. M., iv, 483).
" " 3 " A. A. Hayes (Am. J. Sci., xlviii, 261).
" " 4 " W. P. Blake (Mining Mag., II, ii, 94, 1860).

Color of zincite is characteristic; it is a deep red, sometimes orange-yellow. Streak orange-yellow. Translucent, subtranslucent. Fracture subconchoidal. Brittle. Hardness=4–4.5. Specific gravity = 5.43–5.7; 5.684, orange-yellow crystals (W. P. Blake). Bleaches if heated in a closed tube, but on cooling resumes its natural color. In the reducing flame it gives metallic zinc, which volatilizes, oxidizes, and forms a white ring. Gives a green color with nitrate of cobalt. Shows reaction for manganese. Soluble in acids.

It occurs with Franklinite at Stirling Hill and Mine Hill, Sussex County, N. J.

It is used as an ore of zinc.

SPHALERITE.

The composition of Sphalerite is sulphur 33, zinc 67 (ZnS). The following are a few analyses:

LOCALITIES.	S.	ZN.	FE.	CD.
1. Przibram (fibrous)	33.15	61.40	2.29	1.50
2. New Jersey (white)..........	32.22	67.46	—	Trace.
3. Clausthal (black).............	33.04	65.39	1.18	0.79, Cu 0.18, Sb 0.68.
4. Corinthia Raibel (rh. crystal).	32.10	64.22	1.32	Trace; Sb and Pb 0.72, H 0.80.
5. Chrystophite (black)..........	33.57	44.67	18.25	0.28, Mn 2.66, Sn trace.

Analysis No. 1 by Leöwe (Pogg., xxxviii, 161).
" " 2 " T. H. Henry (Phil. Mag., IV, i, 23).
" " 3 " C. Kuhlemann (Zs. nat. Ver. Halle, viii, 499).
" " 4 " Kersten (Pogg., lxii, 133).
" " 5 " Heinichen (B. H. Ztg., xxii, 27).

The color of sphalerite is very variable; it is rarely colorless, but is generally honey-yellow, brown, black, red, and green. When pure it is generally white or yellow. Streak is white, reddish-brown. Hardness = 3.5–4. Specific gravity = 3.9–4.2; 4.063, white, New Jersey. Lustre resinous to adamantine. Transparent, translucent. Fracture conchoidal. Brittle.

In the open tube it gives off sulphurous fumes, and generally changes color. In the oxidizing flame it gives off sulphurous fumes and often a cadmium coating. The roasting is long and difficult, and after it, in the reducing flame, it gives a coat of zinc, which is yellow when hot and white when cold. Soluble in hydrochloric acid. With nitric acid, very little red vapor is given off, but much sulphydric gas.

Occurs in Derbyshire, Cumberland, Cornwall, Transylvania, Hungary, Harz; Salila, in Sweden; Raliebozitz, in Bohemia, etc. Abounds with the lead ores of Missouri, Wisconsin, Iowa, and Illinois. Found in New York, Massachusetts, New Hampshire, Maine, New Jersey, Pennsylvania, Michigan, and Tennessee.

Sphalerite is one of the most abundant ores of zinc.

SMITHSONITE.

The composition of Smithsonite is carbonic acid 35.2, oxide of zinc 64.8 ($\dot{Zn}\ddot{C}$).

The following are a few analyses:

LOCALITIES.	$\ddot{C}$.	$\dot{Zn}$.	$\dot{Fe}$.	$\dot{Pb}$.	$\ddot{Si}$.
1. Somersetshire............	35.2	64.8	—	—	—
2. Altenberg................	35.13	64.56	—	0.16	0.15
3. Moresnet, Belgium........	33.78	63.06	0.34	—	1.53, $\dot{H}$ 1.28.
	$\dot{Zn}\ddot{C}$.	$\dot{Fe}\ddot{C}$.	$\dot{Mn}\ddot{C}$.	$\dot{Mg}\ddot{C}$.	$\dot{Ca}\ddot{C}$.
4. Altenberg (w. cryst.)......	98.24	0.52	0.15	0.23	0.20, insol. 0.07.
5. Algiers....................	90.10	—	—	1.74	2.30, $\dot{Pb}\ddot{C}$ 0.44, $\dddot{As}$ 3.30, $\dddot{Fe}$ 1.50, sand 0.45.
6. Albrarradon, Mex.........	93.74	—	1.50	0.29	1.48, $\dot{Cu}\ddot{C}$ 3.42.

Analysis No. 1 by Smithson (Nicholson's J., vi, 76).
" " 2 " Heidingsfeld (Ramm., 5th Suppl.)
" " 3 " Schmidt (J. pr. Ch., ii, 257).
" " 4 " H. Risse (Verrh. nat. Ver. Bonn., 36, 1865).
" " 5 " Marigny (Ann. d. M. V., xi, 673).
" " 6 " Genth (Am. J. Sci., xx, 119).

Color of smithsonite may be white, green, yellow, or brown. Streak white. Hardness = 5. Specific gravity = 4–4.45; 4.45 (Levy); 4.42 (Haidinger). Lustre vitreous, inclining to pearly. Subtransparent, translucent. Fracture uneven, imperfectly conchoidal. Brittle. Crystallizes in rhombohedra of 107° 40′. In a closed tube, when heated, loses its carbonic acid. Infusible. On charcoal, with soda, gives vapors which are yellow while hot and white when cold. Soluble in hydrochloric acid with effervescence.

It is found at Nertschinsk in Siberia, at Dognatzka in Hungary, Altenberg near Aix la Chapelle, at Ciguenza, in Scotland, and in Ireland.

In the United States it is found at Brookfield, Conn., in New Jersey at Mine Hill, in Pennsylvania at Lancaster, in Wisconsin, Minnesota, Missouri, and Arkansas.

30. ZIRCONIUM.

The principal Zirconium mineral is Zircon.

ZIRCON.

The composition of Zircon is zirconia 67, silica 33 ($\ddot{\mathrm{Zr}}\ddot{\mathrm{Si}}$). The following are a few analyses:

LOCALITIES.	$\ddot{\mathrm{Si}}$.	$\ddot{\mathrm{Zr}}$.	$\dddot{\mathrm{Fe}}$.	$\dot{\mathrm{Ca}}$.	$\dot{\mathrm{H}}$.
1. Ceylon	32.5	64.5	1.5	—	—
2. Fredericksvaru ?)	33.85	64.81	1.55	0.88	—
3. Buncombe Co., N. C.....	33.70	65.30	0.67	—	0.41

Analysis No. 1, by Klaproth (Beitr., v, 196).
" No. 2, by Hennebergg (J. pr. Ch., xxxviii, 508).
" No. 3, by C. F. Chandler (Am. J. Sci., II, xxiv, 131).

Zircon may be colorless, pale yellow, brownish-yellow, yellowish-green, reddish-brown, gray or blue. Streak colorless. Hardness=7.5. Specific gravity=4.05–4.75. Lustre adamantine. Transparent to subtranslucent and opaque. Fracture conchoidal, brilliant. Double refraction strong, positive. It is infusible. The red varieties before the blowpipe lose their color without losing their transparency, and the dark-colored varieties become white. It is thought possible, therefore, that the color is due to organic matter. Acids do not affect it, but it is decomposed by fusion with alkaline carbonates.

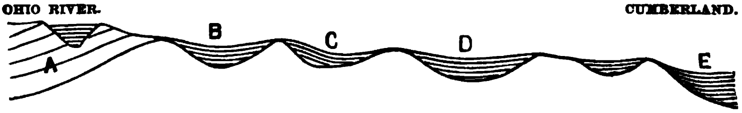
It is found in the alluvial sands in Ceylon, in the gold regions of the Ural near Miask, at Arendal in Norway, in Transylvania, in Bohemia, Tyrol, France, Scotland, Ireland, Greenland and Australia.

In North America it is found in Maine at Litchfield, in Vermont, Connecticut, New York, New Jersey, Pennsylvania, North Carolina and California.

COAL.

Coal is produced by the spontaneous distillation of wood, etc., after life has left the material acted on. The following is the Coal Series.

COAL SERIES.
- VEGETABLE TISSUE, EITHER HERBACEOUS OR LIGNEOUS.
- PEAT.
- LIGNITE.
- BITUMINOUS.
- SEMI-BITUMINOUS.
- ANTHRACITE.
- GRAPHITIC ANTHRACITE.
- GRAPHITE.



A = Bituminous Coal, containing 50% of Volatile Matter.
B = Semi " " " 17–25% " "
C = Inflammable Anthracite " 10–20% " "
D = Lehigh " " 3–10% " "
E = Newport Coal, " 0–7% " "

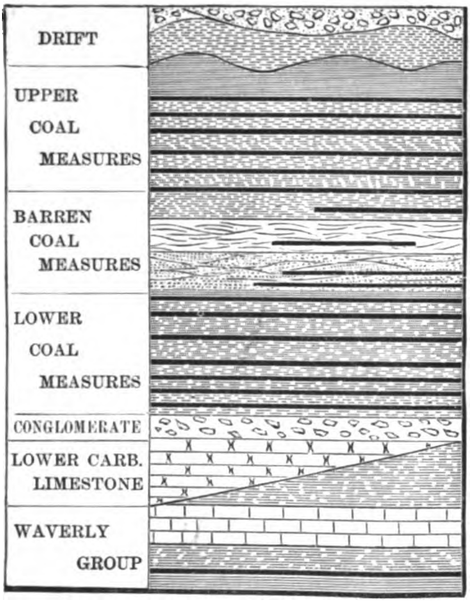
COAL MEASURES.

The following sections, general and local, as shown on p. 337, will serve to give an idea of the mode of occurrence of coal in the carboniferous rocks, and of the nature of the associated strata. (J. S. Newberry, Johnson's Cyc., Article *Coal.*)

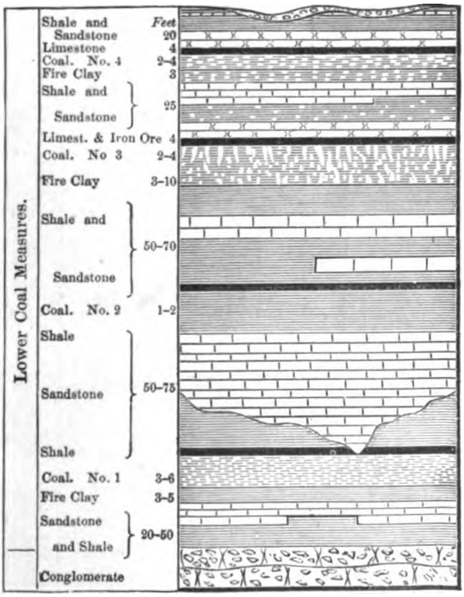
The Brier Hill coal is the best bituminous coal in this country; it has the following composition:

BRIER HILL COAL.	Water	1 to 3%.
	Volatile Combustible	30 to 33%.
	Fixed Carbon	62 to 65%.
	Ash	1.5 to 3%.
	Sulphur	.6 to 1%.

The Brazil coal is the best coal in Indiana.



Carboniferous strata—W. Pennsylvania and Ohio.



Coal Measures—N. Ohio.

COMPOSITION OF WOOD AND COAL.

Variety.....	Oak, Wood.	Oak, Decayed.	Humus from Decayed Oak.		Peat.		Asphalt	Lignite.		
Locality, etc. Authority...	W. A. M.	Liebig.	Meyer.	Will.	Dartmoor. Vaux.	Vulcaire. Regnault.	Mexico. Regnault.	Bovey. Vaux.	Dax. Regnault.	Boghead. W. A. M.
Sp. gravity..	0.81	—	—	—	0.849	—	1.063	1.129	1.272	1.196
Coke........	21.3	—	—	—	29.30	—	9.0	30.8	49.1	30.23
Carbon......	50.10	53.47	54.0	56.0	54.02	56.25	78.10	66 31	69.52	63.10
Hydrogen...	6.07	5.16	5.1	4.9	5.21	5.63	9.30	5.62	5.59	8.91
Nitrogen ..					2.30			0.56		7.25
Oxygen....	43.68	41.37	40.9	39.1	28.17	32.54	9.80	22.86	19.90	
Sulphur...					0.56			2.36		0.96
Ash.........	0.15	—	—	—	9.73	5.58	2.80	2.27	4.99	19.78

THE SAME, ASH FREE.

Carbon......	50.18	—	—	—	59.73	59.57	80.34	67.85	73.18	78.67
Hydrogen...	6.08	—	—	—	5.91	5.96	9.57	5.76	5.88	11.11
Nitrogen .					2.54	2.09		0.58		—
Oxygen...	43.74	—	—	—	31.82	32.38	10.09	28.39	20.94	10.22
Empirical formula	$C_{34}H_{48}O_{22}$	—	—	—	$C_{20}H_{22}O_{8}$	—	—	$C_{27}H_{28}O_{7}$	—	$C_{22}H_{38}O_{2}$

If the empirical formula $C_{34}H_{48}O_{22}$ be assigned to wood, founded on the analysis of oak, as shown above, the approximate empirical formula for peat will be $C_{20}H_{22}O_8$; for Bovey lignite $C_{27}H_{28}O_7$; for Wigan cannel $C_{26}H_{20}O_2$; and for Welsh anthracite $C_{40}H_{16}O$.

Now, if a small amount of oxygen, such as might be supplied by solution in water, be supposed to act upon the woody tissue, each of these varieties of fuel might be formed by the separation of marsh gas, carbonic oxide, and water in the following proportions (Miller):

$$\overbrace{4C_{34}H_{48}O_{22}}^{\text{Wood.}} + 6O_2 = \overbrace{4C_{20}H_{22}O_8}^{\text{Peat.}} + \overbrace{24CH_4}^{\text{Marsh Gas.}} + \overbrace{32CO_2}^{\text{Carb. Anhydride.}} + \overbrace{4H_2O}^{\text{Water.}}$$

$$\overbrace{4C_{34}H_{48}O_{22}}^{\text{Wood.}} + 2O_2 = \overbrace{4C_{27}H_{28}O_7}^{\text{Lignite.}} + 8CH_4 + 20CO_2 + 24H_2O$$

$$\overbrace{4C_{34}H_{48}O_{22}}^{\text{Wood.}} + 4O_2 = \overbrace{4C_{26}H_{20}O_2}^{\text{Cannel.}} + 8CH_4 + 24CO_2 + 40H_2O$$

$$\overbrace{4C_{34}H_{48}O_{22}}^{\text{Wood.}} + 5O_2 = \overbrace{2C_{40}H_{16}O}^{\text{Anthracite.}} + 24CH_4 + 32CO_2 + 32H_2O.$$

ESTIMATED AREAS OF COAL IN PRINCIPAL COUNTRIES.

(PEPPER.)

LOCALITIES.	SQ. MILES COAL AREA.	TOTAL SQ. MILES.
United States	196,650	200,000
British Provinces of North America	7,530	
Great Britain	5,400	8,964
France	984	
Belgium	510	
Rhenish Prussian Saarbrücker coal-field	960	
Westphalia	380	
Bohemia	400	
Saxony	30	
Spain	200	
Russia	100	

Assuming a thickness of 20 feet of coal over 200,000 square miles, North America would contain 4,000,000,000,000 tons of coal.

ANALYSIS OF COALS.

ANTHRACITE.

LOCALITIES.	C.	H.	O.	N.	S.	ASH.
1. Piesberg, Hanover........	87.96	1.97	0.61		—	9.31
2. " "	91.14	2.08	—	—	—	6.81
3. Pennsylvania............	90.45	2.43	2.45	—	—	4.67
4. "	92.59	2.63	1.61	0.92	—	2.25
5. "	84.98	2.45	1.15	1.22	—	10.20

Nos. 1 and 2 by Hilkenkamp and Kempner; 3 by Renault; 4 and 5 by J. Percy.

BITUMINOUS.

CAKING COAL.

LOCALITIES.	C.	H.	O.	N.	S.	ASH.
1. Zweckan.................	72.27	4.16	10.73	0.34	0.88	12.50
2. Northumberland..........	78.65	4.65	14.21	—	0.55	2.49
3. "	82.42	4.82	11.97	—	0.86	0.79
4. River-de-Gier............	87.45	5.14	3.93	1.70	—	1.78
5. Alais....................	89.27	4.85	4.47	—	—	1.41

No. 1 by Stein; 2 and 3 by Dick; 4 and 5 by Regnault.

LIGNITE OR BROWN COAL.

LOCALITIES.	C.	H.	O.	N.	S.	ASH.
Dax, France................	70.49	5.59	18.93		—	4.99
Bovey......................	66.31	5.63	22.86	0.57	2.36	2.27
Irkutsk....................	47.46	4.56	33.02	—	—	14.95

No. 1 by Regnault; 2 by Vaux; 3 by Woskressensky.

NON-CAKING COAL.

LOCALITIES.	C.	H.	O.	N.	S.	ASH.
1. S. Staffordshire...........	72.13	4.32	17.11[a]	—	0.54	6.44
2. "	76.40	4.62	17.43[a]	—	0.55	1.55
3. Scotland.................	80.98	5.21	10.91	1.57	0.63	6.75
4. Mous, France............	82.95	5.42	10.93	—	—	0.70
5. Valenciennes.............	90.54	3.66	2.70	—	—	3.10

Nos. 1 and 2 by Dick; 3 by Rowney; 4 and 5 by Marsilly.

CANNEL COAL.

LOCALITIES.	C.	H.	O.	N.	S.	ASH.
1. Wigan	84 07	5.71	7.82	—	—	2.40
2. "	80.07	5.53	8.10	2.12	1.50	2.70
3. Tyneside	78.06	5.80	3.12	1.85	2.22	8.94

No. 1 by Regnault; 2 by Vaux; 3 by Taylor.

NOTE.—(*) signifies that the nitrogen is included in the oxygen.

The following table is taken from "Report on Coals to Congress, 1844," by Prof. W. R. Johnson:

LOCALITIES.	SPECIFIC GRAVITY.	VOLUME COMBUST. MATTER.	FIXED CARBON.	ASH AND CLINKERS
Pennsylvania (anthracite)	1.590–1.610	3.84	87.45	7.37
Maryland (free-burning bitum. coal).	1.3–1.414	15.80	73 01	9.74
Pennsylvania " " "	1.3–1.407	17.01	68.82	13.35
Virginia " " "	1.29–1.45	36.63	50.99	10.74
Pittsburg (bituminous coal)	1.252	36.76	54.93	7.07
Cannelton, Ind	1.273	33.99	58.44	4.97
Pictou, Nova Scotia	1.318	27.83	56.98	13.39
" " "	1.325	25.97	60.74	12.51

ANALYSIS OF THE ASHES OF COAL.

(Percentage of ash in the coal was 1.99.)

(BY KREMER.)

Silica	15.48
Alumina	5.28
Peroxide of iron	74.02
Lime	2.26
Magnesia	0.26
Potash	0.53
Soda	—
Sulphate of lime	2.17
Total	100.00

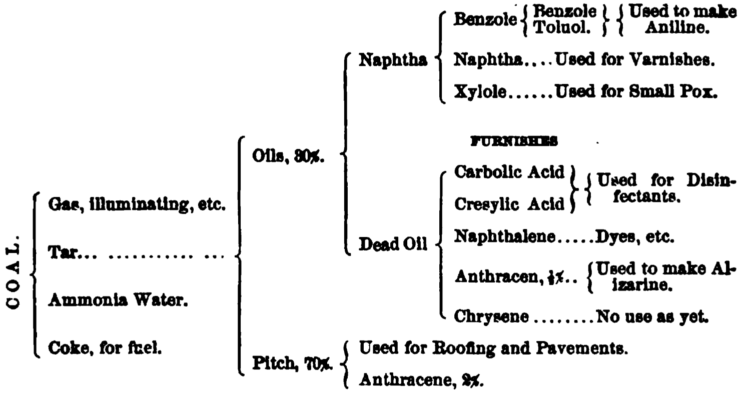
DURABILITY OF DIFFERENT WOODS.

Experiments on this subject have been made on various kinds of wood, of which sticks 2 feet long and 1½ inches square were cut, and driven into the ground until but 1½ inches projected.

The results were as follows:

KIND OF WOOD.	CONDITION AFTER 2½ YRS.	CONDITION AFTER 5 YEARS.
Chestnut oak	Very good	Most specimens moderately, some very much attacked.
Canada chestnut oak	Very much attacked	Very bad, rotten.
Oak from Memel	The same	The same.
Oak from Dantzic	The same	Exceedingly bad.
Hard mahogany	Good	Tolerable.
Soft mahogany	Much attacked	Very bad, entirely rotten.
Cedar of Lebanon	Good	Tolerable.
Virginia cedar	Very good	Very good, the same as when first put in.
Teak wood	The same	Somewhat soft, but good.
Fir	Much attacked	Much rotted.
Pine	Very much attacked	The same.
Virginia pine	Attacked	The same.
Hard pine	⅛ in. attacked, the rest good	¼ inch attacked, the rest tolerable.
Soft pine	Much rotted	Much rotted.
Larch	¼ in. on the surface attacked; had lost in weight	¼ inch much, the rest a little attacked.
English elm	Much rotted	Entirely rotten.
Canadian elm	The same	Rotten.
American ash	The same	The same.
Acacia	Good, except loss in weight	⅛ inch rotted, the rest as sound as when first put in.

PRODUCTS OBTAINED FROM DISTILLATION OF COAL.



The following is a list of the products from the distillation of coal (Chandler*):

I. COKE.

	Per cent.
1. Carbon	90—95
2. Sulphide of iron (Fe_7S_8)	3—10
3. Ash	3—15

II. AMMONIA WATER.

1. Hydro-ammonic carbonate	NH_4HCO_3.
2. Ammonic hydrosulphate	NH_4HS.
3. Ammonic sulphocyanide	NH_4CNS.
4. Ammonic cyanide	NH_4CN.
5. Ammonic chloride	NH_4Cl.

III. TAR.

1. *Hydrocarbons.*

	Formula.	Sp. Gr.	Boiling Points.
1. Benzol	C_6H_6	.850	82°C. = 179°.6F.
2. Toluol, methyl-benzol	C_7H_8	.870	111° = 231°.8
3. Ethyl-benzol	C_8H_{10}	—	132° = 269°.6
4. Xylol, di-methyl-benzol	C_8H_{10}	.867	140° = 284°
5. Cumol, propyl-benzol	C_9H_{12}	.870	153° = 307°.4
6. Methyl-ethyl-benzol	C_9H_{12}	—	160° = 320°

---

* Johnson's Cycl., Article *Gas-Lighting*.

	Formula.	Sp. Gr.	Boiling Points.
7. Tri-methyl-benzol (pseudocumol, mesetylene.	C_9H_{12}	—	166°C. = 330°.8F.
8. Isobutyl-benzol	$C_{10}H_{14}$	—	159° = 318°.2
9. Cymol, methyl-propyl-benzol	$C_{10}H_{14}$	.861	178° = 352°.4
10. Di-ethyl-benzol	$C_{10}H_{14}$	—	178° = 352°.4
11. Di-methyl-ethyl-benzol (ethyl-xylol)	$C_{10}H_{14}$	—	184° = 363°.2
12. Amyl-benzol	$C_{11}H_{16}$	.859	193° = 379°.4
13. Methyl-amyl-benzol	$C_{12}H_{18}$	—	213° = 415°.4
14. Di-methyl-amyl-benzol (amyl-xylol)	$C_{13}H_{20}$	—	232° = 449°.6
15. Phenylene	C_6H_4	—	91° = 195°.8
16. Cinnamene, styrolene	C_8H_8	.924	145° = 293°
17. Naphthalene	$C_{10}H_8$	1.158	220° = 428°
18. Di-phenyl	$C_{12}H_{10}$	—	240° = 464°
19. Anthracene	$C_{14}H_{10}$	1.147	300° = 572°
20. Pyrene	$C_{16}H_{10}$	—	— —
21. Chrysene	$C_{18}H_{12}$	—	— —
22. Benzerytherene	—	—	— —

And probably:

	Formula.	Sp. Gr.	Boiling Points.
23. Quintane	C_5H_{12}	0.60	30° = 86°
24. Sextane	C_6H_{14}	.669	68° = 154°.4
25. Other paraffines	C_nH_{2n+2}	—	— —
26. Quintene, amylene	C_5H_{10}	—	35° = 95°
27. Sextene	C_6H_{12}	—	68° = 154°.4
28. Other olifines	C_nH_{2n}	—	— —
29. Quintine, valerylene	C_5H_8	—	46° = 114°.8
30. Sextine, diallyl	C_6H_{10}	—	58° = 136°.4
31. Other acetylenes	C_nH_{2n-2}	—	— —
32. Dipropyl	$(C_3H_7)_2$	.678	68° = 154°.4
33. Dibutyl	$(C_4H_9)_2$	.706	106° = 222°.8
34. Diamyl	$(C_5H_{11})_2$	.741	158° = 316°.4
35. Dicaproyl	$(C_6H_{13})_2$	.757	202° = 395°.6
36. Other alcohol radicals	$(C_nH_{2n+1})_2$	—	— —

2. *Alcohols.*

	Formula.	Sp. Gr.	Boiling Points.
1. Phenol, carbolic acid	C_6H_5OH	1.065	180° = 356°
2. Cresol, cresylic acid	C_7H_7OH	—	200° = 392°
3. Phlorol, phlorylic acid	C_8H_9OH	1.037	195° = 383°
4. Xylenol	C_8H_9OH	—	213°.5 = 416°
5. Thymol	$C_{10}H_{13}OH$	—	220° = 428°

		Formula.	Sp. Gr.	Boiling Points.	
6.	Methyl-thymol	$C_{11}H_{15}OH$	—	—	—
7.	Ethyl-thymol	$C_{12}H_{17}OH$	—	—	—
8.	Amyl-thymol	$C_{15}H_{23}OH$	—	—	—

3. *Acids.*

1.	Acetic	$H.C_2H_3O_2$	1.062	117°.2	= 243°
2.	Butyric	$H.C_4H_7O_2$	.9817	164°	= 327°.2
3.	Rosolic	$C_{20}H_{16}O_3$	—	—	—
4.	Brunolic	?	—	—	—

4. *Bases.*

1.	Ammonia	H_3N	Gas	—	—
2.	Methylamine	CH_5N	Gas	—	—
3.	Ethylamine	C_2H_7N	.696	19°	= 16°.2
4.	Diethylamine	$C_4H_{11}N$	—	57°.5	= 135°.5
5.	Aniline, phenylamine	C_6H_7N	1.028	182°	= 359°.6
6.	Toliudine	C_8H_9N	—	205°	= 401°
7.	Xylidine	$C_9H_{11}N$	—	215°	= 419°
8.	Cumidine	$C_{10}H_{13}N$	.952	225°	= 437°
9.	Cynudine	$C_{11}H_{15}N$	—	250°	= 482°
10.	Pyridine	C_5H_5N	.985	117°	= 242°.6
11.	Picoline	C_6H_7N	.961	133°	= 271°.4
12.	Lutidine	C_7H_9N	.946	154°	= 309°.2
13.	Collidine	$C_8H_{11}N$	.921	179°	= 354°.2
14.	Parvoline	$C_9H_{13}N$	—	188°	= 370°.4
15.	Coridine	$C_{10}H_{15}N$	—	211°	= 411°.8
16.	Rubidine	$C_{11}H_{17}N$	1.017	230°	= 446°
17.	Viridine	$C_{12}H_{19}N$	1.017	251°	= 483°.8
18.	Pyrrol	C_4H_5N	1.077	133°	= 371°.4
19.	Leucoline, chinoline	C_9H_7N	1.081	238°	= 460°.4
20.	Iridoline, lepidine	$C_{10}H_9N$	—	—	—
21.	Cryptidine, dispoline	$C_{11}H_{11}N$	—	273°.9	= 525°

5. *Pitch.*

Oxidized bituminous bodies, whose nature has not been accurately determined.

IV. GAS.

1. *Luminants.*

		Formula.	Density.
1.	Vapors of paraffines	C_nH_{2n+2}	—
2.	Propyl	$(C_3H_7)_2$	—
3.	Other alcohol radicals	$(C_nH_{2n+1\,2})$	—

	Formula.	Density.
4. Olefiant gas, ethene	C_2H_4	.976
5. Propene	C_3H_6	1.490
6. Butene	C_4H_8	1.946
7. Vapors of other olifines	C_nH_{2n}	—
8. Acetylene	C_2H_2	.920
9. Vapors of other acetylenes (?)	C_nH_{2n-2}	—
10. Valelene (?)	C_nH_{2n-4}	—
11. Benzole	C_6H_6	2.71
12. Vapors of toluol, xylol, etc	C_nH_{2n-6}	—
13. Phenylene, etc. (?)	C_nH_{2n-8}	—
14. Cuinamene, etc. (?)	C_nH_{2n-10}	—
15. Naphthalene	$C_{10}H_8$	—
16. Diphenyl, etc. (?)	$C_{12}H_{10}$	—
17. Anthracene (?)	$C_{14}H_{10}$	—
18. Pyrene (?)	$C_{16}H_{10}$	—
19. Chrysene (?)	$C_{18}H_{12}$	—
20. Phenol, etc. (Alcohols)	$C_nH_{2n-7}OH$	—
21. Bases above mentioned	—	—

2. *Diluents.*

1. Hydrogen	H	.0691
2. Marsh-gas, methene	CH_4	.5594
3. Carbonic oxide	CO	.9727

3. *Impurities.*

1. Sulphuretted hydrogen	H_2S	1.1747
2. Ammonic sulphydrate	NH_4HS	—
3. Carbon di-sulphide	CS_2	—
4. Carbon oxysulphide	CSO	—
5. Sulphurous oxide	SO_2	—
6. Mercaptan, etc	C_2H_5HS	—
7. Sulphur bases, etc	—	—
8. Ammonic sulpho-cyanide	NH_4CNS	—
9. Ammonic cyanide	NH_4CN	—
10. Ammonic *mono*-carbonate	NH_4HCO_3	—
11. Carbonic oxide	CO_2	1.5240
12. Nitrogen	N	.9760
13. Oxygen	O	1.1026
14. Aqueous vapor (water)	H_2O	.6201

PRODUCTS OF COAL.

(MOLESWORTH.)

PRODUCTS.	NEWCASTLE.		CANNEL.	
	From.	To.	From.	To.
Cube feet of gas per ton of coal	9,500	10,000	11,500	15,000
Pounds of coke	1,500	1,540	715	720
Pounds of tar	70	90	710	720
Pounds of ammoniacal liquor	80	120	—	—

Fuel required for retorts, about 20 lbs. per cwt.

AVERAGE EVAPORATING POWER.

(MOLESWORTH.)

1 lb. of coal	evaporates	9 lbs. of water.*
1 lb. of coke	"	9 " "
1 lb. of slack	"	4 " "
1 lb. of oak (dry)	"	4½ " "
1 lb. of pine	"	2½ " "

Coal loses about one-third of its weight in coking, but increases in bulk one-tenth.

PEAT.

IN 100 PARTS.	C.	H.	O AND N.	ASH.	H_2O.	SP. GR.
Condensed Peat	47.2	4.9	22.9	5.0	20.0	1.20
Wood	39.6	4.8	34.8	0.8	20.0	0.75
Anthracite	91.3	2.9	2.8	3.0	—	1.40

(Taken from a book on Peat and its Uses, by S. W. Johnson, A. M.)

HEATING POWER OF DIFFERENT KINDS OF FUEL.

(JOHNSON.)

(The comparison is made in units of heat,† and refers to equal weights of the materials experimented on.)

Air-dried wood	2800
" " peat	2500—3000
Perfectly dry wood	3600

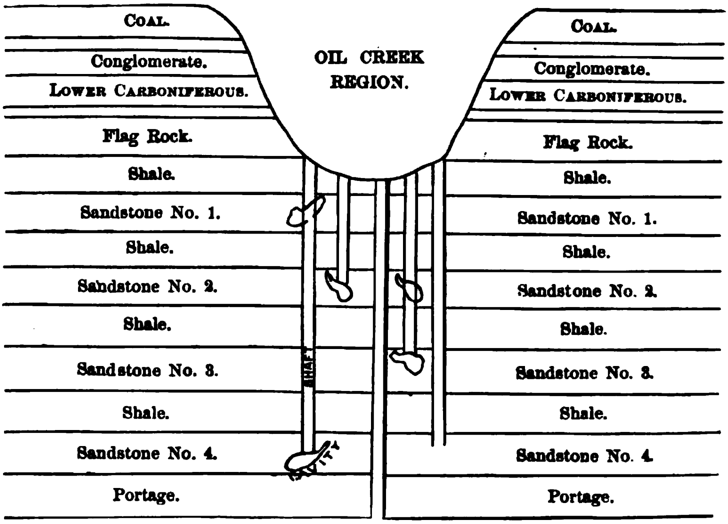
---

[*] Feed-water supplied at 212° F.

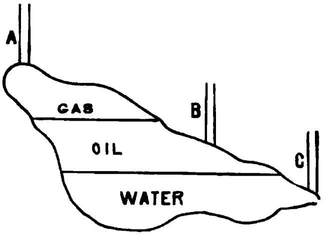
[†] The amount of heat that will raise the temperature of one gram of water one degree of the Centigrade thermometer, is agreed upon as the unit of heat.

Perfectly dry peat	3000—4000
Air dry lignite or brown coal	3300—4200
Perfectly dry lignite or brown coal	4000—5000
Bituminous coal	3800—7000
Anthracite	7500
Wood charcoal	6300—7500
Coke	6500—7000

PETROLEUM.



PETROLEUM CAVITY.



If a petroleum cavity be struck at (A), it often happens that the gas rushes out with such a velocity that all the tools are blown out of the shaft. If struck at (B), petroleum oil will rush out, having a specific gravity at the bottom of the shaft of 50° B.; and at the top 29° B. One cavity has been known to give 100,000 barrels of oil before dry. If the cavity is struck at (c), water will first come out, then oil.

The town of Fredonia, N. Y., has been lighted by gas obtained from a petroleum cavity for the last 40 years. Several buildings at Erie, N. Y., are also lighted from gas wells.

Petroleum is found all the time by the decomposition of animal and vegetable substances. The formation of petroleum may be noticed around the edges of stagnant pools, etc.

PRODUCTS OF THE DISTILLATION OF CRUDE PETROLEUM.

(By C. F. Chandler.)

Price in Bulk, 14 *cents per Gallon.*

Gravity, Beaume.	Name.	Percentage yielded.	Gravity, Beaume.	Uncondensed, Loss.	Price per Gallon.	
Gases.					In bulk.	Retail.
115° B. to 105° B.	Cymogene........	....	110°	Condensed by pump, made by one firm only for an ice machine, boils at 32° F.	$1 50	
105° B. to 95° B.	Rhigolene........	....	100°	Condensed by ice and salt, used as an anæsthetic, boils at 65° F.	$1 00	
95° B. to 80° B.	Gasolene...... ..	1½	85° to 90°	Condensed in worm by cold water, used in "air gas machines" and gas "carbonizers."	35 cts. to 18 cts.	
80° B. to 65° B.	Naptha	10	71° to 76°	For *oil cloths*, cleaning, etc.; so-called "Safety oil," "Danforth's oil," "American Safety Gas," etc.; for adulterating kerosene; cleaning oil wells.	7 cts. to 5 cts.	12 cts. to 20 cts.
65° B. to 60° B.	Benzine..........	4	62° to 65°	For paints and varnishes....	16 cts. to 12 cts.	20 cts. to 16 cts.
60° B. to 38° B.	Kerosene or Refined Petroleum.	55	46°	Ordinary oil for lamps.......	20 cts. to 25 cts.	30 cts. to 40 cts.
38° B. to 25° B.	Paraffin oil.......	19½	39°	Semi-solid when cold. Chilled and pressed to separate paraffin, oil used for lubricating	18 cts. to 14 cts.	
	Coke, gas, and loss.	10				
	Total......	100				

SCALE OF HARDNESS.

(Mohs.)

1. Talc.—Laminated light-green variety. Easily scratched by the nail.
2. Gypsum.—Crystallized variety. Not easily scratched by the nail. Does not scratch a copper coin.
3. Calcite.—Transparent variety. Scratches and is scratched by a copper coin.
4. Fluor.—Crystalline variety. Not scratched by a copper coin. Does not scratch glass.
5. Apatite.—Transparent variety. Scratches glass with difficulty. Easily scratched by the knife.
6. Orthoclase.—White cleavable variety. Scratches glass easily. Not easily scratched by the knife.
7. Quartz.—Transparent variety. Not scratched by knife. Yields with difficulty to the file.
8. Topaz.—Transparent variety. Harder than flint.
9. Sapphire.—Cleavable varieties. Harder than flint.
10. Diamond.—Harder than flint.

THE HARDNESS OF A FEW SUBSTANCES ARRANGED.

Diamond	10	Lapis Lazuli	6
Ruby	9	Feldspar	6
Cymophane	8.5	Amphibole	5.5
Topaz	8	Phosphorite	5
Spinel	8	Fluorspar	4
Emerald	8	Cœlestine	3.5
Garnet	7.5	Barytes	3.5
Dicroite	7.5	Carbonate Lime	3.
Zircon	7	Mica	2.5
Peridote	7	Gypsum	2
Quartz	7	Chlorite	1.5
Tourmaline	7	Talc	1
Opal	6.5–5.5		

Stoichiometry.

m wt : an : 100 : x

$$n = \frac{m\ wt\ x}{100a}$$

STOICHIOMETRICAL CALCULATIONS.

*Example.**—*What is the percentage composition* of calcic sulphate, $CaSO_4$?

Molecular weight = m.
Atomic " of any constituent = a.
Number of atoms of that constituent = n.
Percentage amount = x.

$$m : an :: 100 : x.$$

By the formula, the molecule contains of

Calcium, one atom (atomic weight, 40)	40
Sulphur, " " (atomic weight, 32)	32
Oxygen, four atoms (atomic weight, 16)	64
Molecular weight of calcic sulphate	136

$$\text{From above proportion, } x = \frac{an \times 100.}{m}$$

Substituting in this formula, the quantity of

$$\textit{Calcium} \text{ in 100 parts is } \frac{40 \times 100}{136} = 29.41.$$

$$\textit{Sulphur} \text{ " " " " } \frac{32 \times 100}{136} = 23.53.$$

$$\textit{Oxygen} \text{ " " " " } \frac{64 \times 100}{136} = \underline{47.06}$$

$$100.00$$

Example.—What is the formula of quartz, its molecular weight being 60, and its percentage composition being:

Silicon	46.67
Oxygen	53.33
	100.00

---

* All the following examples are from Barker's Chemistry.

The atomic weight of silicon is 28; hence the number of atoms of

$$\text{Silicon would be } \left(n = \frac{mx}{100a}\right) \frac{60 \times 46.67}{100 \times 28} = 1$$

$$\text{Oxygen '' '' } \left(n = \frac{mx}{100a}\right) \frac{60 \times 53.33}{100 \times 16} = 2$$

The molecular formula of quartz is therefore SiO_2.

Example.—The molecular weight of argentic nitrate is 170; it contains 63.53 per cent. of silver, and has but one atom of silver in a molecule. *What is the atomic weight of silver?*

$$\text{We have } a = \frac{mx}{100n} \text{ or } \frac{170 \times 63.53}{100 \times 1} = 108.$$

Hence the atomic weight of silver is 108.

Example.—Salt contains 39.32 per cent. of sodium, whose atomic weight is 23. In a molecule of salt there is but one atom of sodium. *What is the molecular weight of salt?*

$$\text{We have } m = \frac{an \times 100}{x} \text{ or } \frac{23 \times 1 \times 100}{39.32} = 58.5.$$

The molecular weight of salt is therefore 58.5.

Again, ferric oxide contains three atoms of oxygen, or 30 per cent. *What is its molecular weight?*

$$\text{By the formula } \frac{16 \times 3 \times 100}{30} = 160.$$

Therefore 160 is the molecular weight.

Example.—Ammonic nitrate NH_4NO_3, breaks up under the influence of heat into one molecule of nitrogen oxide, N_2O, and two molecules of $(H_2O)_2$. *How much nitrogen oxide in 100 parts of ammonic hydrate?*

In formula using (a) to indicate the weight of the group, and (n) the number of such group in the molecule

$$\frac{an \times 100}{m} = \text{formula, we have } \frac{44 \times 1 \times 100}{80} = 55.$$

Hence ammonic nitrate yields 55 per cent. of nitrogen oxide.

Example.—How much iodine may be obtained from 236 grams of potassic iodide (KI), the atomic weight of iodine being 127, and the molecular weight of potassic iodide 166?

By proportion.—As 166 parts of KI give 127 of I, it is obvious that the quantity given by 236 parts would be given by the proportion:

$$166 : 236 :: 127 : y.$$

$y = 180.5$. Answer, 180.5 grams iodine.

By formula, $y = \frac{au \times z}{m}$; substituting therefore $y = \frac{127 \times 236}{166} = 180.5$. Hence 236 grams potassic iodide yield 180.5 grams iodine.

Example.—How much potassic iodide would be required to yield 78 grams of iodine?

$z = \frac{m \times y}{au}$; substituting $z = \frac{166 \times 78}{127} = 102$. Answer, 102 grams potassic iodide.

CALCULATION FROM EQUATIONS.

Examples.—Nitric acid is prepared by the action of sulphuric acid upon potassic nitrate (KNO_3), according to the following equation:

$$\begin{array}{ccccccc} KNO_3 & + & H_2SO_4 & = & HNO_3 & + & HKSO_4. \\ 101 & + & 98 & = & 63 & + & 136. \end{array}$$

Problem 1st.—125 grams of nitre yield 77.97 grams of HNO_3, whose molecular weight is 63. *What is the molecular weight of potassic nitrate?*

Representing by M, the molecular weight of substance given, by W, the absolute weight of this substance given in the problem, by m, the molecular weight of the substance required, and by w, the absolute weight of this substance, then, $M : W :: m : w$; from which the following formulas may be derived:

$$M = \frac{m\,W}{w} \ (1); \quad W = \frac{M\,w}{m} \ (2); \quad m = \frac{M\,w}{W} \ (3); \quad w = \frac{m\,W}{M} \ (4)$$

In *Problem 1st*, $m = 63$, W equals 125, and $w = 77.97$; hence $M = \frac{63 \times 125}{77.97} = 101$, Answer.

Problem 2d.—The molecular weight of nitre is 101, and that of nitric acid is 63; how much nitre would be required to yield 77.97 grams nitric acid?

Here the quantities being represented as before, we have:

$$W = \frac{101 \times 77.97}{63} = 125, \text{ Answer.}$$

Problem 3d.—125 grams of nitre yield 77.97 grams nitric acid. The molecular weight of nitre is 101. *What is the molecular weight of* HNO_3?

$$\text{In this problem, } m = \frac{101 \times 77.97}{125} = 63, \text{ Answer.}$$

Problem 4th.—The molecular weight of nitre is 101, and that of HNO_3 is 63. How much HNO_3 would 125 grams of nitre yield?

$$\text{We have } w = \frac{63 \times 125}{101} = 77.97 \text{ grams, Answer.}$$

Problem 5th.—How much nitre is necessary to yield 36 grams of HNO_3?

$$W = \frac{M\,w}{m};\ W = \frac{101 \times 36}{63} = 57.7 \text{ grams, Answer.}$$

Problem 6th.—How much sulphuric acid required in last problem?

$$\text{Here } M = 98;\ \text{hence } W = \frac{98 \times 36}{63} = 56 \text{ grams, Answer.}$$

Problem 7th.—How much hydropotassic sulphate will be produced in *Problem 1st?*

$$M = 136;\ \text{hence } W = \frac{136 \times 36}{63} = 77.7 \text{ grams, Answer.}$$

The last three *problems* were solved by formula (2); the following ones will be solved by formula (4). Formula (2) and (4) are usually employed.

Problem 8*th*.—How much nitric acid may be produced from 500 grams of KNO_3?

$$w = \frac{mW}{M} = \frac{63 \times 500}{101} = 311.88 \text{ grams, Answer.}$$

Problem 9*th*.—How much H_2SO_4 will be required to decompose 500 grams of nitre?

Here $m = 98$; hence $w = \frac{98 \times 500}{101} = 485.15$ grams, Answer.

Problem 10*th*.—How much hydropotassic sulphate would be yielded by the decomposition of 500 grams of KNO_3 by H_2SO_4?

In this problem, $m = 136$; hence $w = \frac{136 \times 500}{101} = 673.27$ grams, Answer.

VOLUME CALCULATIONS.

Problem 1*st*.—How much carbonic dioxide is formed by combustion of 1 litre of carbonous oxide?

As 4 volumes carbonous oxide yield 4 of carbonic dioxide, 1 volume will yield 1 volume, and 1 litre of course 1 litre, Answer.

Problem 2*d*.—How much oxygen is needed to convert 2 litres carbonous oxide to carbonic dioxide?

4 volumes by the equation require 2 of oxygen; hence 2 litres will require 1 litre of oxygen, Answer.

Problem 3*d*.—To form 100 cubic centimetres of carbonic dioxide, how much carbonous oxide must be burned?

4 volumes of carbonic dioxide require the combustion of 4 of carbonous oxide; 100 cubic centimetres will require its own volume therefore, or 100 cubic centimetres, Answer.

RELATION OF WEIGHT TO VOLUME.

Example 1*st*.—What volume is occupied by 6.08 grams of oxygen gas?

The weight of 1 litre of oxygen is 1.43 grams; hence in 6.08 grams there will be as many litres as 1.43 is contained times in 6.08; or 4.25 litres, Answer.

Example 2d.—What is the weight of 25 litres of nitrogen gas?

1 litre of nitrogen gas weighs 1.26 grams; $1.26 \times 25 = 31.5$; hence 25 litres of nitrogen weigh 31.5 grams, Answer.

SPECIFIC GRAVITIES.

Example.—What is the specific gravity of chlorine gas?

The molecular weight of chlorine is 71; its density therefore is $\frac{71}{2}$ or 35.5. $35.5 \times 0.0693 = 2.46$ (0.0693 Sp. Gr. of hydrogen gas). Chlorine gas is therefore 2.46 times heavier than air.

Problem.—The specific gravity of ammonia gas is 0.589. What is its molecular weight?

If the specific gravity is 0.589, its density is $0.589 \div 0.0693$, or 8.5. Hence its molecular weight is 8.5×2 or 17.

GASEOUS VOLUMES FOR PRESSURE.

Example.—What is the true volume which 250 cubic centimetres of hydrogen measured at 742 millimetres would have, if measured at 760 millimetres?

If the volume of a gas under the height H of the barometric column be represented by V, and under any other height H′ by V′, then $V : V' :: H' : H$; whence $VH = V'H'$ or $V' = \frac{VH}{H'}$.

Substituting in the formula

$$V' = 250 \times \frac{742}{760} = 244 \text{ cubic centimetres, Answer.}$$

Example.—A certain volume of nitrogen dioxide gas, under a pressure of 781 millimetres, measured 542 cubic centimetres. *What is its true volume*, measured at 760 millimetres?

Substituting in formula

$$V' = 542 \times \frac{781}{760} = 578.3 \text{ cubic centimetres, Answer.}$$

GASEOUS VOLUMES FOR TEMPERATURE.

In general, if V represent the known volume, V' the unknown volume, and *t* the number of degrees the temperature is raised or lowered, the formula for calculating an increase of volume will be:

$$V' = V \times (1 \times t \times {\cdot}003665).$$

For lower temperature:

$$V = \frac{V'}{(1 + t \times {\cdot}003665)}.$$

Example.—A gas measures 15 cubic centimetres at 0°. *What will it measure at* 60°?

Substituting in formula,

$$V' = 15 \times (1 + 60 \times {\cdot}003665) = 18.298 \text{ c.c., Answer.}$$

Example.—What will a gas measure at 0°, which, at 100, measures 40.1 cubic centimetres?

$$V = \frac{40.1}{(1 + 100 \times {\cdot}003665)} = 29.345 \text{ c.c., Answer.}$$

A gas measures 560 cubic centimetres, at 15°. *What will it measure at* 95°?

Here $t° = 95 - 15 = 80$. Hence,

$$V' = 560 \times (1 + 80 \times {\cdot}003665) = 724.2 \text{ c.c., Answer.}$$

TABLE* OF

W or w—soluble in water. A or a—insoluble in water, soluble in acids (HCl,HNO_3 but soluble in acids. W-I—sparingly soluble in water and acids. A-I–insoluble in refer to notes, p. 362.

	Aluminium.	Ammonium.	Antimony.	Barium.	Bismuth.	Cadmium.	Calcium.	Chromium.	Cobalt.	Copper.	Dyad Iron.
Acetate....	W	W		W	w	w	a	w	w	W	w
Arseniate .	a	w	a	a	a	a	a	a	a	a	a
Arsenite...		w	a	a			a		a	A	a
Benzoate..	w	w		w		w	w			a	w
Borate.....	a	w		a	a	w-a	a	a	a	a	a
Bromide...	w	W	w-a	w	w-a	w	w	w & i	w	w	w
Carbonate.	a	W		A	A	a	A	a	A	A	A
Chlorate...	w	w		W	w	w	w	w	w	w	w
Chloride. .	w	$W_{3.4}$	$W\text{-}A_{10}$	W	$W\text{-}A_{14}$	W	W	W & I	W	W	W
Chromate..		w	a	a	a	a	w-a	a	a	w	
Citrate...	w	w		a		a	w-a	w	w	w	w
Cyanide...		w		w-a		a	w	a	a-i	a	a-i
Ferricy'de.		w					w		i		I
Ferrocy'de		w		w-a			w		i	i	i
Fluoride...	w	W	w	a-i	w	w-a	A	w	w-a	a	w-a
Formate ..	w	w		w	w	w	w	w	w	w	w
Hydroxide	A	W	A	W	a	a	W-A	A	A	a	a
Iodide.....	w	W	w-a	w	a	W	w	w	w	w	W
Malate	w	w		w & a			w & a				
Nitrate....	w	W		W	W_{13}	w	w	W	W	W	W
Oxalate....	a	W	a	a	a	a	A	w-a	A	a	a
Oxide.....	A & I		a_{11}	W	a	a	W & A	A & I	A	A	a
Phosphate.	a	$W_{5.6}$	w-a	w & a	a	a	W & A	a	a	a	a
Silicate....	A-I			a		a	a	a	a	a	a
Succinate..	w-a	w		w-a		w	w-a		w-a	w-a	w
Sulphate ..	$W_{1.2}$	$W_{2.7.8}$	a	A	w	W	W-I	$W\ \&\ A_{17}$	W_{18}	W	W_7
Sulphide ..	a	W	$A_{12.16}$	W	a	A	W-A	a-i	a	A	A
Tartrate...	w	w_9	a_{13}	a	a	w-a	a	w	w	w	w-a

* From Qualitative Analysis (Fresenius).

SOLUBILITY.

and aqua regia). I or i—insoluble in water and acids. W-A—sparingly soluble in water, water, sparingly soluble in acids. Capitals indicate common substances; small figures

Tetrad Iron.	Lead.	Magnesium.	Manganese.	Mercurosum.	Mercuricum.	Nickel.	Potassium.	Silver.	Sodium.	Strontium.	Dyad Tin.	Tetrad Tin.	Zinc.	
W	W	w	w	w-a	w	w	W	w	W	w	w	w	W	Acetate.
a	a	a	a	a	a	a	W	a	W	a	a	a		Arseniate.
a	a	a	a	a	a	a	w	a	w	a	a			Arsenite.
a	a	w	w	a	w-a		w	w-a	w					Benzoate.
a	a	w-a	a			a	W	a	W	a	a		a	Borate.
w	w-i	w	w	a-i	w	w	W	a	W	w			w	Bromide.
a	A	A	A	a	a	A	W	a	W	A			A	Carbonate.
w	w	w	w	w	w	w	W	w	w	w	w		w	Chlorate.
W_2	W-I	W	W	A-I	W_{23}	W	W_{26}	I	W	W	W	W	W	Chloride.
w	A-I	w	w	a	w-a	a	W	a	w	w-a	a		w	Chromate.
W	a	w	a	a	w-a	w	w	a	W	a			w-a	Citrate.
	a	w	a		W	a-i	W	i	w	w			a	Cyanide.
w	w-a	w	i			i	W	i	w				a	Ferricy'de.
I	a	w	a			i	W	i	w	w			a-i	F'rrocy'de.
w	a	a-i	a		w-a	w-a	w	w	w	a-i	w	w	w-a	Fluoride.
w	w-a	w	w	w	w	w	w	w	w	w	w		w	Formate.
A	a	A	a			a	W		W	w	a	a	a	Hydroxide.
w	W-A	w	w	A	A	w	W	i	w	w	w	w	w	Iodide.
w	w-a	w	w	a	w-a		w	w-a	w	w	w	w	w	Malate.
W	W	w	w	W	W	W	W	W	W	W			w	Nitrate.
a	a	a	w-a	a	a	a	W	a	W	a	a	w	a	Oxalate.
A	A	A	A_{20}	A	A	A	W	a	W	W	a	A & I	A	Oxide.
a	a	a_6	a	a	a	a	w	a	W	a	a	a	a	Phosphate.
a	a	a	a			a	W		W	a			a	Silicate.
	a	w	w	a	w	w	w	a	w	w-a		a	w-a	Succinate.
W	A-I	W	W	w-a	w_{22}	W	W_{17}	W-A	W	I	w		W	Sulphate.
A	A	a	a	a	A_{24}	A_{25}	W	a_{27}	W	w	a_{28}	A_{30}	A_{29}	Sulphide.
W_{19}	a	w-a	w-a	w-a	a	a	W	a	w	a	a		a	Tartrate.

Edited by Johnson. Page 425-6-7. (1875.)

NOTES TO TABLE OF SOLUBILITY.

1. Aluminic ammonic sulphate, W.
2. " potassic " W.
3. Ammonic arsenic chloride, W.
4. " platinic " W—I.
5. " sodic phosphate, W.
6. " magnesic " A.
7. " ferrous sulphate, W.
8. " cupric " W.
9. " potassic tartrate, W.
10. Antimonic hypochlorite, A
11. Bismuthic " A.
12. " basic nitrate, A.
16. Calcic sulphantimonate, W—A.
17. Chromic potassic sulphate, W.
18. Cobaltic sulphide. Easily soluble in HNO_3; very slowly in HCl.
19. Ferric potassic tartrate, W.
20. Manganese dioxide. Soluble in HCl; insoluble in HNO_3.
21. Mercurius solubilis Hahnemanni, A.
22. Mercurammonic chloride, A.
23. Mercuric sulphate basic, A.
24. Mercuric sulphide. Insoluble in HCl and in HNO_3; soluble in aqua regia.
25. Nickelic sulphide. (See Cobaltic Sulphide.)
26. Potassic platinic chloride, W—A.
27. Argentic sulphide. Only soluble in HNO_3.
28. Tin sulphides. Soluble in hot HCl; oxidized, not dissolved by HNO_3; sublimed stannic sulphide only soluble in aqua regia.
29. Zincic sulphide. Easily soluble in HNO_3; with difficulty in HCl.
30. Auric sulphide. Insoluble in HCl and in HNO_3; soluble in aqua regia.
31. Auric bromide, chloride, and cyanide, W; iodide, a.
32. Platinic sulphide. Insoluble in HCl; slightly soluble in hot HNO_3; soluble in aqua regia.
33. Platinic bromide, chloride and cyanide, nitrate oxalate and sulphate, W; oxide, a; iodide, i.

REDUCTION OF COMPOUNDS

FOUND TO CONSTITUENTS SOUGHT BY SIMPLE MULTIPLICATION OR DIVISION.

(*Fresenius Quantitative Analysis*, p. 608. 1871 Edition.)

The following table only contains some of the more frequently occurring compounds; the formulæ preceded by ! give absolutely accurate results.

FOR INORGANIC ANALYSIS.

Carbonic Acid.

! Carbonate of lime × 0.44 = carbonic acid.

Chlorine

Chloride of silver × 0.24724 = chlorine.

Copper.

Oxide of copper × 0.79849 = copper.

Iron.

! Sesquioxide of iron × 0.7 = 2 iron.
! Sesquioxide of iron × 0.9 = 2 protoxide of iron.

Lead.

Oxide of lead × 0.9283 = lead.

Magnesia.

Pyrophosphate of magnesia × 0.36036 = 2 magnesia.

Manganese.

Protosesquioxide of manganese × 0.72052 = 3 manganese.
" " " × 0.93013 = 3 protoxide of manganese.

Phosphoric Acid.

Pyrophosphate of magnesia × 0.6396 = phosphoric acid.
Phosphate of sesquioxide of uranium ($2\ Ur_2O_3,PO_5$) × 0.1991 = phosphoric acid.

Potassa.

Chloride of potassium × 0.52445 = potassium.
Sulphate of potassa × 0.5408 = potassa.

$$\left.\begin{array}{c}\text{Potassio-bichloride of platinum} \times 0.30507\\ \text{or}\\ \dfrac{\text{Potassio-bichloride of platinum}}{3.278.}\end{array}\right\} = \left\{\begin{array}{l}\text{Chloride of}\\ \text{potassium.}\end{array}\right.$$

$$\left.\begin{array}{c}\text{Potassio-bichloride of platinum} \times 0.19272\\ \text{or}\\ \dfrac{\text{Potassio-bichloride of platinum.}}{5.188.}\end{array}\right\} = \text{Potassa.}$$

Soda.

Chloride of sodium × 0.5302 = soda.
Sulphate of soda × 0.43658 = soda.

Sulphur.

Sulphate of baryta × 0.13734 = sulphur.

Sulphuric Acid.

Sulphate of baryta × 0.34335 = sulphuric acid.

FOR ORGANIC ANALYSIS.

Carbon.

$$\left.\begin{array}{c}\text{Carbonic acid} \times 0.2727\\ \text{or}\\ \dfrac{\text{Carbonic acid}}{3.666.}\\ \text{or}\\ \dfrac{\text{Carbonic acid} \times 3}{11}\end{array}\right\} = \text{Carbon.}$$

Hydrogen.

$$\left.\begin{array}{c}\text{Water} \times 0.11111\\ \text{or}\\ \dfrac{\text{Water}}{9}\end{array}\right\} = \text{Hydrogen.}$$

Nitrogen.

Ammonio-bichloride of platinum × 0.06269 = nitrogen.
Platinum × 0.1415 = nitrogen.

TABLE

SHOWING THE AMOUNT OF CONSTITUENT SOUGHT FOR ONE PART OF THE COMPOUND FOUND.

ELEMENTS.	FOUND.	SOUGHT.	1.
Aluminium..	Alumina, Al_2O_3.	Aluminium, Al_2.	0.53398
(Ammonium)	Chloride of Ammonium, NH_4Cl.	Ammonia, NH_3.	0.31804
	Ammonio-bichloride of Platinum, $NH_4Cl,PtCl_2$.	Oxide of Ammonium. NH_4O.	0.11644
	Ammonio-bichloride of Platinum, $NH_4Cl,PtCl_2$.	Ammonia, NH_3.	0.07614
Antimony..	Teroxide of Antimony, SbO_3.	Antimony, Sb.	0.83562
	Tersulphide of Antimony, SbS_3.	Antimony, Sb.	0.71765
	Antimonious Acid, SbO_4.	Teroxide of Antimony, SbO_3.	0.94805
Arsenic.....	Arsenious Acid, AsO_3.	Arsenic, As.	0.75758
	Arsenic Acid, AsO_5.	Arsenic, As.	0.65217
	Arsenic Acid, AsO_5.	Arsenious Acid, AsO_3.	0.86087
	Tersulphide of Arsenic, AsS_3.	Arsenious Acid, AsO_3.	0.80488
	Tersulphide of Arsenic. AsS_3.	Arsenic Acid, AsO_5.	0.93496
	Arseniate of Ammonia and Magnesia. $2MgO,NH_4O,AsO_5 + Aq$.	Arsenic Acid, AsO_5.	0.60526
	Arseniate of Ammonia and Magnesia. $2MgO,NH_4O,AsO_5 + Aq$.	Arsenious Acid, AsO_3.	0.52105
Barium.....	Baryta, BaO.	Barium, Ba.	0.89542
	Sulphate of Baryta, BaO,SO_3.	Baryta, BaO.	0.65665
	Carbonate of Baryta, BaO,CO_2.	Baryta, BaO.	0.77665
	Silico-fluoride of Barium, $BaFl,SiFl_2$.	Baryta, BaO.	0.54839
Bismuth.....	Teroxide of Bismuth, BiO_3.	Bismuth, Bi.	0.89655
Boron.......	Boracic Acid, BO_3.	Boron, B.	0.31429
Bromine....	Bromide of Silver, AgBr.	Bromine, Br.	0.42560
Cadmium...	Oxide of Cadmium, CdO.	Cadmium, Cd.	0.87500

ELEMENTS.	FOUND.	SOUGHT.	1.
Calcium.…	Lime, CaO.	Calcium, Ca.	0.71429
	Sulphate of Lime, CaO,So_3.	Lime, CaO.	0.41176
	Carbonate of Lime, CaO,CO_2.	Lime, CaO.	0.56000
Carbon.……	Carbonic Acid, CO_2.	Carbon, C.	0.27273
	Carbonate of Lime, CaO,CO_2.	Carbonic Acid, CO_2.	0.44000
Chlorine.…	Chloride of Silver, $AgCl$.	Chlorine, Cl.	0.24724
	Chloride of Silver, $AgCl$.	Hydrochloric Acid, HCl.	0.25421
Chromium..	Sesquioxide of Chromium, Cr_2O_3.	Chromium, Cr_2.	0.68619
	Sesquioxide of Chromium, Cr_2O_3.	Chromic Acid, $2CrO_3$.	0.31381
	Chromate of Lead, PbO,CrO_3.	Chromic Acid, CrO_3.	0.31062
Cobalt.……	Cobalt, Co.	Protoxide of Cobalt, CoO.	1.27119
	Sulphate of Protoxide of Cobalt, $CoO.SO_3$.	Protoxide of Cobalt, CoO.	0.48387
	Sulphate of Cobalt + Sulphate of Potassa, $2(CoO,SO_3)+(KO.SO_3)$.	Protoxide of Cobalt, $2CoO$.	0.18015
	Sulphate of Cobalt + Sulphate of Potassa, $2(CoO,SO_3)+3(KO.SO_3)$.	Cobalt, $2Co$.	0.14171
Copper.….	Oxide of Copper, CuO.	Copper, Cu.	0.79849
	Subsulphide of Copper, Cu_2S.	Copper, $2Cu$.	0.79849
Fluorine.…	Fluoride of Calcium, $CaFl$.	Fluorine, Fl.	0.48718
	Fluoride of Silicon, $SiFl_2$.	Fluorine, $2Fl$.	0.73077
Hydrogen..	Water, HO.	Hydrogen, H.	0.11111
Iodine.……	Iodide of Silver, AgI.	Iodine, I.	0.54049
	Protiodide of Palladium, PdI.	Iodine, I.	0.70556
Iron.……	Sesquioxide of Iron, Fe_2O_3.	Iron, $2Fe$.	0.70000
	Sesquioxide of Iron, Fe_2O_3.	Protoxide of Iron, $2FeO$.	0.90000
	Sulphide of Iron, FeS.	Iron, Fe.	0.63636
Lead.……	Oxide of Lead, PbO.	Lead, Pb.	0.92825
	Sulphate of Lead, PbO,SO_3.	Lead, Pb.	0.68317

ELEMENTS.	FOUND.	SOUGHT.	1.
Lead	Sulphate of Lead, PbO,SO_3.	Oxide of Lead, PbO.	0.73597
	Sulphide of Lead, PbS.	Oxide of Lead, PbO.	0.93305
Lithium	Carbonate of Lithia, LiO,CO_2.	Lithia, LiO.	0.40541
	Sulphate of Lithia, LiO,SO_3.	Lithia, LiO,	0.27273
	Basic Phosphate of Lithia, $3LiO,PO_5$.	Lithia, $3LiO$.	0.38793
Magnesium	Magnesia, MgO.	Magnesium, Mg.	0.60030
	Sulphate of Magnesia, MgO,SO_3.	Magnesia, MgO.	0.33350
	Pyrophosphate of Magnesia, $2MgO,PO_5$.	Magnesia, $2MgO$.	0.36036
Manganese	Protoxide of Manganese, MnO.	Manganese, Mn.	0.77465
	Protosesquioxide of Manganese. $MnO+Mn_2O_3$.	Manganese, $3Mn$.	0.72052
	Sesquioxide of Manganese, Mn_2O_3.	Manganese, $2Mn$.	0.69620
	Sulphate of Protoxide of Manganese, MnO,SO_3.	Protoxide of Manganese. MnO.	0.47020
	Sulphide of Manganese, MnS.	Protoxide of Manganese. MnO.	0.81609
	Sulphide of Manganese, MnS.	Manganese, Mn.	0.63218
Mercury	Mercury, Hg_2.	Suboxide of Mercury, Hg_2O.	1.04000
	Mercury, Hg.	Oxide of Mercury, HgO.	1.06000
	Subchloride of Mercury, Hg_2Cl.	Mercury, Hg_2.	0.84940
	Sulphide of Mercury, HgS.	Mercury, Hg.	0.86207
Nickel	Protoxide of Nickel, NiO.	Nickel, Ni.	0.78667
Nitrogen	Ammonio-bichloride of Platinum, $NH_4Cl,PtCl_2$.	Nitrogen, N.	0.06071
	Platinum, Pt.	Nitrogen, N.	0.14155
	Sulphate of Baryta. BaO,SO_3.	Nitric Acid, NO_5.	0.46352
	Cyanide of Silver, AgC_2N.	Cyanogen, C_2N.	0.19410
	Cyanide of Silver, AgC_2N.	Hydrocyanic Acid, HC_2N.	0.20156
Oxygen	Alumina, Al_2O_3.	Oxygen, $3O$.	0.46602

ELEMENTS.	FOUND.	SOUGHT.	1.
Oxygen.....	Teroxide of Antimony, SbO_3.	Oxygen, $3O$.	0.16438
	Arsenious Acid, AsO_3.	Oxygen, $3O$.	0.24242
	Arsenic Acid, AsO_5.	Oxygen, $5O$.	0.34783
	Baryta, BaO.	Oxygen, O.	0.10458
	Teroxide of Bismuth, BiO_3.	Oxygen, $3O$	0.10345
	Oxide of Cadmium, CdO.	Oxygen, O.	0.12500
	Sesquioxide of Chromium, Cr_2O_3.	Oxygen, $3O$.	3.31381
	Protoxide of Cobalt, CoO.	Oxygen, O.	0.21333
	Oxide of Copper, CuO.	Oxygen, O.	0.20151
	Protoxide of Iron, FeO.	Oxygen, O.	0.22222
	Sesquioxide of Iron, Fe_2O_3.	Oxygen, $3O$.	0.30000
	Oxide of Lead, PbO.	Oxygen, O.	0.07175
	Lime, CaO.	Oxygen, O.	0.28571
	Magnesia, MgO.	Oxygen, O.	0.39970
	Protoxide of Manganese, MnO.	Oxygen, O.	0.22535
	Protosesquioxide of Manganese, $MnO+M_2O_3$.	Oxygen, $4O$.	0.27947
	Sesquioxide of Manganese, Mn_2O_3.	Oxygen, $3O$.	0.30380
	Suboxide of Mercury, Hg_2O.	Oxygen, O.	0.03846
	Oxide of Mercury, HgO.	Oxygen, O.	0.07407
	Protoxide of Nickel, NiO.	Oxygen, O.	0.21333
	Potassa, KO.	Oxygen, O.	0.16982
	Silicic Acid, SiO_2.	Oxygen, $2O$.	0.53333
	Oxide of Silver, AgO.	Oxygen, O.	0.06898
	Soda, NaO.	Oxygen, O.	0.25810
	Strontia, SrO.	Oxygen, O.	0.15459
	Binoxide of Tin, SnO_2.	Oxygen, $2O$.	0.21333
	Water, HO.	Oxygen, O.	0.88889

ELEMENTS.	FOUND.	SOUGHT.	1.
Oxygen.....	Oxide of Zinc, ZnO.	Oxygen, O.	0.19740
Phosphorus.	Phosphoric Acid, PO_5.	Phosphorus, P.	0.43662
	Pyrophosphate of Magnesia, $2MgO,PO_5$.	Phosphoric Acid, PO_5.	0.63964
	Phosphate of Sesquioxide of Iron, Fe_2O_3,PO_5.	Phosphoric Acid, PO_5.	0.47020
	Phosphate of Silver, $3AgO,PO_5$.	Phosphoric Acid, PO_5.	0.16949
	Phosphate of Sesquioxide of Uranium, $2Ur_2O_3,PO_5$.	Phosphoric Acid, PO_5.	0.19910
	Pyrophosphate of Silver, $2AgO,PO_5$.	Phosphoric Acid, PO_5.	0.23437
Potassium..	Potassa, KO.	Potassium, K.	0.83018
	Sulphate of Potassa, KO,SO_3.	Potassa, KO.	0.54080
	Chloride of Potassium, KCl.	Potassium, K.	0.52445
	Chloride of Potassium, KCl.	Potassa, KO.	0.63173
	Potassio-bichloride of Platinum, $KCl,PtCl_2$.	Potassa, KO.	0.19272
	Potassio-bichloride of Platinum, $KCl,PtCl_2$.	Chloride of Potassium, KCl.	0.30507
Silicon.....	Silicic Acid, SiO_2.	Silicon, Si.	0.46667
Silver......	Chloride of Silver, $AgCl$.	Silver, Ag.	0.75276
	Chloride of Silver, $AgCl$.	Oxide of Silver, AgO.	0.80854
Sodium.....	Soda, NaO.	Sodium, Na.	0.74190
	Sulphate of Soda, $NaSO_3$.	Soda, NaO.	0.43658
	Chloride of Sodium, $NaCl$.	Soda, NaO.	0.53022
	Chloride of Sodium, $NaCl$.	Sodium, Na.	0.39337
	Carbonate of Soda, NaO,CO_2.	Soda, NaO.	0.58487
Strontium...	Strontia, SrO.	Strontium, Sr.	0.84541
	Sulphate of Strontia, SrO,SO_3.	Strontia, SrO.	0.56403
	Carbonate of Strontia, SrO,CO_2.	Strontia, SrO.	0.70169
Sulphur.....	Sulphate of Baryta, BaO,SO_3.	Sulphur, S.	0.13734

ELEMENTS.	FOUND.	SOUGHT.	1.
Sulphur	Tersulphide of Arsenic, AsS_3.	Sulphur, S_3.	0.39024
	Sulphate of Baryta, BaO,SO_3.	Sulphuric Acid, SO_3.	0.34335
Tin	Binoxide of Tin, SnO_2.	Tin, Sn.	0.78667
	Binoxide of Tin, SnO_2.	Protoxide of Tin, SnO.	0.89333
Zinc	Oxide of Zinc, ZnO.	Zinc, Zn.	0.80260
	Sulphide of Zinc, ZnS.	Oxide of Zinc, ZnO.	0.83515
	Sulphide of Zinc, ZnS.	Zinc, Zn.	0.67031

WEIGHT OF SWEDISH FILTER-PAPER ASH.

	ACID.	ALKALINE.
No. 1 (3 in.)	0.0003 grms	0.0010 grms.
No. 2 (4 in.)	0.0006 grms	0.0020 grms.
No. 3 (5 in.)	0.0008 grms	0.0030 grms.

SCHEMES FOR THE

"Quantitative Analysis"

OF THE MOST FREQUENTLY OCCURRING COMPOUNDS.

SCHEME

FOR THE QUANTITATIVE ANALYSIS OF AN IRON ORE OR SLAG.

The ore is sampled and prepared as described under Assay of Iron Ores. The ore may contain Na_2O, K_2O, CaO, MgO, Al_2O_3, Cr_2O_3, Fe, Mn, Zn, Ni, Co, Cu, As, SO_3, P_2O_5, TiO_2, SiO_2, V_2O_5, WO_3, CO_2, Cl, Fe, H_2O—Organic matter.

Make a qualitative examination for Cr_2O_3, Cu, As, and Ti.

I. SPECIAL DETERMINATIONS.

A	B	C
In 1 gram determine H_2O by direct weight. (Fres. Quant. An., § 36.)	In 1 gram determine CO_2 by direct weight. (Fres., § 139, II. e.)	For special determinations of K_2O, Na_2O, Cr_2O, FeO, As, S, SO_3, TiO_2, V_2O_5, WO_3, Cl, Fl—Organic matter. (See Appendix.)

II. MAIN ANALYSIS.

Pulverize five grams to impalpable powder and fuse thoroughly in platinum crucible (Note 2) with 20 grams Na_2CO_3 (increase to 30 grams as the ore contains more SiO_2 and Silicates) and 2 grams $NaNO_3$ (increasing to 5 grams as the ore contains more FeO, sulphides, or organic matter).

After cooling, treat crucible and fused mass in a small beaker with boiling water, until the mass is thoroughly disintegrated (Note 3). If the solution has a *decided* green color, digest with a little alcohol; filter and wash with hot water.—(Fres., § 160, 10, a, and Note 4.)

I. WATER SOLUTION.

It must be clear, but may be colored. It may contain Al_2O_3, ZnO, SiO_2, SO_3, P_2O_5, CrO_3, As_2O_5. Add excess of HCl; evaporate to dryness (Note 5); moisten residue thoroughly with HCl; digest with hot water; filter, and wash with hot water.

Residue *a*.	**Filtrate *a*.** Dilute to 500 c.c., and divide in three portions.		
SiO_2, etc., to be added to and refused with *Residue b.*	**Solution** a^1—300 c.c. (If the ore contains As, see Note 6.) Put into a large flask (to be afterwards combined with solution d^1) after determining Cr_2O_3, if present (Note 7).	**Solution** a^2 100 c.c. Add $BaCl_2$, and determine SO_3 as $BaSO_4$. (Fres., § 132 and Note 8.)	**Solution** a^3 100 c.c. Add to solution d^2, as a little Fe often enters the water solution.

II. INSOLUBLE RESIDUE.

It may contain CaO, MgO, Al_2O_3, MnO, ZnO, NiO, CoO, Fe, As, CuO, P_2O_5, SiO_2, TiO_2 (and Pt from crucible). Dry the residue; transfer it to a casserole; dry and burn the filter and add its ashes; moisten with H_2O; treat with HCl; evaporate to dryness, and add HCl (Note 9). Warm and digest with hot water, with occasional stirring. When dissolved to a clear solution, filter and wash.—(Fres., § 140.)

Residue *b*.

It may contain SiO_2, TiO_2, and *other* substances. Combine it with **Residue *a*.** Wash thoroughly with hot water; ignite and weigh. Add a little H_2SO_4 + NH_4Fl, and heat gently; then ignite to constant weight. Loss = SiO_2. Fuse now with bisulphate of soda, about 10 grams, adding a little more near the end. When crucible is perfectly cold, dissolve in a large amount of H_2O 400 c.c.; when dissolved to clear liquid, dilute to 500 c.c., and divide. Give 100 c.c. to **Solution *d*²**, and 300 c.c. to **Solution *d*¹**.

Filtrate *b* or Hydrochloric Acid Solution.

Combine with Filtrate *c*. Saturate thoroughly with H_2S gas.

Precipitate *d*

may contain Cu, As, Pt, and separated S. Boil with *Aqua Regia*; add NH_4Cl; evaporate to dryness; treat with H_2O and alcohol; filter and wash. (Fres., § 124, b, a.) The precipitate contains Pt from crucible, AsN_2H_4Cl, $PtCl_4$; saturate filtrate with H_2S gas; filter dry; burn filter, and put in crucible; add conc. HNO_3; dry, ignite, and weigh CuO. (Fres., § 119, 1, d, and § 164 B, 3, and B, 8, b.)

Filtrate *d*.

Boil with $KClO_3$, dilute to 500 c.c., and divide into three portions.

Solution *d*¹ 300 c.c.

Combine in a large flask; add $(NH_4)_2CO_3$ almost to neutralization and acetate of sodium in excess; dilute very largely (Note 11), and boil. (Fres., § 113, 1, d.)

Precipitate *e*

may contain Fe_2O_3 and Al_2O_3 (as basic acetates), and perhaps P_2O_5 and TiO_2. Dissolve in HCl and divide in two portions.

Sol'n *e*¹.

$\frac{2}{3}$

Add conc. HNO_3; evaporate until HCl is expelled, and determine P_2O_5 by $(NH_4)_2MoO_4$. (Fres., § 135, I b, *β*, and Note 12.)

Solution *e*².

$\frac{1}{3}$

Add $(NH_4)HO$ in excess, and $(NH_4)_2CO_3$ to prec. Fe_2O_3 + Al_2O_3 + P_2O_5 (TiO_2). Boil till all free NH_3 is expelled; filter and wash thoroughly, etc. (Fres., § 105 and § 113 l, a, and Note 13.) From this weight deduct P_2O_5 found in *e*¹. and Fe_2O_3 calculated from *d*², and difference = Al_2O_3(+TiO_2). If TiO_2 is present, deduct its weight. Calculate from **Solution *d*.** Remainder = Al_2O_3.

Filtrate *e*

may contain Mn, Zn, Co, Ni, Ca, Mg. Concentrate to small bulk; transfer to flask; add NH_4Cl + $(NH_4)HO$ to alkaline reaction and $(NN_4)HS$ until odor is decided, & color yellowish. Fill flask with water, and set aside overnight. (Fres., § 161, 3, and Note 11.)

Precipitate *f*

may contain Mn, Zn, Co, and Ni (as sulphides). Dissolve on the filter with a very dilute HCl, and wash.

Residue *g*

may contain Ni and Co as sulphides; combine with prec. *h*; transfer to crucible; add HNO_3 and H_2SO_4; digest; evaporate; dry; ignite; and weigh as sulphates. (Note 15.)

Solution *g*

may contain Zn and Mn. Boil; add Na_2CO_3 in excess; filter and wash. (Fres., § 108 and § 109, and Note 16.) Dry precipitate and ignite strongly to constant weight. Then dissolve in HCl; add acetate of sodium; saturate with H_2S gas; filter and wash. Dissolve ZnS in HCl; precipitate with Na_2Co_3; filter, wash, etc. (Fres., § 108.) Deduct this weight from the former, and difference = **Mn as Mn_3O_4.**

Filtrate *f*

may contain CaO and MgO. Acidulate with acetic acid; boil and filter. (Note 17.)

Prec. *h*.

Combine with **Residue *g*.**

Filt. *h*.

Precipitate CaO as CaC_2O_4 and MgO as $MgNH_4PO_4$. (Fres., § 104, 2.)

Solution *d*².

100 c.c. Add 100 c.c. from **Residue *b*.** (When the ore contains TiO_2, see Note 10.) Determine the TiO_2 as in Note 10, then the Fe volumetrically. (Fres., § 112, 2, and Note 18.)

Sol. *d*³.

100 c.c. to be reserv'd for accident.

NOTES.

[The references to Fresenius's Quantitative Analysis refer to London edition of 1865.]

NOTE 2. *Preliminary fusion.*—Thoroughly mix the ore and its fluxes on glazed paper; put about a third of the mixture in a two-ounce platinum crucible, and heat over a Bunsen burner until the greatest violence of the effervescence has ceased. Then add and treat the rest in the same way. Finally, heat strongly over a blast-lamp until mass is in complete and quiet fusion.

NOTE 3. *Removal of the fused mass.*—Let crucible cool until just below red-heat, and place it on a clean and dry iron plate, whose lower part is immersed in cold water. When crucible is cold enough to hold in hand, put it in a small beaker in which it can lie on its side, and digest with boiling water. Heat over a water-bath until fused mass all comes out of crucible, or will come out by inverting it. Remove the crucible; wash it; treat it in a small beaker with a little concentrated HCl to remove any adhering particles, and add this to that of the INSOLUBLE RESIDUE (2).

NOTE 4. *Reduction of* H_2MnO_4.—If alcohol is added, heat over a water-bath. If there was no bluish-green tint, no alcohol need be added.

NOTE 5. *Separation of* SiO_2.—In order to render SiO_2 entirely insoluble, the evaporation should be carried to perfect dryness, until no odors of HCl can be detected, and the mass is hard and crumbly. As the residue is to be re-fused with Residue *b*, the drying may be conducted at a temperature somewhat higher than 100° C.

NOTE 6. *Removal of* As.—The As has already been mostly or completely volatilized in the foregoing evaporation. If a trace still remains, saturate with H_2S gas, filter, wash, add a little $KClO_3$ to filtrate, and boil until S is completely oxidized.

NOTE 7. *Determination of* Cr_2O_3.—Add KHO in excess, and boil with sufficient Br. Cool, add HNO_3 almost to neutralization, acidulate with *acetic acid*, add some *sodium acetate* in excess and boil. Filter out *hot* the basic *aluminium acetate* precipitate, wash with hot water, containing a little sodium acetate. To filtrate, add *barium acetate* in slight excess, filter and wash. This last filtrate and the precipitate of *aluminium acetate* contain *all* the P_2O_5 and Al_2O_3 in the WATER SOLUTION. The latter is to be dissolved in HCl, the former to be freed from the excess of *barium acetate* with dilute H_2SO_4, and both to be *added to* SOLUTION d^1. Digest the precipitate of $BaCrO_4$ and $BaSO_4$ with concentrated H_2SO_4, boil, filter and wash. Boil the filtrate with concentrated HCl and alcohol to reduce CrH_2O_4 to Cr_2O_3 and precipitate the latter with $(NH_4)_2O$. (Fres., § 106, 1, a.)

NOTE 8. *Precipitation of* $BaSO_4$.—Add 5 cubic centimetres of $BaCl_2$ at first to hot solution; when precipitate settles, add a little more to see if there is any H_2SO_4 present. Filter, digest with HCl, wash with hot water.

NOTE 9. *Separation of* SiO_2.—Evaporate as in Note 5. Then add HCl pretty freely and warm for some time before adding any water, as the high heat may have produced anhydrous Fe_2O_3, forming an oxychloride which is very slow to dissolve, especially in dilute acid. If acid added be too dilute, concentrate by evaporation, add concentrated HCl, and digest at a moderate heat.

NOTE 10. *Determination of* TiO_2.—Pass H_2S gas into SOLUTION d^2 until it is saturated, boil for an *hour*, occasionally adding H_2S water. Filter off the precipitate and wash. Add a few grains of $KClO_3$ to the filtrate and boil. Precipitate the iron with $(NH_4)HO$. Dissolve it in H_2SO_4 acid, warm dilute, etc., and test volumetrically for Fe. (Note 18.) The precipitate obtained by boiling with H_2S was TiO_2+S. Dry, ignite, and weigh $= TiO_2$ in one gram of ore.

NOTE 11. *Precipitation of the Basic Acetates.*—Dilute the solution to about one litre for each gram of the sesquioxide present. It is sufficient to boil from ten to fifteen minutes for the complete precipitation of the acetates. The filtering should be done as quick as possible—through a rib-filter. Wash the precipitate with boiling water, containing a little sodium acetate. Should any *basic acetate* separate upon concentrating the filtrate, add some *sodium acetate*, boil, filter, dissolve the precipitate in HCl and unite to the solution of the main body.

NOTE 12. *Determination of* P_2O_5.—The following method may be employed for the removal of HCl. Add $(NH_4)HO$ suddenly in large excess, filter, wash once, and redissolve in boiling HNO_3. The solution containing concentrated HNO_3 in large excess, and no more than a trace of HCl must be diluted to about 400 cubic centimetres and heated to boiling. Then add solution of $(H_4N)_2MoO_4$ in large excess; with most ores 100 cubic centimetres are sufficient. Keep near the boiling point several hours and set aside over night in a warm place. Then decant on a rib-filter, if the supernated liquid is colorless, and transfer precipitate to filter by means of small portions of the filtrate. Rinse the beaker and wash the precipitate once with the diluted precipitant. Heat the filtrate and washings to boiling, add a little more of the precipitant and set aside to determine if any more P_2O_5 will be precipitated. Dissolve the precipitate back into the original beaker by pouring dilute $(NH_4)HO$ through the filter. [If a red residue of oxide of iron remains undissolved, pour dilute HNO_3 upon it, allow it to pass into $(NH_4)HO$ solution, acidulate with HNO_3, boil, add more of the precipitant, and set aside as before, filter and wash several times with the diluted precipitant, then dissolve the precipitate on the filter and adhering to the beaker in as little dilute $(NH_4)HO$ as possible into a small beaker.] Add from one to ten cubic centimetres of *magnesia mixture* (Fres., § 62, 6,) and continue as in (Fres., § 134, 1, b, a.).

NOTE 13. *Washing of* $Fe_2O_3.6H_2O$.—Wash this precipitate by boiling up with water and decanting until the wash-water shows very little alkaline reaction with litmus-paper and gives very little precipitate with solution of $AgNO_3$. Then transfer to filter and wash thoroughly with boiling water.

NOTE 14. *Precipitation of the Sulphides.*—Add no more of the yellow ammonic sulphide than is required, as an excess will re-dissolve a portion of the precipitate unless much NH_4Cl be present. But an excess of the latter reagent will interfere with the concentration necessary to precipitate the MgO in filtrate *h*. Cork the flask tightly before setting it aside.

NOTE 15. *Separation of* Co *and* Ni.—Should these constituents be present in considerable quantity, which very rarely happens, it is better, as the nickelous sulphate is likely to be converted into NiO by too strong ignition, to dissolve the sulphides in aqua-regia, neutralize with KHO, precipitate and determine the CoO by Genth and Gibbs' process (Fres., § 160, 12, and § 111, 4), and in the filtrate determine the Ni as oxide.

NOTE 16. *Determination of* Mn.—(Gibbs' process. Am. Jour. Sci., xliv, p. 216.) To the HCl solution, free from H_2S, add $(NH_4)HO$ in excess and solution of Na_2HPO_4 in large excess. Then add dilute H_2SO_4 or HCl until the white precipitate re-dissolves, heat to boiling, and add $(NH_4)HO$ in excess. Digest near the boiling point about an hour, when the precipitate, at first white and gelatinous, becomes crystalline in rose-colored scales. Filter and wash with hot water. If tinged red, re-dissolve the precipitate in dilute HCl and repeat the process. On ignition the precipitate is converted into $Mn_2P_2O_7$, a nearly white powder.

If Zn is present, it must first be separated as ZnS, as in the Scheme.

NOTE 17. *Precipitation of dissolved* NiS.—A trace of NiS, which is somewhat soluble in ammonic sulphide, is often carried through into this filtrate, but is completely thrown down, along with the excess of S, by this acidulation.

NOTE 18. *Volumetric determination of* Fe.—Put solution d^2, after treating it according to NOTE 10, into a flask holding 200 cubic centimetres, cool, dilute with cold water exactly up to the mark, mix by pouring back and forth several times from the flask to a beaker, draw out 100 cubic centimetres with a pipette known to *deliver* that quantity, empty it into a reducing bottle of 250 cubic centimetres capacity, and cover over with a ground plate of glass. Put in each bottle a piece of amalgamated Zn free from iron, and a strip of platinum-foil resting on it, add about 10 cubic centimetres of concentrated H_2SO_4, cover, and set aside over night; when reduction is complete the solution will be colorless. Then in each of two flasks, holding about 75 cubic centimetres, introduce exactly two grams of fine iron wire, add an excess of dilute H_2SO_4, and immediately adjust corks (having bent tubes attached, with their ends immersed in small beakers of warm water) and heat until the complete solution of the wire. By this water-valve arrangement the entrance of the air and oxidation of the $FeCl_2$ solution are avoided, and when the water begins to run back, after the evolution of H has ceased, its warmth prevents the too sudden reduction of the temperature and condensation of the vapors in the flask. After cooling, pour and wash out the contents of each flask with the beaker of water attached, into a large beaker, add dilute H_2SO_4 in excess, dilute to about one litre, and titrate successively and rapidly with the solution of $K_2Mn_2O_8$, to determine its strength.

Now pour and wash the contents of each reduction bottle into a large beaker, add dilute H_2SO_4, dilute to about one litre and titrate successively as before. (In a HCl solution all possible excess of that acid must be avoided, and the solution must be diluted to two litres.) Better evaporate the solution previous to reduction with an excess of H_2SO_4 and drive off HCl.

APPENDIX.

SPECIAL DETERMINATIONS.

Alkalies.—Mix 5 grams of ore, very finely pulverized, with 30 grams of $CaCO_3$ and about 3 grams NH_4Cl; calcine at a bright-red heat in platinum crucible for thirty to forty minutes; boil the cinter mass with water for two to three hours, replacing the loss from evaporation; filter and wash. (Fres., § 140, II, b, 8.) Separate all CaO by addition of $(NH_4)HO$ and $(NH_4)_2CO_3$ in excess, and then a few drops of *ammonic oxalate;* filter and wash. In the filtrate the alkalies occur as chlorides, and may be separated in the usual way. (Fres., § 152, 1, a.)

Chromium.—Fuse, etc., as in Main Analysis, obtain filtrate *a* of the water solution, and determine the Cr as in Note 7.

But if the ore be chromic iron, either employ Hunt's method (Fres., § 160, 10 *a*, a) or that of Gibbs (Amer. Jour. Sci., xxxix, p. 59), as follows: Fuse over blast-lamp with 10 to 15 parts KF, HF; digest with H_2SO_4 until F is expelled; add hot H_2O filter, and in the filtrate separate Cr_2O_3 from Al_2O_3, and determine it as in Note 7.

Ferrous oxide.—Digest one gram of ore, finely pulverized, in a flask with concentrated HCl, passing a current of carbonic anhydride. After complete decomposition, cool in carbonic anhydride, and immediately titrate the solution of $FeCl_2$, without removing the insoluble residue, with $K_2Mn_2O_8$ (Note 18). The presence of organic matter and of the higher oxides of Mn will interfere with the accuracy of the process.

For a special determination of the entire amount of Fe in an ore, either this method may be employed, omitting the use of carbonic anhydride, or the ore may be decomposed by fusion, as in the Main Analysis, without the use of Na_2NO_3, or Clarke's method may be employed as follows (Am. Jour. Sci., xlv, 178): Thoroughly mix 1 gram of ore with 3 grams of NaF or pure powdered cryolite, put in large platinum crucible, and cover with 12 grams of coarsely-powdered $KHSO_4$.

Fuse about twenty minutes; cool; add concentrated H_2SO_4; fuse to homogeneous paste; cool, and dissolve in cold water. When cryolite is used, a bulky white residue of $CaSO_4$ generally remains. Reduce the solution obtained by either of these methods and titrate in usual way.

ARSENIC.—Fuse 5 grams of ore as in MAIN ANALYSIS and obtain the WATER SOLUTION, in which the As will be present as sodium arseniate. Add a little Na_2SO_4 and HCl to slight acid reaction; boil a few minutes until all the As_2O_5 has been reduced to As_2O_3; saturate the warm solution with H_2S gas; filter, and wash with H_2S water. Dry filter and contents, and oxidize them in a beaker with fuming HNO_3. Dilute, warm gently with a little $KClO_3$, to oxidize organic matter, and proceed as in Fres., § 127, 2.

SULPHURIC ACID.—Boil 5 grams ore with 50 c.c. HCl + 50 c.c. H_2O + 10 c.c. alcohol. Filter and precipitate with $BaCl_2$ in the filtrate. The difference between the sulphuric anhydride thus found and the total found in the MAIN ANALYSIS will give the amount equivalent to the S actually existing in the ore as metallic sulphide.

TITANIC ACID.—The ore must be decomposed and the TiO_2 brought into solution in cold water by Clarke's method, described under FERROUS OXIDE. Then proceed as in Fres., § 107 and § 235, and Note 10.

VANADIC AND TUNGSTIC ACIDS.—These acids, which occur in very small quantities in some European ores, may be separated and detected as follows: Treat Residue *a*, obtained from 10 to 20 grams of ore, like Residue *c* in the Scheme, until all SiO_2 is expelled. Any residue which remains may contain Al_2O_3, TiO_2, V_2O_5, and WO_3. Ignite and weigh, fuse it with Na_2CO_3, dissolve in HCl, boil, add NH_4HO in excess, and saturate with H_2S gas. A red color will denote the presence of V_2O_5, and a brown precipitate that of WO_3 (Pogg. Anal., 21, 47. H. Rose's Handb. d. Anal. Chem., ii, 764).

CHLORINE.—Proceed as in Fres., § 167, 3, c.

Fluorine.—Proceed as in Fres., § 166, 5, a, or if the ore contains apatite, as in Fres., § 166, 6.

Organic matter.—Roast 1 gram in an open crucible, at a red heat, and (when the protoxide of iron, the higher oxides of manganese, sulphur, and arsenic are absent) the loss diminished by the amounts of carbonic anhydride and H_2O present, will be approximately equivalent to the amount of organic matter.

ANALYSIS OF A.

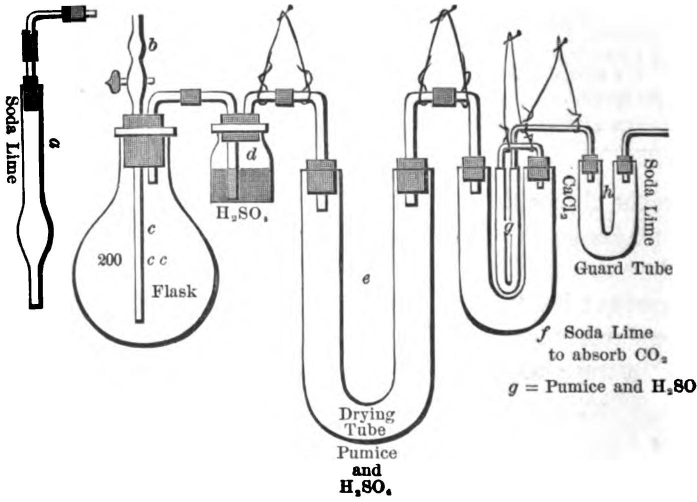
Brown Hematite or Limonite.		Hematite or Specular Ore.		Magnetic Iron Ore.	
Ferric oxide	90.05	Ferric oxide	95.16	Ferric oxide	62.20
Ferrous oxide.		Ferrous oxide.		Ferrous oxide	17.32
Manganous oxide	0.88	Manganous oxide	0.24	Manganous oxide	0.14
Alumina	0.14	Alumina	0.06	Zinc oxide.	
Lime	0.06	Lime	0.07	Alumina	3.81
Magnesia	0.20	Magnesia.		Lime	5.52
Potash.		Potash.		Magnesia	1.82
Silica	0.92	Soda.		Potash and Soda	0.10
Titanic acid.		Silica	5.66	Silica	9.66
Carbonic acid.		Carbonic acid.		Carbonic acid.	
Phosphoric acid	0.09	Phosphoric acid	traces.	Phosphoric acid	0.10
Sulphuric acid	traces.	Sulphuric acid		Sulphuric acid.	
Iron pyrites.		Iron pyrites		Iron pyrites	0.17
Water hygroscopic		Water hygroscopic		Water combined	0.28
combined	9.22	combined.		hygroscopic	0.34
Organic matter.		Organic substance.		Insoluble in acid.	
Percentage of Iron	63.04	*Percentage of Iron*	69.10	*Percentage of Iron*	57.01

In the foregoing analysis, it may be seen that (for instance) the magnesia in the given analysis of hematite does not exist, neither the potash in the limonite or the zinc oxide in the magnetite; but in some ores these substances are present, in an appreciable amount. The **magnetite** of this state most always, if not always, contains TiO_2.

CAST OR PIG IRON ANALYSIS.

Total carbon: Rogers' process (see J. Chem. Soc., London, May 1869). To 2.5 grams borings or filings add 50 c.c. of a solution of $CuSO_4$ (1 salt to $5H_2O$); heat gently for ten minutes. Fe dissolves, and Cu separates; carbon remains. Now add 20 c.c. of $CuCl_2$ (1 to 2) + 50 c.c. strong HCl, and heat for some time nearly to boiling until Cu dissolves; filter through broken glass and asbestos; wash thoroughly with boiling water, and finally wash with small jet into flask (*c*), and add three grams CrO_3, and arrange apparatus as shown in the Figure. Then add 30 c.c. of strong H_2SO_4, little at a time, shaking constantly, closing cock of funnel tube each time. Finally heat gently to boiling, not allowing more than three bubbles of gas to pass per second. Boil one minute; attach guard-tube (*a*) and aspirator to guard tube (*b*) and draw air (3 bubbles per second). Increase weight of tube (*f*)=CO_2, etc.

APPARATUS USED.



GRAPHITE AND SILICON.

Eggertz process. (Chem. News, Am. Reprint, vol. iv, p. 25.) Add 5 grams of fine borings to 10 cubic centimetres of H_2SO_4 + 50 cubic centimetres H_2O; boil one-half hour, evaporate one-third and cool. Add 10 cubic centimetres HNO_3, boil one-quarter hour, evaporate on water-bath until no vapors pass off, to dry or nearly dryness, add 75 cubic centimetres H_2O + 13 cubic centimetres HCl and boil one-quarter hour. Add more HCl if anything remains undissolved. (Filter through a filter washed with acid, dried and weighed.) Wash first with cold water until no more iron appears in washings, then with boiling water + 5 per cent HNO_3. Dry at 100° C. and weigh. Ignite strongly and weigh again. *Loss* = GRAPHITE. Expel SiO_2 with NH_4F. *Loss* = SiO_2.

NOTE.—SiO_2 dried at 100° C. contains 6 per cent H_2O, which goes off on ignition, and must be deducted *from* GRAPHITE after SiO_2 is determined.

SULPHUR.

By Eggertz process. (Chem. News, Am. Reprint, vol. iii, p. 1.) Dissolve 10 grams $KClO_3$ in 200 cubic centimeters H_2O and add 5 grams of borings; boil and add 60 cubic centimetres HCl (little by little), boil until Fe dissolves. Evaporate, dry on bath to ensure oxidation of sulphur. Thorough dryness not necessary, as SiO_2 does not interfere in acid solutions. Now add 10 cubic centimetres HCl + 30 cubic centimetres H_2O and leave on bath until all Fe_2Cl_6 is dissolved. Then add 20 cubic centimetres H_2O and wash thoroughly. Add 2 cubic centimetres saturated solution of $BaCl_2$ (enough for H_2SO_4 from 0.100 S); after cooling, add 5 cubic centimetres $(NH_4)HO$, stir and leave for twenty-four hours. Filter and wash by decantation with cold water, two or three times, and then with hot water. If precipitate shows iron after ignition, treat with HCl, etc.

PHOSPHORUS.

Dissolve as in sulphur determination. Dry at 140° C., some anhydrous Fe_2O_3 will be left with SiO_2. Fuse with a little $K_2S_2O_7$ (bisulphate of potash), soften with H_2SO_4, and dissolve in water. Filter out SiO_2 and determine it as a check on regular determination. Add filtrate to main one, dilute largely and precipitate sesquioxides + P_2O_5 by large excess of $(NH_4)HO$ cold, wash by decantation two or three times with cold water, and then on a large filter. Dissolve on the filter with hot dilute HNO_3. Boil out any Cl remaining in the solution, and precipitate P_2O_5, as in Note 12 of Iron Ore Scheme.

IRON.

Dissolve 0.200 grams in H_2SO_4, reduce with Zn and Pt, and titrate with $KMnO_4$; when oxidation is nearly complete, use solution one-tenth strength. Note 18, Iron Ore Scheme.

BASES OF GROUPS II, III AND IV.

Dissolve 10 or 20 grams in HCl. Extract SiO_2, and proceed as in Iron Ore Analysis. It is *better* to determine *aluminum* separately.

ANALYSIS OF FOREIGN MALLEABLE IRON.

	SWEDISH.		
Iron	99.863	99.220 —	98.78
Carbon	0.054	0.087 —	0.84
Silicon	0.028	0.056 —	0.12
Sulphur*	0.055	0.632 —	....
Phosphorus	Trace	0.005 —	....
Manganese	Trace	..... —	0.05
Copper		..... —	0.07
Arsenic		Trace —	0.02
Total,	100.00	100.00	99.88

---

* Sulphur determinations are probably too high.

ANALYSIS OF CAST IRON.

Ore used	Spathic.	Magnetic.	Clay Iron Ore of Coal Measure.		
Fuel used	Charcoal.	Charcoal.	Coke.		
Analyst	Fresenius.	Henry.	Woolwich Arsenal.		
			Cold Blast.		
				No. 3 Pig.	No. 1 Pig.	Forge Pig.

	Fresenius.	Henry.
Iron	82.860	92.906
Carbon { Combined	4.323	4.809
Carbon { Graphite	—	—
Silicon	0.979	0.176
Sulphur	0.014	Trace.
Phosphorus	0.059	0.122
Manganese	10.707	1.987
Copper	0.066	—
Aluminum	0.077	—
Calcium	0.091	—
Magnesium	0.045	—
Total	99.945	100.00

Cold Blast.	No. 3 Pig.	No. 1 Pig.	Forge Pig.
Iron	92.91	94.69	94.83
Carbon { Combined	0.04	—	2.37
Carbon { Graphitic	3.10	3.40	
Silicon	2.16	1.36	1.09
Sulphur	0.11	0.07	0.73
Phosphorus	0.63	0.29	0.76
Manganese	0.50	0.28	0.22
Nickel and Cobalt	0.05	—	—
Total	99.50	100.09	100.00

ANALYSIS OF SLAG FROM BLAST FURNACE.

Works,	Dowlais.		Dudley.	
Ore used,	Clay Iron Ore of Coal Measure.			
Fuel used,	Coke.			
Kind of Iron,	White Forge Pig.	Gray Pig.	Hot Blast.	
Analyst,	Riley.		Forbes.	Perey.
Ferrous oxide	6.91	0.76	0.98	1.27
Manganous oxide	1.67	1.62	2.79	0.40
Alumina	15.51	15.13	13.01	14.11
Lime	23.81	32.82	31.43	35.70
Magnesia	4.38	7.44	7.27	7.61
Potash	1.98	1.92	2.60	1.85
Silica	44.88	38.48	37.91	38.05
Phosphoric acid	0.43	0.15	—	—
Calcium	0.59	1.23	3.65	0.82
Sulphur	0.47	0.99		
Total	100.63	100.54	99.59	99.81
Percentage Iron	5.87	0.60	0.62	0.99

CHROMIC IRON ANALYSIS.

T. S. HUNT *and* (F. A. GENTH. *Zeitschrift f. Anal. Chem.*, i., 498.)

Take 0.5 gram of the impalpable powder, and fuse in a capacious platinum crucible with 6 grams potassic hydrosulphate for fifteen minutes, at a temperature scarcely above the fusing of the latter; then raise the heat somewhat, so that the bottom of the crucible may just appear red, and keep it so for fifteen or twenty minutes. The fusing mass should not rise higher than half-way up the crucible. The mass begins to fuse quietly, and abundant fumes of sulphuric acid escape. At the expiration of twenty minutes the heat is increased as much as necessary to drive out the second equivalent of sulphuric acid, and even to decompose partially the iron and chromic sulphate. To the fused mass now add 3 grams pure sodic carbonate; heat to fusion, and add a small portion from time to time during an hour of 3 grams nitre, maintaining a gentle red heat all the while; then heat for fifteen minutes to bright redness. Treat the cold mass with boiling water; filter hot; wash the residue with hot water; then digest in the heat with hydrochloric acid. If anything remains undissolved, it is a portion of the ore undecomposed, and must be subjected again to the above operation.

To weigh such a residue and deduct it from the ore first taken, is not good, as it never possesses the composition of the original substance. The alkaline solution, which often contains, besides the chromic acid, also some silicic, titanic, and manganic acids and alumina, is evaporated with excess of ammonic nitrate on a water-bath nearly to dryness, and till all free ammonia is expelled. On addition of water, the silicic acid, alumina, titanic acid, and manganic oxide, remain undissolved, while the chromic acid passes into solution. Filter and thoroughly wash residue. To filtrate, add HCl and alcohol, when the chromic acid is converted into chromic oxide (sesquioxide of chromium) by heating the solution for some time.

All the alcohol must be expelled by heat. Then to the solution, which must not be concentrated, heated to 100° in a beaker, is added ammonic hydrate in slight excess, and the mixture exposed to a temperature approaching boiling-point, until the fluid over the precipitate is perfectly colorless, presenting no longer the last shade of red; let the solid particles subside; wash three times by decantation, and lastly on a filter, with hot water, dry thoroughly and ignite and weigh as Cr_2O_3 (chromium sesquioxide). This method is very accurate.

ANALYSIS OF CHROMIC IRON.

CHESTER CO., PA.		BALTIMORE.	
FeO	35.14	FeO	30.04
MgO	—	MgO	—
Cr_2O_3	51.56	Cr_2O_3	63.37
Al_2O_3	9.72	Al_2O_3	1.95
SiO_2	2.90	CaO	2.02
Total,	99.32	SiO_2	2.21
		Total,	99.59

SCHEME FOR THE ANALYSIS OF PIG LEAD.

(See FRES., *Zeit. Ann. Ch.*)

Determine the SILVER by cupellation, or wet way, in 200 grams. For other metals present in the lead, dissolve 200 grams in 1.5 litres of water + 550 c.c. strong nitric acid, using a large flask and filtering, should the solution be turbid.

RESIDUE *a*.

Sb_2O_3 – SnO_2 may be left. If so, dissolve it in HCl, pass in H_2S gas, filter and reserve the prec. to go with PREC. *r*. (Note 1.)

SOLUTION *a*.

Add 65 c.c. of pure H_2SO_4, shake and allow to stand till settled. Then filter and wash thoroughly.

PRECIPITATE *b*.

Equal $PbSO_4$. Reject.

SOLUTION *b*.

Evaporate until fumes of sulphuric acid appear; cool, and add 60 c. c. of water; filter and wash with hot water.

PRECIPITATE *c*

= $PbSO_4$ and perhaps Sb. Dissolve in HCl, add 10 volumes H_2S water, pass H_2S gas in, and filter, etc.

SOLUTION *d*.

Reject it.

PRECIPITATE *d*

= Sb_2S_3 + PbS, add it to PRECIPITATE *f*. (Note 2.)

SOLUTION *c*.

Dilute to 200 c.c., heat to 70° C., pass H_2S gas in, allow to stand 12 hours, filter, etc.

SOLUTION *f*.

Evaporate to 500 c. c., add $(NH_4)HO$ + $(NH_4)HS$, fill flask and allow it to stand 12 hours for precipitate to settle; filter, etc.

PRECIPITATE *g*

= FeS, ZnS, CoS, NiS. Treat on the filter with a mixture of 6 parts H_2S water + 1 part dilute HCl, pouring back several times so as to avoid bulk; filter, etc.

RESIDUE *h*

= CoS, NiS. Dry, ignite to oxides *r*, test with the blowpipe.

SOLUTION *h*

= FeS, ZnS. Add HNO_3, boil; then add $(NH_4)HO$ in excess; filter, etc.

PREC. *i*.

= Fe_2O_3.

SOLUTION *i*.

Add $(NH_4)HO$ + $(NH_4)HS$ in a flask and allow to stand for twenty-four hours; filter, etc.

SOL. *j*.

PRECIPITATE *j*

= ZnS. Dissolve in HCl and boil with Na_2CO_3 in excess; filter, etc., ignite and weigh as ZnO.

SOLUTION *g*.

Acidulate with $HC_2H_3O_2$ and boil to recover NiS; filter, etc.

PRECITATE *k*

= NiS, add to PREC. *g*.

FILTRATE *k*.

Reject.

PRECIPITATE *f*

= Sb_2S_3, As_2S_3, SnS_2, Bi_2S_3, CuS, CdS, PbS, etc. Add PREC. *d*. Treat with K_2S, filter, etc. (Note.)

RESIDUE *l*

= Bi_2S_3, CuS, CdS. Pbs. Spread the filter in a dish, and treat nearly to boiling with HNO_3; when dissolved, filter, wash, dry and burn filter; throw the ash into the HNO_3 solution. Then add 2 c.c. H_2SO_4 and evaporate till white fumes appear; add H_2O and allow to settle; filter, etc.

PRECIPITATE *m*.

$PbSO_4$; reject.

SOLUTION *m*.

Neutralize nearly with pure KHO; add Na_2CO_3 and a little KCy (free from K_2S); filter, etc. (N.B. Note 4.)

PRECIPITATE *n*

= Bi_2O_3. Dissolve in dilute HNO_3 and prec. with $(NH_4)_2CO_3$ as above.

SOLUTION *n*.

Add a little more KCy and then a few drops K_2S; filter and wash. Have SOL. *o* and PREC. *o*.

SOLUTION *l*

= As_2S_3, Sb_2S_3, SnS_2 in K_2S solution. Add HCl and filter.

PREC. *r*.

Sb_2S_3, As_2A_3, SnS_2. Add precip. from RESIDUE *a*; dry, treat with CS_2, and dry again. Evaporate after adding fuming HNO_3, until paper is destroyed and most of the acid gone. Then dilute a little and add Na_2CO_3 to alkaline reaction, and then $NaNO_3$ and evaporate to dryness, and heat carefully to fusion. After cooling, extract the cake with water, etc.

(See Fres., *q. a.*, p. 427.)

SOL. *r*.

Reject.

<table>
<tr><th>Solution *o*.</th><th colspan="2">Precipitate *o*</th><th>Residue *s*.</th><th>Sol. *s*.</th></tr>
<tr><td rowspan="3">Add a little HNO_3 + H_2SO_4 + HCl, and evaporate until no odor of KCy is perceptible. Filter if necessary. Precipitate the Cu with H_2S.</td><td colspan="2">= Ag_2S, CdS. Wash with dilute HNO_3. (Note 3.)</td><td rowspan="3">$NaSbO_3$. Dissolve in HCl + $H_2C_4H_4O_6$ and pass in H_2S = Sb_2S_3 + S, oxidize with HNO_3 and weigh as SbO_2. Add result from Residue *t*.</td><td rowspan="3">As, Sb, Sn. Evaporate off alcohol, add dilute H_2SO_4, evaporate until no fumes of HNO_3 are perceptible and pass H_2O gas in at 70° C. and filter, wash, etc. Dissolve in K_2S and add large excess solution of sulphurous acid, and digest for some time in a water-bath, and then boil until two-thirds of water and all SO_2 is gone, filter, etc.</td></tr>
<tr><th>Residue *x*</th><th>Solution *x*</th></tr>
<tr><td>= Ag_2S. Rejected as Ag, is determined separately.</td><td>= CdS. Evaporate nearly to dryness and add Na_2CO_3. If no precipitate appears, add KHO, and if one then appears, filter and wash; filter with NH_4NO_3 and burn = CdO.</td></tr>
</table>

Residue *t*.	Solution *t*.
Sb_2S_3 + SnS_2. The Sb_2S_3 here will only be a trace. Oxidize in a crucible with HNO_3 and weigh; then ignite in hydrogen to expel the SbO_2, and oxidize again with HNO_3 and weigh the SnO_2. The loss, SbO_2.	As_2S_3. Pass in H_2S gas, filter and wash, oxidize with fuming HNO_3, dilute a little, warm gently with $KClO_3$ and precipitate as ammonio-magnesic arseniate. The washing must be with NaCl, and the latter displaced by $(NH_4)C_2H_3O_2$, the latter washings being rejected.

Note *x*.—In case no CdS be present, Bi and Cu may be separated by $(NH_4)HO$ and $(NH_4)_2CO_3$.

Note 1.—There will not (probably) be any Sn in the lead. Should there be any it must be looked for in Filtrate *s*.

Note 2.—If precipitate *d* contained much Pb, better treat separately to the point of oxidizing with HNO_3, and then add to Precipitate *r*.

Note 3.—Better dissolve thoroughly Precipitate *r*. The Cd with $(NH_4)_2CO_3$, which will not dissolve the same.

Note 4.—If the KCy contains K_2S, the precipitated carbonate may contain sulphides. Filter, wash, and dissolve in boiling HNO_3. Filter out any separated sulphur. Again precipitate with $(NH_4)_2CO_3$ in slight excess and *boil*.

Ag will not be precipitated. Cd may be. Filter and wash with water and then with a little KCy. The $CdCO_3$ is so readily soluble in KCy that it will be carried through the filter into the solution.

ANALYSIS OF PIG LEAD.

	Harz.	Havre.
Copper	0.00476	0.0022
Antimony	0.00317	0.0052
Iron	0.00166	0.0007
Zinc	0.00265	—
Silver	0.00060	0.0006
Lead	99.98716	99.9913
Total	100.00000	100.0000

SCHEME FOR THE ANALYSIS OF A NICKEL ORE.

Fuse 2 grams of finely-powdered niccolite (niccolite arsenide + cobalt + iron) with 2 parts of potassic nitrate and 2 parts of carbonate of soda, in a platinum crucible, the bottom and sides of which have been previously lined with Na_2CO_3; the mass is then ignited for some time, and when cold, digested in water; the oxides formed are filtered off and thoroughly washed. The solution contains all the arsenic in the form of arsenates of the alkalies; it is supersaturated with HCl, then mixed with $(NH_4)HO$ and $MgSO_4$. Let the precipitate stand for twenty-four hours, then filter through a weighed filter washed with dilute $(NH_4)HO$, dried at 100° and weighed.

The oxides are dissolved in concentrated HCl, and the copper and bismuth, precipitated, by H_2S. The filtrate from H_2S treatment is heated to boiling, and mixed with some $KClO_3$ in order to peroxidize the iron, which may then be separated from the nickel and cobalt in the same manner as from manganese, by baric carbonate. From the liquid separated from the baric carbonate, the dissolved baryta is precipitated by H_2SO_4, and filtered. The filtrate contains the nickel and cobalt, which are precipitated from a hot solution by potassic hydrate.

The precipitate containing the hydrated oxides of Ni and Co is gradually mixed with potassic cyanide (free from cyanate), and a gentle heat applied until dissolved. By this process the cobaltous and potassic cyanide, $KCy,CoCy_2$, in the solution is converted into potassio-cobaltic cyanide ($K_6Co_{12}Cy_2$), whilst the nickelous-potassic cyanide remains unaltered. Add to the solution, while hot, levigated mercuric oxide. By this method the nickelous-potassic cyanide is decomposed, and all the nickel precipitated, partly as oxide and partly as cyanide. Filter and wash; ignite; with excess of air, leaves pure oxide of nickel behind, which weigh. Neutralize the filtrate with HNO_3 and solution of mercurous nitrate, as neutral as possible, added as long as it produces a precipitate of mercurous-cobaltous cyanide. After being filtered (through a weighed filter), washed, and dried, it is ignited with excess of air, when it is converted into cobaltic oxide, which, after weighing, must be reduced by hydrogen to metallic cobalt.

ANALYSIS OF NICCOLITE.

As.	54.05	54.89	52.71
Ni.	43.50	43.21	45.37
Fe.	0.45	0.54	—
Pb.	—	—	—
Co.	0.32	—	—
Sb.	0.05	—	—
S.	2.18	1.35	0.48
Gangue	0.20	—	Cu 1.44
Total	100.75	99.99	100.00
Analysis by...	EBELMEN.	GRUNOW.	SCHNABEL.

SCHEME FOR THE ANALYSIS OF A COPPER ORE.

Weigh out 2 grams of the powdered ore (impalpable powder), and put into a beaker. Add concentrated $H_2SO_4 + HNO_3$. Cover with convex cover; heat gently until effervescence ceases; remove the cover, and expel all the HNO_3 over a water-bath by evaporation, until fumes of H_2SO_4 are given off.

Wash down the sides of the beaker with hot water, then filter into a weighed platinum dish; after diluting with water, throw in a piece of zinc (soluble in hydrochloric acid without residue), and add, if necessary, a little more acid. Cover the dish with a watch-glass, which is afterwards rinsed into the dish. The separation of the copper commences immediately. Heat, if necessary.

After an hour or two test a portion of the supernated liquid with H_2S water; if no brown tint is imparted, the copper is all precipitated. Press the copper together with a glass rod, decant the clear fluid; wash; precipitate with boiling H_2O, and decant again; rinse the dish with strong alcohol; heat over water-bath; when Cu is dry, let it cool, and weigh. The precipitation may be done in a porcelain or glass dish, but it will take longer.

ANALYSIS OF COPPER PYRITES.

S	35.87	36.10	33.88
Cu	34.40	32.85	32.65
Fe	30.47	29.93	32.77
Quartz	0.27	—	0.32
Mn	—	—	Trace.
Pb	—	0.35	—
Total	101.01	99.23	99.62
Analysis by	Rose.	Smith.	Forbes.

SCHEME FOR THE ANALYSIS OF A ZINC ORE.

The ore may contain Zn, Fe, Al_2O_3, CaO, MgO, PbO, SiO_2, S, H_2O, CO_2.

Dissolve 2 grams of pulverized ore in a mixture of 5 c.c. of $HNO_3 + 5$ c.c. of HCl at a gentle heat, then add 5 c.c. of N_2SO_4 and evaporate until fumes of sulphuric acid are given off; then add boiling H_2O and filter.

PRECIPITATE.	FILTRATE.
$SiO_2 + PbSO_4$. Weigh; then boil with ammonic citrate and filter. Residue will be SiO_2. The filtrate will be Pb in solution; add H_2S and the precipitate will be PbS; put in crucible, add $HNO_3 + H_2SO_4$, and ignite, which will give $PbSO_4$, which weigh.	Fe_2O_3, Al_2O_3, ZnO, CaO, MgO, in solution; neutralize with Na_2Co_3; add sodic acetate and boil. Precipitate will be Fe_2O_3 and Al_2O_3; filter off.

The filtrate will contain in solution Zn, CaO, MgO. Add H_2S water; then pass in the solution H_2S gas until Zn is all precipitated as ZnS. Filter and wash with H_2S water. Dissolve ZnS in HCl on filter; then wash into beaker with boiling H_2O; add a few crystals of $KClO_3$ and boil; filter off the sulphur which may separate; then add Na_2CO_3, and the Zn will be precipitated as $ZnCO_3$; filter and wash; ignite in a porcelain crucible and weigh as ZnO, from which the Zn may be calculated. The solution filtered from ZnS will contain CaO and MgO. Precipitate CaO as oxalate, and MgO as $MgNH_4PO_4$. Make special determinations for S, H_2O and CO_2.

The above analysis is principally for the determination of Zn.

ANALYSIS OF ZINC BLENDE.

S	32.10	33.82	33.82
Zn	64.22	64.39	54.17
Fe	1.32	—	11.19
Cd	Trace.	0.98	0.82
Cu	—	0.32	—
Pb*	0.72	0.78	—
Mn	—	—	0.88
H_2O	0.80	—	—
Total	99.16	100.29	100.88
	Analysis by KERSTEN.	SMITH.	SCHEERER.

ANALYSIS OF PYROLUSITE

FOR ITS COMMERCIAL VALUE.

The following analysis is founded on the fact that when oxalic acid comes in contact with manganese in presence of water and sulphuric acid, manganous sulphate is formed, and carbonic acid is evolved.

$$MnO_2 + H_2SO_4 + C_2O_3 = MnSO_4 + 2CO_2 + H_2O.$$

Each equivalent of available oxygen, or, what amounts to the same, each 1 eq. manganese dioxide = 43.5, gives 2 eq. carbonic acid = 44.

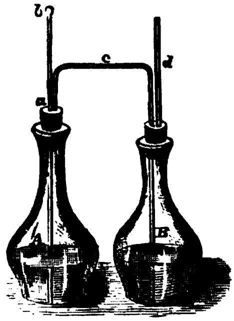
As 44 parts by weight of CO_2 correspond to 43.5 of manganese dioxide, the CO_2 found need simply be multiplied by 43.5 and the product divided by 44, or the CO_2 may be multi-

---

* Sb and Pb.

plied by $\frac{43.5}{44} = 0.9887$ to find the corresponding amount of manganese dioxide.

Take (0.9887) × 2 or 3 grams of ore, which is finely pulverized, and introduce into a weighed flask A (capable of holding 120 c.c. up to the neck); now add 5–6 grams of sodic oxalate or 7.5 grams potassic oxalate, in powder, and enough water to fill the flask two-thirds full. Insert the cork into A and see that it does not leak.



A = 120 c.c. to neck.

B = 100 c.c. to neck.

B for sulphuric acid.

A for ores, etc.

***a* is closed at *b* with wax ball.**

***Note.*—Exact weight of A and B must be known after they are charged—that is, before CO_2 is allowed to come off.**

Now make some H_2SO_4 flow from B to A, by applying suction to *d* by means of a rubber-tube. CO_2 goes off immediately; when it ceases, let some more H_2SO_4 pass in, and complete this until the manganese ore is completely decomposed. Take five to ten minutes.

Let the apparatus be weighed again after becoming cool. The loss will equal CO_2. The number of centigrams lost, divided by 2 or 3, according to the multiple of 0.9887 gram used, expresses the percentage of manganese dioxide in the ore treated.

ANALYSIS OF PYROLUSITE.

$\dot{\mathrm{M}}\mathrm{n}$, $\dddot{\mathrm{M}}\mathrm{n}$	83.56	85.62
O	14.58	11.60
BaO	—	0.66
SiO_2	—	0.55
H_2O	1.86	1.57
Total	100.00	100.00
Analysis by	ARFVEDSON.	TURNER.

SCHEME FOR THE ANALYSIS OF ILMENITE.

Fuse 1 gram with 3 grams of NaF + 12 grams $K_2S_2O_7$ thoroughly. Dissolve in large volume of cold water. If there is any residue, fuse and dissolve as before. Neutralize with Na_2CO_3 until a slight precipitate appears, which dissolve in H_2SO_4, so the fluid will be slightly acid. Saturate with H_2S gas; boil one hour, adding from time to time H_2S water. Filter off the precipitate, and wash with water containing H_2S. The precipitate will be TiO_2+S. Ignite and weigh $=TiO_2$. If the precipitate contains iron, fuse over again, etc.

ANALYSIS OF ILMENITE.

	(Hystatite.)	(Ilmenite.)	(Hystatite.)
TiO_2	24.19	46.67	25.28
Fe_2O_3	53.01	11.71	51.84
FeO	19.91	35.37	22.86
MnO	—	2.39	—
MgO	0.68	0.60	—
CaO	0.33	0.25	—
SiO_2	1.77	2.80	—
Cr_2O_3	—	0.38	—
Total	99.89	100.17	99.98
Analysis by	Mosander.	Mosander.	Kendall.

SCHEME FOR THE ANALYSIS OF NATROLITE.

Moisten 2 grams of the pulverized mineral with water, and digest in concentrated HCl; heat, evaporate over water-bath; break up residue with stirring-rod, and get a powder.

It must neither be under or over heated. Cover with paper and put in air-bath, heat to 125° C. Let it dry for two or three hours, moisten with concentrated HCl and let stand a few minutes. Warm gently, then add water. The bases go into solution and SiO_2 separates, which is weighed.

Divide filtrate into two parts:

1st Part.	2d Part.
To determine Na_2O, add caustic baryta, which precipitates Al, Fe, Mg. The filtrate will contain BaO, CaO, and alkalies. To remove BaO and CaO add $(NH_4)_2CO_3$ and filter. Test to see if CaO is present and burn off $(NH_4)HO$. Wash out evaporating dish with smallest amount of water, add HCl and evaporate in a weighed dish, and the residue will be NaCl, which weigh.	To determine Fe, Al, Mg, treat this 2d part in the usual manner. Precipitate the Fe and Al by $(NH_4)HS$, etc.

ANALYSIS OF NATROLITE.

SiO_2	48.00	47.21	44.50
Al_2O_3	24.25	25.60	30.05
Fe_2O_3	1.75	1.35	0.98
CaO	—	—	0.83
NaO	16.50	16.12	13.52
H_2O	9.00	8.88	9.93
Total	99.50	99.16	99.81
Analysis by	Klaproth.	Fuchs.	Scheerer.

SCHEME FOR FELDSPAR OR ORTHOCLASE ANALYSIS.

Mix the finely-powdered mineral, dried at 200°, with four or five parts of baric carbonate; this is then exposed to an intense white heat by a blowpipe. When the contents are aggregated into a cinder-like mass, the mass is then turned out of the crucible into a capacious dish, a quantity of water poured over it, and hydrochloric acid added in slight excess until it is completely dissolved, with the exception of some gelatinous SiO_2 which separates. The whole solution is then evaporated to perfect dryness; then moisten with HCl and dissolve in H_2O and filter off SiO_2, which weigh.

Precipitate the baryta in the filtrate with H_2SO_4 (very little); filter, and concentrate the filtrate, add $(NH_4)HS$ and precipitate the Al_2O_3, and filter. Evaporate the filtrate to dryness, and ignite it to expel ammonia salts. The residue is sulphate of potash, and is weighed. If soda is present it must be separated.

ANALYSIS OF FELDSPAR (ORTHOCLASE).

SiO_2	66.75	67.01	65.10
Al_2O_3	17.50	18.60	20.12
Fe_2O_3	1.75	0.85	
MgO	—	0.19	—
CaO	1.25	0.56	—
Na_2O	—	2.01	2.42
K_2O	12.00	11.41	12.80
Total	99.25	100.63	100.44
Analysis by	Rose.	Duerre.	Hayes.

SCHEME FOR THE ANALYSIS OF DOLOMITE OR MARBLE.

It may contain CaO, MgO, SiO_2, Al_2O_3, Fe_2O_3. Dissolve 1.5 grams in $HCl + HNO_3$, evaporate to dryness, moisten with HCl, add H_2O and filter.

Residue.

SiO_2 and silicates fuse in platinum crucible with Na_2CO_3; moisten with H_2O, add an excess of HCl, evaporate, dissolve in H_2O and filter.

Residue.

SiO_2, weigh.

B Filtrate.

Add to first Filtrate A.

A Filtrate + B.

Warm, add $NH_4Cl + (NH_4)HO$, and filter.

Precipitate.

$Al_2O_3 + Fe_2O_3$ (CaO, MgO?).

Wash with a little hot water, dissolve in HCl, reprecipitate, filter, add Filtrate (C) to Filtrate (E). The precipitate = $Al_2O_3 + Fe_2O_3$, which weigh or separate.

E Filtrate + C.

CaO, MgO.

Concentrate if too bulky; acidify with HCl if cloudy; then add $(NH_4)HO + (NH_4)_2C_2O_4$; allow the precipitate to stand over night; pour the clear liquid through the filter; wash the precipitate in the beaker once or twice with H_2O; pour the clear liquid through the filter and dissolve the precipitate in HCl. Reprecipitate with $(NH_4)_2C_2O_4$ and filter.

Precipitate.	**Filtrate.**
CaC_2O_4. Moisten with H_2SO_4 = $2CaSO_4$ and ignite in platinum crucible; cautiously moisten with dilute H_2SO_4; heat and weigh.	MgO. Concentrate if too bulky, and acidify if cloudy with HCl. Add an excess of $(NH_4)HO$, then add Na_2HPO_4. Filter off precipitate = $MgHPO_4$; wash with $[1(NH_4)HO + 8H_2O]$; dry and weigh.

For CO_2 determination take about 1.5 grams, use apparatus which is used in Pyrolusite.

For S and PO_5 determinations, digest 6 grams in HNO_3 and divide.

ANALYSIS OF DOLOMITE.

	(Jena, cryst.)	(Miemite.)	(La Valenciana.)
$CaCO_3$	55.22	57.91	53.18
$MgCO_3$	44.77	38.97	34.35
$FeCO_3$	—	1.74	10.46
$MnCO_3$	—	0.57	
H_2O	—	—	1.22
FeO	—	—	0.22
Total	99.99	99.19	99.43
Analysis by	Suckow.	Rammelsberg.	Roth.

SCHEME FOR THE ANALYSIS OF WHITE LEAD.

The substances likely to be found are $BaSO_4$, clay, ZnO. $PbSO_4$, $PbCO_3$, $CaCO_3$, $CaSO_4$, H_2O+oil. Digest 10 grams of the material in a flask with ether; filter and wash. Weigh out of the powder 2 grams, and dissolve in HNO_3; boil and filter.

Residue A.	**Filtrate A.**
$BaSO_4$, clay; weigh, and separate if desirable.	ZnO, PbO, CaO; treat with H_2S in presence of considerable acid, and filter.
Precipitate B.	**Solution B.**
= PbS; weigh as $PbSO_4$.	Zn + CaO in solution; add $(NH_4)HO + (NH)_4HS$; filter and wash.
Residue C.	**Filtrate C.**
= ZnS; convert into $ZnCO_3$, and weigh as ZnO.	CaO; add $(NH_4)_2C_2O_4$, and the precipitate will be CaC_2O_4.

To determine SO_3 in the shape of $PbSO_4 + CaSO_4$, dissolve 3 grams in boiling dilute HCl; add a little ammonic citrate or acetate; filter and determine SO_3 as usual.

This scheme will apply also to zincic pigments.

SCHEME FOR THE ANALYSIS OF TYPE METAL.

May contain Sb, Pb (Sn, Zn, Fe). Dissolve 1 gram of metal in HNO_3 + tartaric acid at a gentle heat; filter and wash.

Solution.

Sb, Pb (Zn + Fe); add H_2SO_4 to solution; heat to boiling, and filter.

Residue.

SnO_2 may contain a little Pb and Sb; ignite the residue and weigh. Fuse with $Na_2CO_3 + S$; dissolve in hot H_2O and filter. Residue = PbS. Heat in porcelain crucible with HNO_3 which gives $PbSO_4$; ignite and weigh. Add to Residue A.

Residue A.

Will be $PbSO_4$; dry and weigh.

Precipitate.

$SbS_3 + PbS$; digest with yellow sulphide of ammonia and filter.

Residue.

Will be PbS; heat in a porcelain crucible with HNO_3, which gives $PbSO_4$; ignite and weigh, and add to Residue A.

Solution.

Sb, Pb (Zn and Fe); pass in H_2S gas and filter, washing with H_2S water.

Solution.

Add $(NH_4)HS$; precipitate = Fe and Zn.

Solution.

$(NH_4)HS$, Sb_2S_3; precipitate with HCl = $SbS_3 + S$; evaporate with HNO_3 in a porcelain crucible; burn filter paper with NH_4NO_3 and add; ignite the whole and weigh as SbO_4.

Residue.

SnO_2 may contain a little Pb and Sb_2; ignite the residue and weigh. Fuse with $Na_2CO_3 + S$; dissolve in hot H_2O, and filter. Residue = PbS. Heat in a porcelain crucible with HNO_3 which gives $PbSO_4$; ignite and weigh. Add to Residue A.

Solution.

Add HCl; precipitate = $Sb_2S_3SnS_2$; oxidize with HNO_3; fuse with NaHO in silver dish. Dissolve mass in 8 alcohol + $1H_2O$ and filter.

Residue.

$NaSbO_3$; warm with HCl; dilute with H_2O and precipitate with H_2S the Sb as Sb_2S_3; treat as before.

Solution.

Sn as Na_2SnO_3; acidulate with HCl; precipitate by $H_2S = SnS_2$; ignite with SnO_2, and weigh.

NOTE.—The above schemes show only how to separate the constituents. For further information, see Fresenius.

ANALYSIS OF TYPE METAL.

Metals.	Antimony.	Lead.	Copper.	Tin.	Bismuth.	Zinc.
Type metal	15.5	69	—	—	15.5	—
Printing characters	20	80	—	—	—	—
Babbitt metal	7.3	—	3.7	89	—	—
Britannia metal	50	—	—	25	25	—
White metal	56.8	—	7.4	28.4	—	7.4
Pewter	14	—	—	86	—	—
Metal that expands in cooling	16.7	75	—	—	8.3	—

SCHEME FOR THE ANALYSIS OF A SILVER COIN.

It contains Au, Ag_2S, Ag, Pb, Cu.

Boil in KHO to clean it; then weigh, dissolve in HNO_3 (free from Cl), and filter.

Precipitate.

Au, Ag_2S. Dry; weigh; wrap in a piece of Pb and cupel. This destroys the AgS. Add also a little piece of silver (the weight of which must be known); dissolve the button in HNO_3, and filter.

Residue.

Au.

Filtrate.

$AgNO_3$; add to Filtrate A.

Filtrate A.

$AgNO_3$, $Pb(NO_3)_2$, $Cu(NO_3)_2$; add HCl and filter.

Precipitate.

AgCl.

Filtrate.

$PbCl_2 + CuCl_2$; add about 10 c.c. of H_2SO_4; evaporate to dryness; dissolve in H_2O; filter and wash with water containing a little alcohol.

Precipitate.

$= PbSO_4$.

Filtrate.

$= CuSO_4$. Precipitate with KHO, and test filtrate with HS.

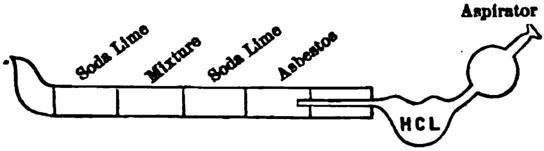
ANALYSIS OF SILVER COIN.*

Ag	51.49
Cu	47.91
Pb	.63
Au	.02
Total	100.05

---

* Poor, Spanish coin.

SCHEME FOR THE ANALYSIS OF FERTILIZERS.



NITROGEN TUBE.

Fertilizers owe their value to P_2O_5 (soluble and insoluble to NH_3 and K_2O).

1st. Those that furnish insoluble P_2O_5; as bone ash, bone black, rock guanos, apatite, green marl.

2d. Those that furnish insoluble $P_2O_5 + NH_3$; as bones, meat scraps, dried blood, and almost all animal matter.

3d. Those that furnish NH_3.

4th. Those that furnish soluble P_2O_5, as superphosphates.

To determine *insoluble* P_2O_5, weigh out 2 grams, place in a porcelain dish and evaporate with HNO_3, and bring into solution. To destroy organic matter, add $KClO_3$. Divide the solution in halves, and heat with MoO_3. Wash the yellow precipitate with MoO_3 and dissolve it in $(NH_4)HO$, and reprecipitate with magnesia mixture.

To determine the *soluble* P_2O_5, take 1.5 grams, pulverize finely, and dissolve in cold H_2O, and determine P_2O_5 as usual.

The determination of the nitrogen is conducted by mixing the substance with soda-lime and heating. The H which is formed goes to the N, and O to C, by splitting H_2O.

The nitrogen tube, as shown in the figure, is placed in a gas furnace, or in a charcoal furnace. Determine NH_3 with $PtCl_4$ or with a normal HCl solution.

Multiply the determined value of P_2O_5 in bone phosphate by $2.18 = Ca_3(PO_4)_2$.

COMPLETE ANALYSIS.

May contain: SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, K_2O, Na_2O, CO_2, NH_3, insoluble P_2O_5, soluble P_2O_5, H_2SO_4, H_2O, organic matter.

Use special methods for total P_2O_5, soluble P_2O_5, K_2O, Na_2O, NH_3, H_2O, CO_2.

For SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, H_2SO_4, dissolve 5 grams in HCl, evaporate to dryness, moisten with HCl, add water, and filter.

<table>
<tr><td colspan="2">Residue A
= SiO_2, ignite and weigh.</td><td colspan="2">Solution A.
Dilute to 500 c.c.
Divide in four parts.</td></tr>
<tr><td>1st. 200 c.c.
Precipitate CaO by H_2SO_4 and alcohol. (Not too much alcohol nor too little. About 2 vols. alcohol to 1 of solution was with this solution. Precip. = $CaSO_4$. Test after weighing for Al_2O_3 and Fe_2O_3.</td><td>2d. 100 c.c.
Determine Fe with $K_2Mn_2O_8$.</td><td>3d. 100 c.c.
Determine H_2SO_4 with $BaCl_2$.</td><td>4th. 100 c.c.
Determine Al_2O_3 by adding a solution of 4 grams of metallic iron to liquid + Na_2Co_3 + $NaC_2H_3O_2$. The precipitate = $Al_2O_3 + Fe_2O_3 + P_2O_5$. Ignite and weigh, and deduct Fe_2O_3 + P_2O_5.</td></tr>
<tr><td colspan="4">To filtrate from 1st part add $NaHPO_4$ and $(NH_4)HO$, and precipitate = $MgNH_4PO_4$. Ignite and weigh as $Mg_2P_2O_7$, and determine MgO.</td></tr>
</table>

ANALYSIS OF WATERS.

BRIEF RULES WITH REGARD TO MINERAL WATERS.

I. If the water reddens blue litmus-paper before boiling, but not afterward, and the blue color of the reddened paper is restored upon warming, it is a carbonate.

II. If it possesses a nauseous odor, and gives a black precipitate with acetate of lead, it is sulphurous.

III. If, after the addition of a few drops of hydrochloric acid, it gives a blue precipitate with yellow or red potassium prussiate, the water is a chalybeate.

IV. If it restores the blue color to litmus-paper after boiling, it is alkaline.

V. If it possesses neither of the above properties in a marked degree, and leaves a large residue on evaporation, it is saline water.

COMPLETE ANALYSIS OF MINERAL WATERS,

WHEN CONTAINING ALKALINE CARBONATES.

For Total Solids.—Evaporate 0.5 litre in weighed Pt dish; dry to constant weight at 130° C., and weigh.

For $Fe_2O_3 + Al_2O_3 + CaO + MgO — SiO_2$, acidulate 1 litre and evaporate to dryness in Pt dish; moisten with HCl and treat with hot water; filter, wash, etc. Dry residue, ignite and weigh. Then expel SiO_2 with NH_4Fl, and weigh again. The loss is SiO_2. Should any residue be left, *examine* it in the spectroscope.

Treat the filtrate with $(NH_4)HO$ and NH_4Cl; boil to precipitate Fe_2O_3, Al_2O_3, and P_2O_5; filter, etc. Dissolve the precipitate, and reprecipitate; add the filtrate and washings to the first, and in the combined filtrates determine the CaO, MgO as usual.

For SO_3, acidulate 1 litre with HCl, evaporate to small volume in a porcelain dish, and precipitate with $BaCl_3$ as usual.

For Sodic Carbonate, evaporate 1 litre of the water to dryness; treat with water and test with a standard solution of H_2SO_4 or other acid $+ Na_2CO_3 + Li_2CO_3$; or evaporate 1 litre to dryness, dissolve in water, filter, wash. The sodic or lithic carbonate go into solution. To the filtrate add a mixture of $CaCl_2 + (NH_4)HO$ [prepared by dissolving 60 grams $CaCl_2$ in 250 c.c. water, adding 100 c.c. $(NH_4)HO$] in excess; filter and wash rapidly.

The CO_2 goes to the lime; the soda and lithia are washed out as chlorides. Dissolve the $CaCO_3$ on the filter with HCl, then precipitate as oxalate; either determine as $CaSO_4$ or ignite to CaO, and estimate the corresponding amount of $CaCO_3$; from this calculate the Na_2CO_3 by the proportion,

At. Wt. $CaCO_3$: At. Wt. Na_2CO_3 : : $CaCO_3$ found : Na_2CO_3.

FOR POTASSIC OXIDE.—Take 1 litre of water; evaporate nearly to dryness in a silver dish; filter, wash with boiling water, evaporate in Pt or porcelain dish with slight excess of HCl + $PtCl_4$ to dryness, or nearly so, on water-bath. Then dissolve in a mixture of 2 parts alcohol and 1 part ether. Filter out KCl, $PtCl_4$; wash very completely with the same; dry, transfer to crucible, and ignite with oxalic acid. (See Fresenius.)

TOTAL CHLORINE.—Test $\frac{1}{100}$ gallons with standard solution $AgNO_3$ — (1 c.c. = 0.1 grain NaCl).

FOR CARBONIC ACID.—Take 200 c.c. of the water previously treated at the spring with "$CaCl_2+(NH_4)HO$ preparation," being careful to clear the neck of the bottle from all fat, etc. Keep the bottle in boiling water until the effervescence ceases; then filter out the $CaCO_3$, rinsing the bottle thoroughly with water. Keep the bottle for after treatment. Wash the $CaCO_3$ on the filter, as long as the wash-water gives a reaction with $(NH_4)_2C_2O_4$.

This washing should be done rapidly, to avoid the formation of $CaCO_3$ by the CO_2 in the atmosphere, acting on the CaH_2O_2 present. Then dissolve the $CaCO_3$ adhering to the bottle with a little HCl, and wash into a beaker. Then punch a hole in the filter and wash the $CaCO_3$ into same beaker, cleansing the filter with HCl. Boil to expel CO_2, and determine the lime as oxalate or caustic, and calculate the CO_2.

MAIN ANALYSIS.

Evaporate 10–20 gallons of the water to dryness in large porcelain dishes (perfect dryness is not necessary). Treat the residue in the dishes with water; boil; decant through a filter, repeating the operation a number of times; finally bring the insoluble residue on the filter; wash with boiling water until the residue gives only a faint trace of lithia in the spectroscope (in case lithia is present).

TREATMENT OF THE RESIDUE. Insoluble in hot water (in case lithia be *not* present in such quantity or in such a form as not to be completely removed by hot water). Dissolve residue in HCl; evaporate to dryness; add concentrated HCl to the dry mass; dilute with water and filter off residue, which consists of SiO_2 and perhaps $BaSO_4$, in case SO_3 and BaO are present in the water. Divide filtrate from SiO_2 into three equal parts.

Treatment of first one-third part of solution for

PHOSPHORIC ACID.

Drive off excess of HCl from solution, and then remove it entirely by boiling with concentrated HNO_3; precipitate with $(NH_4)_2MoO_4$ and proceed as usual.

Treatment of second one-third part of solution for

IRON.

Precipitate the iron with NH_4HO and NH_4Cl, as usual; filter, wash, and re-dissolve the precipitate in HCl (or perhaps better H_2SO_4); reduce with amalgamated zinc and Pt, determine volumetrically with $K_2Mn_2O_8$.

Treatment of third one-third part of solution for

BARYTA AND STRONTIA.

Dilute solution with water and add dilute H_2SO_4; boil (enough acid should be added to precipitate a little lime, or else some SrO may remain in solution). The precipitate, consisting of $(BaSO_4)$ $SrSO_4$, $CaSO_4$, should be treated with a strong solution of $(NH_4)_2CO_3$, which converts the $CaSO_4$ and $SrSO_4$ into carbonates, while the $BaSO_4$ is unaffected. The carbonates are then dissolved away from the $BaSO_4$ on the filter with hot HCl. The HCl solution, containing $CaCl_2$ and $SrCl_2$, is evaporated to dryness; the chlorides converted into nitrates; the calcic nitrate dissolved out by digesting with a mixture of alcohol and ether. (See Fres.) The $Sr(NO_3)_2$ is dissolved in water and precipitated as $SrSO_4$ with dilute H_2SO_4.

All the precipitates should be examined in the spectroscope, to ascertain if the operations have been perfect.

TREATMENT OF THE RESIDUE, insoluble in hot water. In case lithia be present in such quantity, or in such a form, as not to be completely removed by boiling water, divide the HCl solution into four equal parts, and take one part for the determination of lithia, using the other three as already stated. Precipitate out with $(NH_4)_2CO_3$ and proceed according to Fresenius, § 209, p. 564, in order to free the lithia from all other bases precipitable by $NaPO_3$.

TREATMENT OF WATER SOLUTION resulting from the digestion with hot water of the residue obtained by evaporation of 10 to 20 gallons. Evaporate to dryness, pulverize the residue, and weigh; divide into two portions, one for lithia, and one for iodine and bromine.

DETERMINATION OF LITHIA.

Moisten the dry salt with HCl and evaporate on the water-bath to dryness, in order to convert the lithia into the chloride.

Place the salt in a glass flask and agitate with *absolute* alcohol, decanting solution through a filter until the salt gives no reaction for lithia in the spectroscope. Evaporate off the alcohol on a water-bath; dissolve the residue in water. Treat the solution thus obtained according to Fresenius (§ 101, p. 159), in order to separate lithia.

DETERMINATION OF IODINE AND BROMINE.

Place the dry salt in a flask, boil on a water-bath repeatedly with 70% alcohol, until the salt gives no reaction for bromine when treated with chlorine water and carbon disulphide. Evaporate the alcoholic solution upon the water-bath; dissolve the residue in water. Add $PdCl_2$ to a slight excess and heat; allow the whole to stand for some time, then filter out the precipitated PdI_2, wash with warm water, dry and ignite.

Divide the filtrate from the PdI into two equal portions. Precipitate each with $AgNO_3$. Filter off the $AgCl + AgBr$; wash, dry, ignite one precipitate, and weigh. Place the other precipitate of $AgCl + AgBr$ in a beaker and digest in the heat for 1 hour, with a solution of $KBr (1KBr + 9H_2O)$, whereby the $AgCl$ is completely converted into $AgBr$. From these data estimate the amount of bromine in the first precipitate. About as much KBr is required for the conversion as there is $AgCl$ in the precipitate. See "Wittstein Zeitschrift für Analytische Chemie," 1863, S. 159.

$CaCl_2 + (NH_4)HO$ MIXTURE.

60 grams $CaCl_2$ in 250 c.c. H_2O. Add 100 c.c. $(NH_4)HO$, boil, filter, add 100 c. c. $(NH_4)HO$, dilute to 500 c.c.

NOTE I.—In case H_2SO_4 be present in a water, the residue insoluble in HCl may contain $BaSO_4$, and perhaps $SrSO_4$. Treat residue with pure NH_4Fl, to expel SiO_2, weigh, and test the residue in the spectroscope.

GRAMS IN U. S. GALLON (231 cubic inches).

58318	1	349908	6
116636	2	408226	7
174954	3	466544	8
233272	4	524862	9
291590	5	583180	10

METHOD OF CALCULATING WATER ANALYSIS.

United States gallon contains 231 cu. inches = 58318 grains of distilled H_2O at 60° Fah.

Suppose an analysis of a litre of water gave the following. Required the number of grains of each substance in a gallon.

	1 Litre.	Grains in a Gallon.
Na_2O	0.031	1.807
CaO	0.173	10.089
Cl	0.172	10.030
SiO_2	0.250	14.579

Multiply each substance by 58318 and divide each by 1000.

TO CALCULATE HOW ACIDS AND BASES COMBINE.

ORDINARY DRINKING WATERS.

	1 U. S. Gallon.		Combined.
Na_2O	0.326	K_2SO_4	.179
K_2O	0.097	NaCl	.400
CaO	0.988	Na_2SO_4	.263
MgO	0.524	$CaSO_4$	.156
Cl	0.243	$CaCO_3$	1.650
SO_3	0.322	$MgCO_3$	1.100
SiO_2	0.621	SiO_2	.621
Organic and volatile matter.	0.670	Org. and volatile matter..	.670
CO_2 (calculated)	1.302	Total	5.039
Total	5.093		

1st. Give SO_3 to K_2O.
2d. " Cl " remainder K_2O.
3d. " " " Na.
4th. " " " Mg.
5th. " " " Ca.
6th. " SO_3 " Na_2O.
7th. Give SO_3 to CaO.
8th. " " " MgO.
9th. " CO_2 " Na_2O.
10th. " " " CaO.
11th. " " " MgO.

5.093 — .054 (amount of oxygen in Na used to make NaCl) = 5.039.

ANALYSIS OF A MINERAL WATER.

HATHORN SPRING, SARATOGA SPRINGS.

By C. F. Chandler.

Sodic Chloride	509.968	grains.
Potassic Chloride	9.597	"
Sodic Bromide	1.534	"
Sodic Iodide	.198	"
Calcic Fluoride	A trace.	
Lithic Dicarbonate	11.447	"
Sodic Dicarbonate	4.288	"
Magnesic Dicarbonate	176.463	"
Strontic Dicarbonate	A trace.	
Baric Dicarbonate	1.737	"
Ferrous Dicarbonate	1.128	"
Potassic Sulphate	None.	
Sodic Phosphate	.006	"
Sodic Diborate	A trace.	
Aluminic Oxide	.131	"
Silicic Oxide	1.260	"
Organic Matter	A trace.	
Total solid contents	888.403	grains.

Carbonic oxide (CO_2) in 1 gal., 375.747 inches; density 1.009.

ANALYSIS OF THE ATLANTIC OCEAN

(By Von Bibra)

AND OF THE DEAD SEA

(By the Herepaths).

	Atlantic Ocean.	Dead Sea.
Specific Gravity	1.0275	1.17205
Sodic Chloride	1671.34	6702.73
Potassic Chloride	—	682.63
Ammonic Chloride	—	3.35
Calcic Chloride	—	1376.75
Magnesic Chloride	199.66	4457.23
Aluminic Chloride	—	31.37
Ferrous Chloride	Trace.	1.50
Manganous Chloride	—	3.35
Sodic Bromide	31.16	156.53
Carried forward	1903.18	13416.61

	Atlantic Ocean.	Dead Sea.
Brought forward	1903.18	13416.61
Sodic Iodide	Trace.	Trace.
Potassic Sulphate	108.46	—
Magnesic Sulphate	34.99	—
Calcic Sulphate	93.30	88.07
Sodic Phosphate	Trace.	—
Calcic Carbonate	Trace.	Trace.
Silver	Trace.	—
Copper	Trace.	—
Lead	Trace.	—
Arsenic	Trace.	—
Silicic Oxide	Trace.	Trace.
Organic Matter	Trace.	34.59
Bitumen	—	Trace.
Total in 1 U. S. gallon	2139.93 gr.	13489.17 gr.
Per cent. by weight	3.569	19.733
Water	96.431	80.267
Total	100.000	100.00
Weight of 1 gallon	59922. grs.	68352. grs.

POTABLE WATER ANALYSIS.

(*J. Chem. Society, London*, vol. xxi, p. 771.)

I. TOTAL SOLIDS.

Evaporate ½ litre to dryness rapidly at 100° C. to constant weight.

II. ORGANIC CARBON.

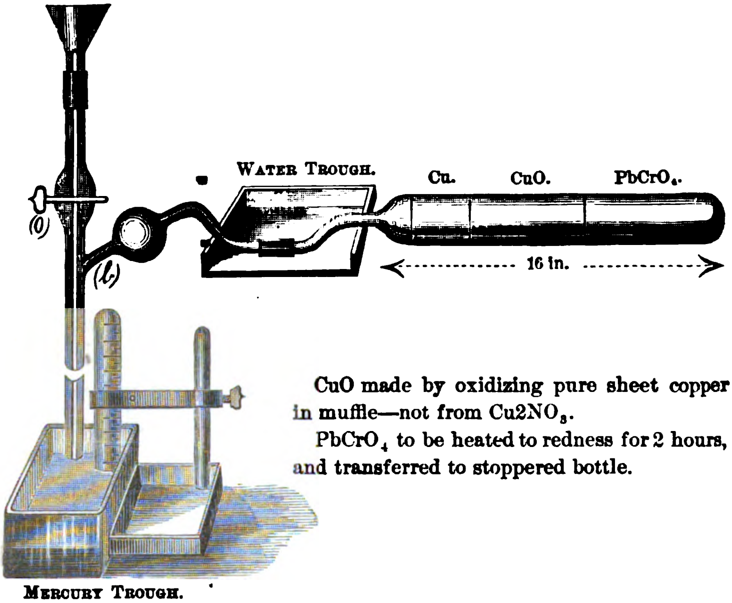
To 2 litres in a stoppered bottle add 60 c.c. saturated solution sulphurous acid; ½ of this (1 litre) sulphurized water is boiled for two or three minutes (unless it contains a considerable amount of carbonates); then add 0.200 grams sodic sulphite to secure saturation of SO_3 formed during subsequent evaporation. To secure expulsion of N, existing as nitrate, add 2 drops $FeCl_2$ or Fe_2Cl_6. Then evaporate boiled water to dryness in glass capsule of 100 c.c. capacity, keeping capsule without a lip, covered with paper stretched on a hoop to keep out dust; there should be no $(NH_4)HO$ in the atmosphere; when dry, a few grams plumbic chromate, powdered, are added, and triturated with contents in an agate mortar; when the mixture is complete the contents are transferred to a combustion tube sixteen inches long sealed at one end, and the capsule rinsed with $PbCrO_4$, and the tube charged with CuO and about three inches bright copper turnings. Then draw out open end and connect with a Sprengel pump, letting the ends of glass tubes touch inside of rubber tube, and plunge the joint under water. The furnace is lighted around the forward end of combustion tube and the pump worked for five or ten minutes. The delivery end of the pump dips into a mercury bath, and a tube filled with mercury is placed over it. The combustion is conducted as usual. When the organic matter begins to burn, the operation proceeds slowly until the vacuum is impaired or carbonic oxide will be formed. Combustion lasts forty-five minutes to one hour. Generally no gases will have passed into the mercury tube unless the residue is very rich in organic matter. The pump is now worked for ten minutes, when all the gases will be transferred to the inverted tube. The gases are CO_2, N, and NO_2. (For separation and determination of these, see J. Chem. Soc., vol. vi, p. 197.)

The weights of carbon and nitrogen are deducted from the volumes of these gases, expressed in 100.000 parts of water. The nitrogen may have been present as organic nitrogen or a constituent of NH_3. The latter is determined in the water directly by Nessler's test. The nitrogen in this deducted from total nitrogen = organic nitrogen.

NOTE.—CO_2 is determined by solution of K_2O of 1.8 specific gravity, and oxygen by solution of pyrogallic acid (1 acid to 6 water).

A correction is made by boiling distilled water for 24 hours with alkaline potassic permanganate, and then distilling it; refusing the distillate as long as it shows any reaction for $(NH_4)HO$ by Nessler's test, and then slightly acidulating it with H_2SO_4, and rectifying it. A litre of this is acidified with 15 c. c. H_2SO_4, containing about 1.100 grams recently ignited $NaCl$, and evaporated. The residue must now be burned in

FIG. 2.



CuO made by oxidizing pure sheet copper in muffle—not from Cu2NO$_3$.

PbCrO$_4$ to be heated to redness for 2 hours, and transferred to stoppered bottle.

vacuo, and the carbon and nitrogen obtained deducted from that obtained from the water analyzed.

N. B.—See J. Ch. Soc., London, vol. xxi, for apparatus for measuring gases, also without absorbing same, and tables for calculating weight of nitrogen, etc. See particularly Russell on Gr. Analysis, J. Chem. Soc., London, vol. xxi, p. 128.

3. NITRATES AND NITRITES.

The solid residue of ½ litre of water is treated with a small quantity of distilled water—a very slight excess of Ag_2SO_4 added, to convert chlorides into sulphates. The filtered liquid concentrated in a small beaker to 2 or 3 c. c. This is transferred to a tube with a cup and stop-cock (see Fig. 2) filled with mercury and standing in a mercury-trough—the beaker being washed once or twice with a little recently-boiled distilled water, finally with pure H_2SO_4 in greater volume than solution and rinsings. If air gets in, push tube down in mercury and draw it out. Finally, close the tube firmly at the bottom with the thumb, and shake; resisting the flowing out of the mercury between the acid liquid and the thumb. In 3 to 5 minutes the reaction is complete, when the gas is transferred to a measuring apparatus over mercury.

Half the volume of NO_2 in tube $=$ N; the weight calculated from the volume. Miller proposes to estimate the nitrates by the $K_2Mn_2O_8$ solution, of which 1 c.c. $= 0.00237$ grams N_2O_3. He adopts Pugh's process for nitrates. Or, J. Ch. Soc., vol. xii, p. 35.

MILLER'S METHOD OF $K_2Mn_2O_8$.

1 c.c. $= 0.0001$ gram oxygen requiring 0.395 gram to 1 litre water. Test it with a solution of oxalic acid containing 0.7875 gram to 1 litre water; 100 c.c. of this, warmed with a very dilute solution of H_2SO_4 should decolorize 100 c.c. $K_2Mn_2O_8$ solution. 250 c.c. of the water to be tested is placed in a flask with 3 c.c. dilute H_2SO_4 (1 acid + 3 water). Add the $K_2Mn_2O_8$ solution in successive portions of 0.5 c.c. until the color disappears, and until after the last addition no change takes place for one-half hour. After it is found that no change takes place, the last 0.5 c.c. added is subtracted as excess.

ORGANIC MATTER IN WATER.

(Permanganate Test.)

Solution made is that 1 c.c. yields 0.0001 gram oxalic acid, then 1 litre yields 0.100 gram oxalic acid.

$$H_2C_2O_4 \text{ and } 2H_2O = 126 \text{ requires } 1 \text{ At. } O = 16.$$

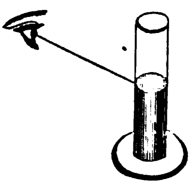
$$16 : 126 :: 0.100 : .7875 = \text{oxalic acid.}$$

Then .7875 oxalic acid requires 0.100 oxygen.

Then .7875 oxalic acid dissolved in 1 litre H_2O require for each c.c. $\frac{.100}{1000}$ = .0001 oxygen. Permanganate is diluted until 1 c.c. oxidizes 1 c.c. oxalic acid solution; so 1 c.c. $K_2.Mn_2O_8$ carries 0.0001 available oxygen.

AMMONIA.

If the $(NH_4)HO$ be not alone one part in 10,000,000, which is obtained by distillation alone or with Na_2CO_3, use Hadow's modification of Nessler's test. If it be alone this, Nessler's test must be applied directly to the water. The water must be colorless, free from carbonates of magnesia and lime. Any tint in a column six or eight inches deep is fatal. In this case add a few drops of concentrated solution of calcic chloride to one-half litre water, and precipitate with slight excess Na_2CO_3; filter after an hour; use 100 c.c. of the filtrate. To this volume 1 c.c. of the Nessler solution is added, and the color observed. See Miller on Potable Waters, J. Ch. Soc., vol. xviii, p. 125.



Use a cylinder of such diameter that 100 c.c. form a column seven inches deep; place it near a window.

AMMONIA.

(MILLER'S METHOD)

Into a capacious retort one litre water is introduced, and the retort connected with a Liebig's condenser; 25 c.c. of baric hydrate is then added; 250 c.c. water distilled over. The residue in the retort is filtered and separated from salts of baryta (carbonate and sulphate) and evaporated for determination of nitrates by Pugh's method. The distillate is divided into two equal portions; one for Nessler's test, as practised by Hadow.

NESSLER'S SOLUTION.

Make a concentrated solution of 40 grams corrosive sublimate ($HgCl_2$). Dissolve 62.5 grams KI in 300 c.c. water, and add to this the mercurial solution until the mercury iodide ceases to be dissolved on agitation. Next dissolve 150 grams K_2O in its own weight of water and add it gradually to the iodized mercurial solution, stirring while mixing; then dilute to one litre; let it stand for a day or two until the brown color disappears, and it becomes clear. Decant the clear liquid.

About 3 c.c. of the above solution is added to the half of the distillate, same as one-half litre. If $(NH_4)HO$ be present, a yellow color will appear; if the NH_3 be $\frac{1}{2000000}$ part, make a solution of NH_4Cl 0.317 grams to one litre of water, which is equal to 0.1 gram NH_3 in one litre.

Place 3 c.c. of this solution in a beaker of same size used for the distillate; dilute with 150 c.c. water; add 3 c.c. *test liquor*. If the colors coincide then, calculate the quantity of NH_3. When the NH_3 exceeds 0.6000 milligram per litre, it must be determined by neutralizing with a test acid solution. The other one-half of the distillate is used. The solution contains 2.882 grams H_2SO_4 in one litre water; 1 c.c. = 0.001 NH_3, as usual with litmus solution.

NITRIC ACID.

(Fuch's *Zelochi Anal. Chem.*, vi, 175.)

Concentrate two litres water, adding $K_2Mn_2O_8$ to pink color. Filter; concentrate fluid; add pure H_2SO_4 and distil into a flask containing $BaCO_3$ suspended in H_2O until H_2SO_4 goes over. Filter and determine the Ba existing as $Ba(NO_3)_2$ and $BaCl_2$. Determine Cl elsewhere and calculate the HNO_3.

TOTAL RESIDUE.

(WANKLYN.)

Evaporate 100 c.c. in a small platinum dish holding about 125 c.c. The dish is heated, covered, to 130° C., cooled on a thick piece of cold iron (still covered). Evaporate over steam so as not to allow the dish to come in contact with the boiling water. Use a can with a funnel in it, the dish standing in the funnel. When dry, wipe, transfer to air-bath; dry at 130° C., at first with lid on, afterwards without it; cool the dish, covered, as at first, on cold iron, and weigh. If the air-bath is at a temperature of 130° when the dish is put in, the determination can be made in 1¼ hours. Liability to error on account of dust, destruction of organic matter on account of long drying, avoided.

SOAP TEST.

Dissolve marble in HCl; dry; fuse in a weighed crucible; weigh. Difference = $CaCl_2$. Dissolve with water; from known weight calculate water necessary to make solution so that 1 litre = 1.110 grams $CaCl_2$; each cubic centimetre = 0.001 = 1 c.c. $CaCl_2$ = 1 c.c. $CaCO_3$.

Take 2 parts lead plaster and 1 K_2CO_3; pound together a little at a time. Extract with 90% alcohol, 30 times as much as the lead plaster; allow to stand for some time; filter; dilute with its own volume of water.

If this cannot be obtained, use good potash soap. Measure accurately 10 c.c. of the soap solution, put it into a bottle with 70 c.c. water, and add $CaCl_2$ solution until frothing stops. Shaking up properly, from this calculate how much dilution is necessary to make 17 c.c. of soap solution consume 16 c.c. $CaCl_2$ solution; dilute accordingly with alcohol of 40%, and verify. [N. B.—17 c.c. standard soap test should neutralize 16 c.c. of standard $CaCl_2$ solution, in presence of 70 c.c. pure water. Each c.c. of soap solution will then be equal to 1 milligram $CaCO_3$, or its equivalent, or 0.010 grams per litre.]

Take 70 c. c. of the water, put it into a bottle, add soap solution until it lathers; each c. c. of soap = 1 gram in an English gallon. To get it in litres, take 100 c.c. water; each c.c. soap = 10 milligrams $CaCO_3$ per litre. (This is not *absolutely* exact.)

If more than 17 c.c. of soap is required in 70 c.c., dilute the water with its own volume of distilled water, and go on, etc. Wanklyn claims that 70 c.c. distilled water have a soap-destroying power = 1 milligram $CaCO_3$.

NITRATES AND NITRITES.

100 c. c. water are introduced into a non-tubulated retort; 50–70 c. c. solution of $NaHO$ added (100 grams Na_2O to 1 litre water).

Distil until not more than 100 c. c. remain, and until no NH_3 comes over. Now cool, and introduce a thin sheet of aluminium.

Then incline neck upwards; close it with a cork through which passes the narrow end of a small tube 2 or 3 inches long, filled with broken tobacco clay-pipe moistened with dilute HCl, connected with a second tube holding pumice saturated with H_2SO_4; allow to stand for some hours; then wash the contents of the pipe-clay tube back into the retort with a little water and distil down one-half into 80 c.c. water. Make the distillate up to 150 c.c. To 50 c.c. of this add Nessler's solution.

If the color is not too strong, the estimation may be made directly. If it is too strong, dilute the remainder, test, etc.

TO DETERMINE NH_3 BY TITRATION.

Use 1 litre evaporated to small bulk; treat in same way as above, receiving the distillate in *standard* acid *instead* of water. Soda may be purified from nitrates by dissolving aluminum in cold solution, and boiling.

WITHOUT DISTILLATION.

Prepare soda by dissolving 100 grams solid soda, diluting to 1 litre; dissolve a very little Al in it, to decompose nitrates.

1st. Then to 200 c. c. of this add 200 c. c. of the sample of water and add a little more Al. This contains *original ammonia and that from nitrates.*

2d. Take 200 c.c. of the soda ley, dissolve in it a little Al as before, then add 200 c.c. water, and allow to subside. This will have the nitrates *unreduced.* Decant, and determine NH_3 by Nessler's solution.

Test in both 1st and 2d. Difference = nitrates.

N.B.—To both samples of water, before mixing with soda ley, add a little $CaCl_2$ to get an appreciable precipitate.

ANALYSIS OF THE "CROTON WATER."

(Calculated for 100,000 parts water.)

$CaH_2C_2O_6$ (Calcic Bicarbonate)	4.53
$MgH_2C_2O_6$ (Magnesic Bicarbonate)	3.25
SiO_2	1.05
Fe_2O_3	Trace.
Al_2O_3	Trace.
$CaSO_4$	0.26
Na_2SO_4	0.44
K_2SO_4	0.30
NaCl	0.68
Organic Matter	1.13
Total	11.64

PURITY OF CITY WATERS.*

Impurities contained in one wine gallon of 231 cubic inches expressed in grains.

City.	Source.	Inorganic Matter.	Organic and Volatile Matter.	Total Solids.
New York.......	Croton, 1869..........	4.11	0.67	4.78
" "	Well, 8th Ave........	38.95	4.59	43.54
Brooklyn.........	Ridgewood, 1869......	3.37	0.59	3.92
Jersey City......	Passaic River.........	4.58	2.86	7.44
Trenton..........	Delaware River.......	2.93	0.55	3.48
Philadelphia.....	Schuylkill River......	2.30	1.20	3.50
Boston..........	Cochituate Lake.......	2.40	0.71	3.11
Albany..........	Hydrant..............	8.47	2.31	10.78
Troy.............	Hydrant..............	6.09	1.34	7.43
Schenectady......	Well, State St........	46.88	2.33	49.21
Utica...........	Hydrant..............	5.50	0.96	6.46
Syracuse........	New Reservoir........	12.13	1.80	13.93
Rochester.......	Genesee River........	12.02	1.23	13.25
Cleveland.......	Lake Erie............	4.74	1.53	6.27
Chicago..........	Lake Michigan........	5.62	1.06	6.68
Dublin...........	Lough Valley...... ...	1.77	1.34	3.11
London..........	Thames River........	15.55	0.83	16.38
"	Well, Leadenhall St...	90.38	9.59	99.97
Paris............	River Seine...........	7.83	1.00	8.83
Amsterdam......	River Vecht..........	14.45	2.13	16.58
"	Well..................	64.55	4.38	68.93

*** Taken from Lec. on Mineralogy by T. Egleston, E. M.**

COAL ANALYSIS.

In the ordinary analysis there is determined moisture; volatile and combustible matter; fixed carbon (coke), and sulphur.

(*a.*) Determination of moisture.* Pulverize the coal finely; heat one or two grains in a covered platinum or porcelain crucible, fifteen minutes in an air-bath at 212° to 240° F. Cool and weigh, repeat until weight is constant or begins to rise. Loss = MOISTURE.

(*b.*) Determination of volatile and combustible matter.

---

* See "Notes on Assaying," p. 95, by Ricketts, Ph.D.

Heat the same crucible, with contents, to bright redness, over a Bunsen burner or alcohol lamp, exactly three and one-half minutes, and then three and one-half minutes over a blast-lamp. Cool and weigh. Loss = volatile and combustible matter. This includes one-half of sulphur of any sulphide of iron contained in the coal.

(*c.*) Fixed carbon. Heat over the burner until the ash is white and constant weight. Loss = fixed carbon and one-half the sulphur from the sulphide of iron.

(*d.*) The sulphur may be determined as follows: Weigh out one to two grams of the finely pulverized coal and oxidize with nitric acid and potassic chlorate in a flask until action ceases; then filter and wash. If the residue contain sulphur, dry and weigh it; then ignite and weigh. The difference will be the sulphur unoxidized; add to this a little hydrochloric acid, and then baric chloride in slight excess; heat for a few moments and allow the particles to settle. Pour off the liquid through a filter and wash with dilute hydrochloric acid, then with water. Dry and ignite the residue in a porcelain crucible; multiply the weight of the precipitate less that of the filter-ash by $\frac{16}{116.5}$; the product equals the sulphur in the sample taken.

The following analyses are of different semi-bituminous coals (by Pierre de Peyster Ricketts):

Moisture	3.310	0.965
Volatile Combustible Matter	27.300	30.111
Fixed Carbon	61.965	61.033
Ash	7.425	7.829
Sulphur	3.863	1.347

27.300 minus $\frac{3.863}{2}$ and 30.111 minus $\frac{1.347}{2}$ gives the correct amount of volatile matter. 61.965 minus $\frac{3.863}{2}$ and 61.033 minus $\frac{1.347}{2}$, the correct amount of fixed carbon. Phosphorus not determined.

CLAY ANALYSIS.

I. May contain Al_2O_3, $4SiO_2 + 6H_2O$, with variable quantities of K_2O, MgO, FeO, MnO, feldspar, sand, etc.

Dry a quantity of clay at 100° C., and weigh; ignite and weigh again. Loss = H_2O. Treat then with H_2SO_4 (concentrated); heat; evaporate off excess of acid; dissolve in concentrated HCl, and filter off the SiO_2 (weigh). If the clay contain an admixture of sand or feldspar, the silica is dissolved in a boiling concentrated solution of sodic carbonate, which leaves the sand and feldspar undissolved.

The hydrochloric acid solution is considerably diluted, and gradually neutralized with sodic carbonate. Precipitate out ferric and aluminic oxide, then manganous, calcic, and magnesic oxides remain in the solution as dicarbonates.

The Fe_2O_3 and Al_2O_3 are then separated, as also the manganous, calcic, and magnesic oxides.

II. The clay is fused with three times its weight of potassic and sodic carbonate, the fused mass dissolved in dilute HCl, the solution evaporated to dryness, the residue dissolved in water containing HCl, and the solution filtered off. The separation of the other bases contained in the solution is then effected as in I.

III. For the determination of the alkali a separate portion of the clay is decomposed by fusion with baric hydrate or carbonate; the baric oxide and the other bases are precipitated from the solution by a mixture of ammonic hydrate and carbonate; after gently heating, the solution is filtered off, the solution evaporated, and the residue ignited, when potassic and sodic chloride are left, which may be separated if required.—(From Wöhler's Mineral Analysis.)

ANALYSIS OF CLAYS.

The hard, dark clay used for the substance of the Mount Savage fire-brick.

(JOHN M. ORDWAY.)

Silica	50.457
Alumina	35.904
Protoxide of Iron	1.504
Oxide of Manganese	Trace.
Lime	0.133
Magnesia	0.018
Water and Organic Matter	12.744
Potash	Inappreciable.
	100.760

GUNPOWDER ANALYSIS.

I. For the estimation of moisture, 5 or 6 grams of powder are dried over H_2SO_4, or in the air-bath at 100°.

II. A similar quantity of powder is moistened with water, triturated in a mortar, rinsed into a filter, and thoroughly washed. The solution of nitre thus obtained is evaporated to dryness in a small weighed porcelain dish, the dry residue heated for some time to 200°, or even until the nitre fuses, and its weight determined.

III. In order to determine the sulphur 5 grams are intimately mixed with 5 grams anhydrous Na_2CO_3, 5 grams of nitre, and 20 grams of decrepitated NaCl, and the mixture heated to redness in a platinum crucible. When cool, the mass is dissolved in water, the solution slightly acidified with HNO_3, and the H_2SO_4 precipitated with $BaCl_2$.

The amount of carbon may be inferred by difference. In order to determine its quality, and to ascertain whether it has been completely or incompletely carbonized, the mixture of sulphur may be separated with carbon disulphide, which dissolves the sulphur and leaves the carbon, which must be well washed and dried.

ANALYSIS OF GUNPOWDER.

GUNPOWDERS.	CHARCOAL.	SULPHUR.	NITRE.	AUTHORITY.
Swedish war powder..........	9.0	16.0	75.0	Meyer.
Hessian artillery powder......	10.7	15.1	74.2	"
" musket "	10.7	15.6	73.7	"
French sporting "	13.5	9.6	76.9	Prechtl.
English " "	13.7	10.1	76.2	Ure.
Russian powder.....	17.7	11.7	70.6	Meyer.
Chinese "	23.1	15.4	61.5	Prechtl.

SCHEME FOR THE ANALYSIS OF GLASS.*

Two analyses are made, one by fusion with an alkaline carbonate, for the determination of silicic acid; the other by decomposing the glass with hydrofluoric acid, in order to estimate the alkali.

I. The very finely-powdered glass is fused with three times its weight of potassic and sodic carbonate; the mass is then softened with water, dissolved in dilute hydrochloric acid, evaporated to dryness, redissolved in water, acidulated with hydrochloric acid, and the silica filtered off and washed.

From the solution, the small accidental impurities of ferric, manganous, and aluminic oxides which are usually contained even in white glass, are precipitated by ammonic hydrate, after the solution has been mixed with some chlorine water to peroxidize the manganous oxide.

The lime is afterwards precipitated by oxalic acid, and the solution filtered from the calcic oxalate is tested for magnesia, which may, moreover, have been precipitated with the aluminic oxide.

If the glass contain plumbic oxide, that metal is precipitated by sulphydric acid from the solution filtered from the silicic acid.

---

* Mineral Analysis, Wöhler, p. 209.

II. For the determination of the alkalies, a second quantity of very finely-powdered glass is decomposed by hydrofluoric acid, or by ignition with baric carbonate.

In the last case after fusion the mass is dissolved in water, evaporated to dryness with a little hydrochloric acid, then dissolved again in water and the insoluble silica filtered off, when a solution will be obtained from which may be determined the alkalies, as also the other bases if necessary.

The following table contains the analysis of different specimens of glass:

ANALYSIS OF GLASS.

*Pale-green Glass used for Medical Bottles and Chemical Apparatus.**

CONSTITUENTS.	BOTTLE GLASS.					MEDICAL-BOTTLE GLASS.			
K_2O	3.1	3.2	3.2	5.48	6.1	10.6	10.5	8.0	—
Na_2O			—	—	—	—	—	3.0	16.4
BaO	—	0.9	—	—	—	—	—	—	—
CaO	22.3	20.7	18.0	29.22	28.1	10.0	16.2	13.0	15.6
MgO	—	0.6	7.0	—	—	—	—	0.6	2.2
MnO	1.2	—	0.4	—	—	0.3	1.2	—	—
Fe_2O_3	4.0	3.8	4.4	5.74	6.2	1.5	2.5	1.6	0.7
Al_2O_3	8 0	10.4	6.8	6.01	14.0	3.0	4.5	3.6	2.4
SiO_2	60.0	60.4	59.6	53.55	45 6	71.6	62.5	69.6	62.0
P_2O_5	0.4	—	—	—	—	—	—	—	—
	99.0	100.0	99.4	100.00	100.00	97.0	97.4	99.4	99.3

The last four analyses are by Berthier.

ANALYSIS OF WINDOW GLASS.

CONSTITUENTS.	*a*	*b*	*c*	*d*	*e*	*f*	*g*
Na_2O	15.22	11.30	12.88	17.70	13.7	10.1	11.1
CaO	13.31	17.25	16.17	9.65	7.8	14.3	12.5
Al_2O_3	1.32	2.20	2.40	4.00	10.0	7.6	7.4
SiO_2	69.65	69.25	68.55	68.65	68.5	68.0	69.0
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

a to *f* is French; *g*, English; *f* and *g*, the hardest and most infusible; *b*, the next; *d*, the softest and most easily fused of

---

* Watt's Dic. Chem., Article *Glass.*

the whole. In France, a mixture is used of 100 parts of quartz-sand with between 30 and 40 parts of dry sodic carbonate (or as much sulphate with charcoal) and 30 to 40 parts of calcic carbonate (Dumas). Window-glass may be approximately represented by the formula $Na_2O.2SiO_2 + CaO.2SiO_2$.

CHLORIMETRY.

Chlorimetry has for its object the determination of the available chlorine in the "*bleaching powder*" of commerce. Bleaching powder is called "chloride of lime;" it is a mixture of calcic hypochlorite, calcic chloride, and calcic hydrate.

The following method of chlorimetry* is based upon the conversion of arsenious acid into arsenic acid; the conversion is effected in an alkaline solution. Potassic iodide starch-paper is employed to ascertain the exact point when the reaction is completed.

(*a.*) PREPARATION OF POTASSIC IODIDE STARCH-PAPER.

(*Fresenius*, § 212.)

Stir 3 grams of potato starch in 250 c.c. of cold water, boil with stirring, add a solution of 1 gram potassic iodide and 1 gram crystallized sodic carbonate, and dilute to 500 c.c. Moisten strips of Swedish paper with this fluid, and dry. Keep in a closed bottle.

(*b.*) PREPARATION OF SOLUTION OF ARSENIOUS ACID.

Dissolve 4.436 grams of pure arsenious acid and 13 grams pure crystallized sodic carbonate in 600–700 c.c. of water, with the aid of heat; let the solution cool, and then dilute to one litre. Each c.c. of this solution contains 0.004436 grams arsenious acid, which corresponds to 1 c.c. chlorine gas of 0° and 760 m.m. atmospheric pressure.

---

* By A. Penot, Dingler's Polytech. Jour., 127, 134.

PREPARATION OF SOLUTION OF "CHLORIDE OF LIME."

Weigh 10 grams of "chloride of lime," triturate finely with a little water, add gradually more water, pour the liquid into a litre flask, triturate the residue again with water, and rinse the contents of the mortar carefully into the flask; fill the latter to the mark, shake the milky fluid and examine it at once. 1 c.c. of this solution = 0.01 gram chloride of lime.

(c.) THE PROCESS.

Put 50 c.c. of solution of "chloride of lime" in a beaker, and from a 50 c.c. burette add slowly, and at last drop by drop, the solution of arsenious acid, with constant stirring, until a drop of the mixture produces no longer a blue-colored spot on the iodized paper. The number of $\frac{1}{2}$ c.c. used indicates directly the number of chlorometric degrees. Suppose 40 c.c. of arsenious acid solution were used, the quantity of "chloride of lime" used in the experiment contains 40 c.c. of chlorine gas. Now the 50 c.c. of solution employed corresponds to (1 c.c. = 0.01 gram) 0.5 gram of chloride of lime; therefore 0.5 gram of chloride of lime contains 40 c.c. chlorine gas; therefore 1000 grams contain 8000 c.c. = 80 litres of chlorine gas.

Organic Analysis.

THE ELEMENTARY OR ULTIMATE

ANALYSIS OF ORGANIC COMPOUNDS.

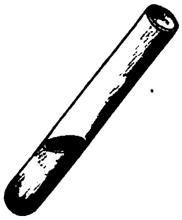
(*From* FOWNES' CHEMISTRY, *London*, 1872.)

Organic compounds contain, for the most part, only a small number of elements. Many consist only of carbon and hydrogen. A very large number, including most of those which occur ready-formed in the bodies of plants and animals, consist of carbon, hydrogen, and oxygen; others consist of carbon, hydrogen, and nitrogen. Others, again, including most of the proximate principles of the animal organism, consist of four elements, carbon, hydrogen, oxygen, and nitrogen. Some contain sulphur, phosphorus, chlorine, and metallic elements; in fact, artificially prepared carbon compounds may contain any elements whatever. Moreover, even those which contain only a small number of elements often exhibit great complexity of structure, in consequence of the accumulation of a large number of carbon-atoms in the same molecule.

DETERMINATION OF CARBON AND HYDROGEN.

The quantities of these elements are determined by heating a known weight of the body to be analyzed in contact with some easily-reducible metallic oxide, black oxide of copper being the substance generally used. The organic body then undergoes complete combustion at the expense of the oxygen of the cupric oxide, the carbon being completely converted into carbonic oxide, and the hydrogen into water. These products are collected and their weights determined, and from the data thus obtained the quantities of carbon and hydrogen present in the organic substance are calculated. When nothing but carbon and hydrogen, or those bodies together with oxygen, is present, one experiment suffices; the carbon and hydrogen are determined directly, and the oxygen by difference.

FIG. 1.



The substance to be analyzed, if solid, must be carefully freed from moisture. If it will bear the application of a moderate heat, this desiccation is very easily accomplished by a water or steam bath; in other cases, exposure at common temperatures to the absorbent powers of a large surface of oil of vitriol in the vacuum of an air-pump must be substituted.

The dried powder is weighed in a narrow open tube, about 2½ or 3 inches long; the tube and substance are weighed together, and, when the latter has been removed, the tube with any little adherent matter is re-weighed. This weight, subtracted from the former, gives the weight of the substance employed in the experiment. As only half a gram (5 or 6 grains) is used, the weighings should not involve a greater error than a milligram (or $\frac{1}{200}$ part of a grain).

The cupric oxide is best made from the nitrate by complete ignition in an earthen crucible; it is reduced to a powder and reheated just before use, to expel hydroscopic moisture, which it absorbs, even while warm, with avidity. The combustion is performed in a tube of hard, white Bohemian glass, having a diameter of 0.4 or 0.5 inch, and varying in length from 14 to 18 inches; this kind of glass bears a moderate red heat without becoming soft enough to lose its shape. One end of the tube is drawn out to a point, as shown in the figure, and closed; the other is simply heated, to fuse and soften the sharp edges of the glass.

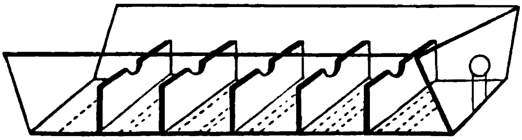
The tube is now two-thirds filled with the yet warm cupric oxide, nearly the whole of which is transferred to a small por-

FIG. 2.

celain or Wedgwood mortar, and very intimately mixed with the organic substance. The mixture is then transferred to the tube, and the mortar rinsed with a little fresh and hot oxide, which is added to the rest; the tube is lastly filled to within an inch of the open end with oxide from the crucible. A few gentle taps on the table suffice to shake together the contents, so as to leave a free passage for the evolved gases from end to end. The arrangement of the mixture and the oxide in the tube is represented in the above figure.

The tube is then ready to be placed in the furnace or chauffer; this, when charcoal is the fuel employed, is constructed of thin sheet-iron, and is furnished with a series of supports of equal height, which serve to prevent flexure of the combustion-tube when softened by heat. The chauffer is placed upon flat bricks or a piece of stone, so that but little air can enter the grating, unless the whole be purposely raised. A slight inclination is also given towards the extremity occupied by the mouth of the combustion-tube, which passes through a hole provided for the purpose.

FIG. 3.



To collect the water produced in the experiment, a small light tube of the form represented in Fig. 4, or a U-tube, as in Fig. 7, filled with fragments of spongy calcic chloride, is attached by a perforated cork, thoroughly dried, to the open extremity of the combustion-tube. The carbonic oxide is absorbed by a solution of potassic hydrate, of specific gravity 1.27, which is contained in a small glass apparatus on the principle of a Woulfe's bottle, shown in Fig. 5. The connection between the latter and the calcic-chloride tube is completed by a little tube of caoutchouc, secured with silk cord. The whole is shown in Fig. 6, as arranged for use. Both the calcic-chloride tube and the potash apparatus are weighed with the utmost care before the experiment.

Fig. 4.

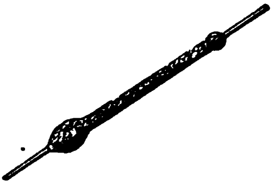


Fig. 5.

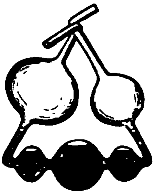
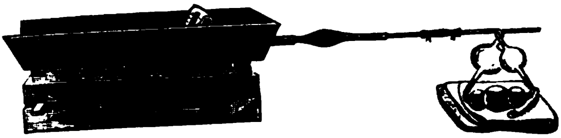


Fig. 6.

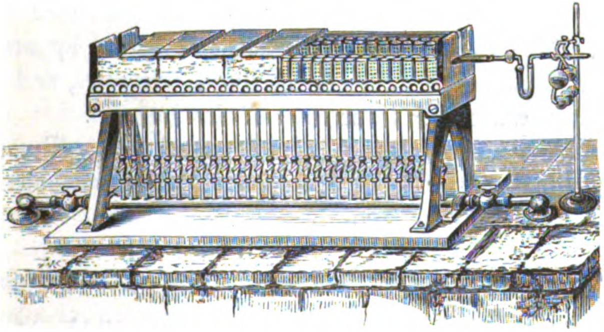


DRAWING OF THE WHOLE ARRANGEMENT.

The tightness of the junctions may be ascertained by slightly rarefying the included air by sucking a few bubbles from the interior through the liquid, using the dry lips, or, better, a little bent tube with a perforated cork; if the difference of level in the liquid in the two limbs of the potash-apparatus be preserved for several minutes, the joints are perfect. Red-hot charcoal is now placed around the anterior portion of the combustion-tube, containing the pure cupric oxide; and when this is red-hot, the fire is slowly extended towards the farther extremity by shifting the movable screen represented in the drawing. The experiment must be so conducted, that a uniform stream of carbonic oxide shall enter the potash-apparatus by bubbles which may be easily counted; when no nitrogen is present, these bubbles are, towards the termination of the experiment, almost completely absorbed by the alkaline liquid, the little residue of air alone escaping. In the case of an azotized body, on the contrary, bubbles of nitrogen gas pass through the potash-solution during the whole process.

When the tube has been completely heated from end to end, and no more gas is disengaged, but, on the other hand, absorption begins to be evident, the coals are removed from the farthest extremity of the combustion-tube, and the point of the latter broken off. A little air is drawn through the whole apparatus, by which the remaining carbonic oxide and watery vapor are secured. The parts are, lastly, detached, and the calcic-chloride tube and potash-apparatus re-weighed.

FIG. 7.



The mode of heating the combustion-tube with red-hot charcoal is the original process, and still extensively employed, the construction of the furnace being most simple, and charcoal everywhere accessible. But since the use of coal gas has been universally adopted in laboratories, many contrivances have been suggested, by means of which this convenient fuel may

FIG. 8.

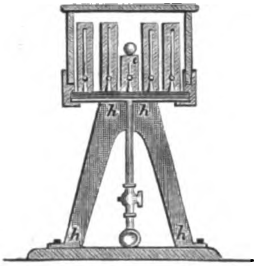
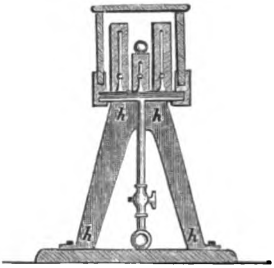


FIG. 9.



be employed also in organic analysis. An apparatus of this kind* is the one represented in Fig. 7, in which the combustion-tube is heated by a series of perforated clay burners. These are fixed on pipes provided with stopcocks, so that the gas may be lighted according to the requirements of the case. The stopcocks being appropriately adjusted, the gas burns on the surface of the burners with a smokeless blue flame, which renders them in a short time incandescent. The construction of this furnace is readily intelligible by a glance at Figs. 8 and 9, which exhibit the different parts of the apparatus in section, Fig. 8 representing furnace with five rows, and Fig. 9 a smaller furnace with three rows of clay burners.

The following account of a real experiment will serve to illustrate the calculation of the result obtained in the combustion of crystallized sugar:

Quantity of sugar employed	4.750	grains.
Potash-apparatus weighed after experiment..	781.13	"
" " " before " ..	773.82	"
Carbon dioxide	7.31	"
Calcium-chloride tube after experiment......	226.05	"
" " " before "	223.30	"
Water	2.75	"

---

* Hoffmann, Journal of Chemical Society, vol. xi, p. 30.

7.31 gr. carbon dioxide = 1.994 gr. carbon; 2.75 gr. water = 0.3056 gr. hydrogen; or, in 100 parts sugar,*

Carbon	41.98
Hydrogen	6.48
Oxygen by difference	51.59
	100.00

When the organic substance cannot be mixed with cupric oxide in the manner described, the process must be slightly modified. If, for example, a volatile liquid is to be examined, it is inclosed in a little glass bulb with a narrow stem, which is weighed before and after the introduction of the liquid, the point being hermetically sealed. The combustion-tube must have, in this case, a much greater length; and as the cupric oxide cannot be introduced hot, it must be ignited and cooled out of contact with the air, to prevent absorption of watery vapor. This is most conveniently effected by transferring it, in a heated state, to a large platinum crucible to which a closely-fitting cover can be adapted. When quite cold, the cover is removed, and instantly replaced by a dry glass funnel, by the assistance of which the oxide may be directly poured into the combustion-tube with merely momentary exposure to the air. A little oxide is put in, then the bulb, with its stem broken at *a*, a file-scratch having been previously made; and lastly, the tube is filled with the cold and dry cupric oxide.

It is arranged in the chauffer, the calcic-chloride tube and potash-apparatus adjusted, and then some six or eight inches of oxide having been heated to redness, the liquid in the bulb is, by the approximation of a hot coal, expelled, and slowly converted into vapor, which, in passing over the hot oxide, is completely burned. The experiment is then terminated in the usual manner.

---

* The theoretical composition of sugar, $C_{12}H_{22}O_{11}$, reckoned to 100 parts, gives:

Carbon	42.11
Hydrogen	6.43
Oxygen	51.46
	100.00

FIG. 10.

Fusible fatty and wavy substances, and volatile concrete bodies, as camphor, are placed in little boats of glass or platinum.

Cupric oxide, which has been used, may be easily restored by moistening with nitric acid and igniting to redness; it becomes, in fact, rather improved than otherwise, as, after frequent employment, its density is increased, and its troublesome hygroscopic powers diminished.

For substances which are very difficult of combustion, from the large proportion of carbon which they contain, and for compounds into which chlorine enters as a constituent, fused and powdered lead chromate is very advantageously substituted for the cupric oxide. Plumbic chromate freely gives up oxygen to combustible matters, and even evolves, when strongly heated, a little of that gas, which thus ensures the perfect combustion of the organic body.

ANALYSIS OF AZOTIZED SUBSTANCES.

The presence of nitrogen in an organic compound is easily ascertained by heating a small portion with solid potassic hydrate in a test-tube; the nitrogen, if present, is converted into ammonia, which may be recognized by its odor and alkaline reaction.

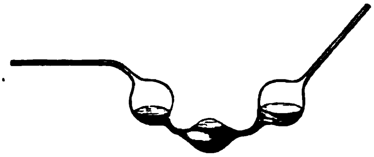
In determining the carbon and hydrogen in such bodies, by combustion with cupric oxide, as above described, a longer tube than usual must be employed, and four or five inches of its anterior position filled with copper turnings rendered perfectly metallic by ignition in hydrogen.

This serves to decompose any nitrogen oxides formed in the process of combustion, which, if suffered to pass off undecomposed, would be absorbed by the potash, and vitiate the determination of the carbon.

The nitrogen may be estimated either by converting it into ammonia, by igniting the substance with an alkaline hydrate, as above mentioned, or by evolving it in the free state and measuring its volume.

1. By *conversion into ammonia:* Will and Varrentrapp's method.—An intimate mixture is made of 1 part sodic oxide and 2 or 3 parts quicklime, by slaking lime of good quality with the proper proportion of strong sodic oxide, drying the mixture in an iron vessel, and then heating it to redness in an earthen crucible. The ignited mass is rubbed to powder in a warm mortar, and carefully preserved from the air. The lime is useful in many ways; it diminishes the tendency of the alkali to deliquesce, facilitates mixture with the organic substance, and prevents fusion and liquefaction. A proper quantity of the substance to be analyzed, namely, from 5 to 10 grains, is dried and accurately weighed out; this is mixed in a warm porcelain mortar with enough of the soda-lime to fill two-thirds of an ordinary combustion-tube, the mortar being rinsed with a little more of the alkaline mixture, and, lastly, with a small quantity of powdered glass, which completely removes everything adherent to its surface; the tube is then filled to within an inch of the open end with the lime-mixture, and arranged in a chauffer in the usual manner. The ammonia is collected in a little apparatus of three bulbs (Fig. 11), containing moderately strong hydrochloric acid, attached by a cork to the combustion-tube. Matters being thus adjusted, fire is applied to the tube commencing with the anterior extremity. When it is ignited throughout its whole length, and when no gas issues from the apparatus, the point of the tube is broken, and a little air drawn through the whole. The acid liquid is then emptied into a capsule, the bulbs rinsed into the same, first with a little alcohol, and then repeatedly with

FIG. 11.



distilled water; an excess of pure platinic chloride is added; and the whole evaporated to dryness in a water-bath. The dry mass, when cold, is treated with a mixture of alcohol and ether, which dissolves out the superfluous platinic chloride, but leaves untouched the yellow crystalline ammonic chloroplatinate. The latter is collected upon a small weighed filter, washed with the same mixture of alcohol and ether, dried at 100°, and weighed; 100 parts correspond to 6.272 parts of nitrogen. Or, the salt with its filter may be very carefully ignited, the filter burned in a platinum crucible, and the nitrogen reckoned from the weight of the spongy metal, 100 parts of that substance corresponding to 14.18 parts nitrogen. The former plan is to be preferred in most cases.

Bodies very rich in nitrogen, as urea, must be mixed with about an equal quantity of pure sugar, to furnish incondensable gas, and then diminish the violence of the absorption which otherwise occurs; and the same precaution must be taken, for a different reason, with those which contain little or no hydrogen.

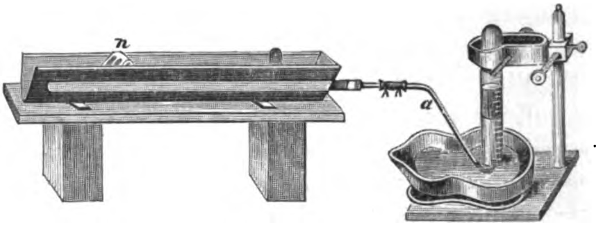
A modification of this process has been suggested by Peligot, which is very convenient if a large number of nitrogen-determination is to be made. By this plan, the ammonia, instead of being received in hydrochloric acid, is conducted into a known volume (one-half to one cubic inch) of a standard solution of sulphuric acid contained in the ordinary nitrogen-bulbs. After the combustion is finished, the acid containing the ammonia is poured out into a beaker, colored with a drop of tincture of litmus, and then neutralized with a standard solution of soda in water, or of lime in sugar-water, the point of neutralization becoming perceptible by the sudden appearance of a blue tint. The lime solution is conveniently poured out from an alkalimeter. The volume of lime-solution necessary to neutralize the same amount of acid that is used for condensing the ammonia, having been ascertained by a preliminary experiment, it is evident that the difference of the quantities used in the two experiments gives the ammonia collected in the acid during the combustion. The amount of nitrogen may thus be calculated.

If, for instance, an acid be prepared containing 20 grams of pure hydrogen sulphate (H_2SO_4) in 1000 grain-measures, then 200 grain-measures of this acid, the quantity introduced into the bulbs, will correspond to 1.38 grains of ammonia, or 1.14 grains of nitrogen. The alkaline solution is so graduated that 1000 grain-measures will exactly neutralize the 200 grain-measures of the standard acid. If we now find that the acid, partly saturated with the ammonia disengaged during the combustion of a nitrogenous substance, requires only 700 grain-measures of the alkaline solution, it is evident that $\frac{200 \times 300}{1000}$ $= 60$ grain-measures were saturated by the ammonia, and the quantity of nitrogen is obtained by the proportion, $200 : 1.14 = 60 : x$, wherefore $x = \frac{1.14 \times 60}{200} = 0.342$ grains of nitrogen.

2. By *measure as free nitrogen.*—When the nitrogen exists in the organic substance in the form of an oxide, as in nitrobenzine, $C_6H_5(NO_2)$, ethyl nitrate, $C_2H_5(NO)O$, etc., the preceding method cannot be employed, because these nitrogen oxides are not completely converted into ammonia by heating with alkaline hydrates: it fails also in the case of certain organic bases. In such cases the nitrogen must be evolved in the free state by heating the organic body with cupric oxide, and its volume determined by collecting it over mercury in a graduated jar. There are several ways of effecting this: the one most frequently employed is that of Dumas, as simplified by Melseus:

A tube of Bohemian glass, 28 inches long, is securely sealed at one end; into this enough dry hydrosodic carbonate is put to occupy 6 inches. A little pure copper oxide is next introduced, and afterwards the mixture of oxide and organic substance; the weight of the latter, between 4.5 and 9 grains, in a dry state, having been correctly determined. The remainder of the tube, amounting to nearly one-half of its length, is then filled up with pure cupric oxide and spongy metal, and a round cork, perforated by a piece of narrow tube, is securely adapted to its mouth. This tube is connected by means of a caoutchouc joint with a bent delivery-tube, *a*, and the combustion-tube is arranged in the furnace. A few coals are now applied to the farther end of the tube, so as to decompose a portion of the hydrosodic carbonate; the remainder of the carbonate, as well as of the other part of the tube, being protected from the heat by a screen, *n*. The current of carbonic oxide thus produced is intended to expel all the air from the apparatus. In order to ascertain that this object, on which the success of the whole operation depends, is accomplished, the delivery-tube is depressed under the level of a mercurial trough, and the gas which is evolved, collected in a test-tube filled with concentrated potash-solution. If the gas be perfectly absorbed, or, if after the introduction of a considerable quantity only a minute bubble be left, the air may be considered as expelled. The next step is to fill a graduated glass jar two-thirds with mercury and one-third with a strong solution of potash, and to invert it over the delivery-tube, as represented in Fig. 12.

FIG. 12.



This done, fire is applied to the tube, commencing at the front end, and gradually proceeding to the closed extremity, which still contains some undecomposed hydrosodic carbonate. This, when the fire at length reaches it, yields up carbonic oxide, which chases forward the nitrogen lingering in the tube. The carbonic oxide generated during the combustion is wholly absorbed by the potash in the jar, and nothing is left but the nitrogen. When the operation is at an end, the jar with its contents is transferred to a vessel of water, and the volume of the nitrogen read off. This is properly corrected for temperature, pressure, and aqueous vapor, and its weight determined by calculation. When the operation has been very successful, and all precautions minutely observed, the result still leaves an error in excess, amounting to 0.3 or 0.5 per cent, due to the residual air of the apparatus, or that condensed in the pores of the cupric oxide.

A modification of the process, by which this error is considerably diminished, has been devised by Dr. Maxwell Simpson.*

The method just described is applicable to the estimation of nitrogen in the oxides and oxygen-acids of nitrogen, in metallic nitrates and nitrites, and, in fact, to the analysis of all nitrogenous bodies whatever.

ANALYSIS OF CHLORINATED COMPOUNDS.

The case of a volatile liquid containing chlorine is of very frequent occurrence, and may be taken as an illustration of the general plan of proceeding. The combustion with cupric oxide must be very carefully conducted, and two or three inches of the anterior portion of the tube kept cool enough to prevent volatilization of the cupric chloride into the calcic-chloride tube. Plumbic chromate is much better for the purpose.

The chlorine is correctly determined by placing a small

---

* Quarterly Journal of the Chemical Society, vi, 299.

weighed bulb of liquid in a combustion-tube, which is afterwards filled with fragments of pure quicklime. The lime is brought to a red heat, and the vapor of the liquid driven over it, when the chlorine displaces oxygen from the lime, and gives rise to calcic chloride. When cold, the contents of the tube are dissolved in dilute nitric acid, the liquid is filtered, and the chlorine precipitated by silver nitrate.

Bromine and iodine are estimated in a similar manner.

ANALYSIS OF ORGANIC COMPOUNDS CONTAINING SULPHUR.

When a body of this nature is burned with cupric oxide, a small tube containing plumbic oxide may be interposed between the calcic-chloride tube and the potash apparatus, to retain any sulphurous acid that may be formed. It is better, however, to use plumbic chromate in such cases. The proportion of sulphur is determined by oxidizing a known weight of the substance with strong nitric acid, or by fusion in a silver vessel with ten or twelve times its weight of pure potassic hydrate and half as much nitre. The sulphur is thus converted into sulphuric acid, the quantity of which can be determined by dissolving the fused mass in water, acidulating with nitric acid, and adding a barium salt. Phosphorus is, in like manner, oxidized to phosphoric acid, the quantity of which is determined by precipitation as ammonic-dimagnesic phosphate, or otherwise.

EMPIRICAL AND MOLECULAR FORMULÆ.

A chemical formula is termed *empirical* when it merely gives the simplest possible expression of the composition of the substance to which it refers. A *molecular* formula, on the contrary, expresses the absolute number of atoms of each of its elements supposed to be contained in the molecule, as well as mere numerical relations existing between them. The empirical formula is at once deduced from the analysis of the substance, reckoned to 100 parts.

The case of sugar already cited, may be taken as an example.

This substance gives by analysis:

Carbon	41.98
Hydrogen	6.43
Oxygen	51.59
	100.00

If each of these quantities be divided by the atomic weight of the corresponding element, the quotient will express the relations existing between the numbers of atoms of the three elements; these are afterwards reduced to their simplest expression.

This is the only part of the calculation attended with any difficulty. If the members were rigidly correct, it would only be necessary to divide each by the greatest divisor common to the whole; but as they are only approximative, something is of necessity left to the judgment of the experimenter.

In the case of sugar, we have

$$\frac{41.98}{12} = 3.50; \ \frac{6.43}{1} = 6.43; \ \frac{51.59}{16} = 3.42,$$

or 350 atoms carbon, 643 atoms hydrogen, and 342 atoms oxygen. Now it is evident, in the first place, that the hydrogen and oxygen are present nearly in the proportion to form water, or twice as many atoms of the former as of the latter. Again, the atoms of carbon and hydrogen are nearly in the proportion of 12 : 22, so that the formula $C_{12}H_{22}$, O_{11} appears likely to be correct. It is now easy to see how far this is admissible, by reckoning it back to 100 parts, comparing the results with the number given by the actual analysis, and observing whether the difference falls fairly, in direction and amount, within the limits of error of what may be termed a good experiment, viz.: two or three tenths per cent. deficiency in the carbon, and not more than one-tenth or two-tenths per cent. excess in the hydrogen:

Carbon	$12 \times 12 = 144$
Hydrogen	$1 \times 22 = 22$
Oxygen	$16 \times 11 = 176$
	342

$342 : 144 = 100 : 42.11$

$342 : 22 = 100 : 6.43$

$342 : 176 = 100 : 51.46$

To determine the molecular formula, several considerations must be taken into account—namely, the combining or saturating power of the compound; if it is acid or basic, the number of atoms of any one of its elements (generally hydrogen) which may be replaced by other elements; the law of even numbers, which requires that the sum of the numbers of atoms of all the perissad elements (hydrogen, nitrogen, chlorine, etc.) contained in the compound shall be divisible by 2; and the vapor-density of the compound (if it be volatile without decomposition), which, in normally constituted compounds, is always half the molecular weight.

The molecular formula may either coincide with the empirical formula, or it may be a multiple of the latter. Thus, the composition of acetic acid is expressed by the formula CH_2O, which exhibits the simplest relations of the three elements; but if we want to express the quantities of these, in atoms, required to make up a molecule of acetic acid, we have to adopt the formula $C_2H_4O_2$; for only one-fourth of the hydrogen in this acid is replaceable by metals to form salts, $C_2H_3KO_2$, for example; and its vapor-density, compared with hydrogen, is nearly 30, which is half the weight of the molecule, $C_2H_4O_2 = 2 . 12 + 4 . 1 + 2 . 16$. Again, the empirical formula of benzine is CH; but this contains an uneven number of hydrogen atoms; moreover, if it expressed the weight of the molecule of benzine, the vapor-density of that compound should be $\frac{12 + 1}{2} = 6.5$, whereas experiment shows that it is six times as great, or equal to 39; hence the molecular formula of benzine is C_6H_6.

Organic acids and salt-radicals have their molecular weights most frequently determined by an analysis of their lead and silver salts, by burning these latter with suitable precautions in a thin porcelain capsule, and noting the weight of the lead oxide or metallic silver left behind. If the lead oxide be mixed with globules of reduced metal, the quantity of the latter must be ascertained by dissolving away the oxide with acetic acid. Or the lead salt may be converted into sulphate, and the silver compound into chloride, and both metals thus estimated. An organic base, on the contrary, has its molecular weight fixed by observation of the quantity of a mineral acid or organic salt-radical, required to form with it in compound having the characters of neutrality.

It is scarcely necessary to observe that the methods just described for determining the empirical and molecular formula of an organic compound from the results of its analysis, together with its physical properties and chemical reactions, are equally applicable to inorganic compounds.

SCHEME FOR THE ANALYSIS OF BLOOD.

(STRECKER HANDW. D. CHEM., ii [2], 115.)

WATER DETERMINATION.—Evaporate a weighed quantity; dry the residue at 120°–130° C., and weigh.

FIBRINE DETERMINATION.—The blood, as it runs from a vein, is received in a tared vessel, and stirred from five to ten minutes with a glass rod, the weight of which is included in the tare, till the fibrine is completely separated. The blood, together with the separated fibrine, is then weighed, strained through linen, and the fibrine which remains thereon is placed for some time in water, then dried, well boiled with alcohol and ether, to free it from fat, and weighed after drying at 120° C. (Bacquerel and Rodier.)

ESTIMATION OF ALBUMEN AND OTHER MATTERS COAGULABLE BY HEAT.—A weighed quantity of blood, slightly acidulated with acetic acid, is added by drops to boiling water, the liquid is poured through a weighed filter, and the coagulum collected thereon; it is then washed on the filter with boiling water, and dried, first at a gentle heat, afterwards at 120° to 130° C. The residue may be freed from fat by treatment with boiling ether. If the blood had not been previously freed from fibrine, the weight of that substance, determined as above, must be deducted from the total weight of the coagulum.

Estimation of the Extractive Matter.—The filtrate obtained in the last determination is evaporated on a water-bath in a tared platinum basin, the residue dried at 120° C., weighed, and burnt in a muffle at as low a heat as possible. The weight of the ash, deducted from that of the total dried residue, gives approximately the amount of extractive matter.

Estimation of Fat.—A quantity of blood (which need not be weighed) is dried at 100° C.; the residue is pulverized and dried at 120° C., and a weighed portion thereof is treated with ether in a flask; the ether is passed through a small filter into a tared platinum capsule; and the treatment of the residue with ether is repeated several times. The collected ethereal solution is carefully evaporated, and the residue dried at 100° C. As the weight of the solid constituents of the blood have been previously determined, the quantity of blood from which this fat has been obtained may be calculated from that of the residue which was subjected to treatment with ether.

Estimation of Mineral Constituents.—A weighed quantity of the blood is dried, mixed with ignited sodic carbonate, then dried and incinerated in the muffle at the lowest possible temperature, then treated according to scheme for the analysis of ash.

Separate Estimation of the Serum and Coagulum, with their Constituents.—The fresh blood is collected in a tared cylindrical vessel, having a ground edge, and not too shallow; it is covered with a glass plate and left to stand till the coagulation is complete, after which the edge of the clot is detached from the sides of the vessel by means of a needle. The blood is then weighed, and after the clot has contracted as much as possible, the serum is poured off, and the quantity of albumen, etc., contained in it is determined as above described. The clot and the inner surface of the vessel are then freed from serum as completely as possible by wiping with bibulous paper, and the clot is weighed on the vessel. This weight deducted from the total weight of the blood, gives the *proportion of serum.*

The clot contains the blood-corpuscles, the fibrine, and a certain quantity of serum; the amount of water contained in it may be determined by drying at 120° to 130° C.; but there is no known method of directly estimating the amount of the blood-corpuscles. Prevost and Dumas estimated it approximately, on the assumption that the water contained in the clot is all due to adhering serum, and accordingly deducted from the weight of the dried clot an amount of serum-constituents corresponding to the quantity of water in the clot, together with the amount of fibrine separately determined. As, however, the blood-corpuscles themselves contain water, this method necessarily makes the quantity of dried corpuscles too small.

The separation of hematin from globulin cannot be effected; but if the quantity of iron in the dried coagulum be determined, the amount of blood pigment may be calculated on the supposition that this pigment contains 6.64 per cent. of iron. (See Analysis of Man.)

SCHEME FOR THE ANALYSIS OF URINE.*

The following method is designed more particularly for the analysis of the urine of herbivorous animals, but it may be applied in the examination of that of carnivorous animals and man also.

Specific Gravity. — Determine this by comparing the weights of equal volumes of the urine and of water, or with the urometer, a species of hydrometer constructed expressly for this purpose; when this instrument is used, all foam must be carefully removed from the surface of the liquid by filter-paper.

A difference of 4° C. in the temperature of the liquid usually makes a difference of about 1° in the reading of the urometer.

The specific gravity of urine ranges between 1.01 and 1.04.

1. Total Amount of Dry Substance in Solution.—Determine this by evaporating a weighed quantity in a current of dry hydrogen in such a manner as to estimate the ammonia that is expelled at the same time. Take 4–6 c.c. of the urine, accurately weighed; the evaporation to dryness is completed in 4–5 hours.

In human urine, that has an acid reaction due to acid sodic phosphate, the ammonia may be assumed to have been driven from urea, and by multiplying the amount of it by 1.765 the corresponding amount of urea will be obtained. But in the urine of herbivorous animals, the ammonia resulting from *this* decomposition must be estimated by the difference between the ammonia set free on evaporation to dryness and that found in the urine by direct determination. Generally, however,

---

* Taken from Agric. Chem. Anal. Caldwell.

these quantities of ammonia are very small, and can be left out of consideration.

2. The NON-VOLATILE MATTER in this residue left on evaporation, is determined by evaporating a fresh quantity of 100 c.c. of the urine in a platinum dish, and igniting the residue; determine carbonic acid in the ash.

3. CARBONIC ACID (free and combined).—Determine this in two portions of 100 c.c. of the fresh urine. To one portion add baric chloride containing ammonic hydrate in excess, and to the other baric chloride alone; heat both mixtures nearly to boiling; collect the precipitates on dried and weighed filters; wash, and dry them at 100°; weigh, and determine carbonic acid in 1–2 grams of each precipitate; the first precipitate contains the total carbonic acid, the second only the combined.

4. NITROGEN.—The residue left from (1) may be used for the determination of nitrogen, or another portion of 5–10 c.c. of the urine may be acidified with oxalic acid, mixed with ignited gypsum, and evaporated to dryness. In the former case this second residue will contain only so much of the nitrogen as was not expelled in the form of ammonia during the desiccation; in the latter, the oxalic acid will prevent the escape of any nitrogen as ammonia. The dry substance may be completely rinsed off the sides of the dish with some of the soda-lime used in the combustion.

Or, this method of Voit may be used: Weigh out about 5 c.c. of the urine; mix it in a shallow dish with a sufficient quantity of fine quartz-sand to absorb it all; put the dish under the receiver of an air-pump, and exhaust the air; the whole becomes quite dry in a few hours and may be pulverized easily, and completely loosened from the sides of the dish and mixed with the soda-lime.

The combustion may be performed in a short combustion-tube, and very rapidly, without fear of losing any of the ammonia.

5. ACTUAL AMMONIA.—Determine this by Schlössug's method in 20 c.c. of the urine, after filtration to remove slimy or sedimentary matters. In the fresh urine of horned cattle, the actual ammonia does not amount to more than 0.009–0.01 per cent., but in human urine it ranges as high as 0.078–0.143 per cent.

6. COMPLETE ANALYSIS OF THE ASH.—Evaporate 200–500 grams of the urine to dryness; incinerate the residue, and examine the ash for its constituents in the usual manner. The ash of the urine of herbivorous animals is poor in alkaline earths, and 8–10 grams will be required for their determination. In the urine of ruminants, phosphoric acid is found in hardly determinable quantity; while in that of swine, and often of calves, it is present in large quantity and should be estimated.

7. CHLORINE AND UREA.—These are determined with the aid of the standard solution of mercuric nitrate. The urine must first be freed from phosphoric and hippuric acids. Acidify 200 c.c. with nitric acid; boil the mixture to expel the carbonic acid; neutralize the nitric acid with freshly ignited magnesia, and cool the liquid to the temperature of the room, by immersing the flask in cold water; transfer the liquid to a graduated cylinder, rinse the flask into the cylinder and bring the volume of its contents to 220 c.c.; add 30 c.c. of an aqueous solution of ferric nitrate of such a degree of concentration that, with this quantity of the solution added, the salt will be slightly in excess; the excess may be recognized by a weak reaction of the solution on a slip of filter-paper soaked in a dilute solution of potassic ferrocyanide; too large an excess of the ferric salt will be indicated by a re-solution of the precipitate that was formed at first on its addition; filter the liquid immediately through a large, dry, ribbed filter, and to 150 c.c.

of the filtrate add 50 c.c. of a solution of baryta mixed with a little calcined magnesia; filter again, and for each determination of sodic chloride and urea take 15 c.c. of this filtrate, corresponding to 9 c.c. of urine.

(*a.*) *Chlorine* (common salt).—Acidify exactly 15 c.c. of the liquid with a drop of nitric acid, and allow the standard solution of mercuric nitrate to flow in from the burette, with constant stirring, until a permanent turbidity appears. A mere opalescent appearance of the liquid, which may be presented even in the beginning, is easily distinguished from the cloudy turbidity which is the real indication of saturation. Estimate the amount of sodic chloride, or of chlorine, on the basis of the standard of the solution already determined.

(*b.*) *Urea.*—In a second portion of 15 c.c. of the liquid, proceed to determine urea with the same standard solution. Subtract from the total amount of solution required, the amount used in one; and also make the correction required for dilution of the solution.

8. HIPPURIC ACID.—Evaporate 200 c.c. of the urine down to 50 c.c., and precipitate the acid with hydrochloric acid, etc. It may be well to first digest the urine with animal charcoal in the proportion of two grams of charcoal to 10 c.c. of the liquid, in order to decolorize it.

There are usually only traces of uric acid in the urine of herbivora, and it cannot be estimated; but in the urine of carnivora the proportion of uric acid generally exceeds that of the hippuric.

According to the process of Meissner and Shepard, for separating these two acids, evaporate the urine until it begins to crystallize; add so much absolute alcohol to the hot liquid that a further addition causes no more precipitation; let the mixture cool, and filter it; the best absolute alcohol must be used, and it must not be spared, else succinic acid may remain in solution with the hippuric and cause trouble. Evaporate the alcoholic solution, at first in a flask on the water-bath, until *all* the alcohol and the water are expelled and only a brown syrup remains, that solidifies to a crystalline mass on cooling; extract this mass, while yet warm and liquid, with ether and a few drops of hydrochloric acid added after the ether; agitate the mixture violently, and repeat the process two or three times with fresh portions of ether. If the alcohol and water were not carefully removed in the preceding evaporation, some of the urea will pass into this ethereal solution. Collect the ethereal extracts, distil off most of the ether, and let the rest evaporate spontaneously in the air.

Hippuric acid appears then in the form of handsome crystals. If the crystals are not colorless, or they are not readily formed, dilute the residue, left by the evaporation of the ether, with water, boil the mixture with lime-water, filter, concentrate the colorless filtrate, and precipitate the hippuric acid by hydrochloric acid in excess.

9. Phosphoric Acid.—(*a*.) This may be determined directly in the urine, with the standard uranic solution. Filter the urine, if necessary, add 5 c.c. of sodic acetate to 50 c.c. of the filtrate, and titrate the mixture with uranic acetate.

(*b*.) To obtain a more accurate determination, add the magnesia mixture to 50 c.c. of the clear urine, collect and wash the precipitate in the usual manner, dissolve it, without drying, in acetic acid in not to great excess, dilute the solution to 50 c.c. with water, add 5 c.c. of the solution of sodic acetate, and titrate as before with the uranic solution.

(*c*.) To determine the phosphoric acid that is combined with alkaline earths only to 100–200 c.c. of the urine, according to its strength, add ammonic hydrate until alkaline reaction ensues, let the mixture stand twelve hours, and collect and treat the precipitate in the manner described in (*b*). In another precisely equal quantity of urine, the precipitate by ammonic hydrate is ignited and weighed; the amount of magnesic pyrophosphate in this mixture may be estimated by multiplying the amount of phosphoric acid in it, as determined above, by 2.1831, subtracting the sum of the phosphates from this product, and multiplying the remainder by 2.5227. If it is desired to determine lime and magnesia directly, dissolve the mixture of the phosphates, obtained above by precipitating with ammonic hydrate, without drying it, in as small a quantity of acetic acid as possible; precipitate the lime by ammonic oxalate, and the magnesia as phosphate again by excess of ammonic hydrate.

10. Sulphuric Acid.—Heat 50–100 c.c. of the urine, add some nitric acid, and then baric chloride in slight excess.

11. Sulphur.—To determine the total sulphur, mix 50 c.c. of the urine in a silver crucible with solid potassic oxide and a little saltpetre; evaporate the mixture cautiously to dryness, ignite the residue strongly until it is quite white, exhaust it with water, and determine sulphuric acid in the filtered solution, in the usual manner.

12. Carbon and Hydrogen.—Absorb 10 c.c. of the urine by fine quartz-sand that has been previously boiled with acid, washed and ignited, dry the mixture, and burn it with plumbic chromate.

The following is an analysis of healthy urine, by Marchand:

Water	933.199
Urea	32.675
Uric acid	1.065
Lactic acid	1.521
Extractive matters	11.151
Mucus	0.283
Potassic sulphate	3 587
Sodic sulphate	3.213
Ammonic diphosphate	1.552
Sodic chloride	4.218
Ammonic chloride	1.652
Calcic and magnesic phosphate	1.210
Lactates	1.618
	1000.000

The following analyses are by Vernois and Becquerel, showing the comparative composition of male and female urine:

CONSTITUENTS.	MEAN COMPOSITION OF THE URINE OF FOUR HEALTHY MEN.	MEAN COMPOSITION OF THE URINE OF FOUR HEALTHY WOMEN.	GENERAL MEAN.
Specific gravity	1.0189	1.01512	1.01701
Water	968.815	975.052	971.935
Solid constituents	31.185	24.948	28.066
Urea	13.838	10.366	12.102
Uric acid	0.391	0.406	0.398
Other organic matters	9.261	8.038	8.647
Fixed salts	7.695	6.143	6.919
Consisting of—			
Chlorine	—	—	0.502
Sulphuric acid	—	—	0.855
Phosphoric acid	—	—	0.317
Potassic oxide	—	—	1.300
Sodic, calcic, and magnesic oxide	—	—	3.944

SCHEME FOR THE QUANTITATIVE ANALYSIS OF MILK.

Evaporate to dryness at a gentle heat over a water-bath 5 grams of milk; heat the same in an air-bath to 105° C., until constant weight.

Loss in Weight will equal the Water.	Weight of Residue will equal the Milk-solids.

TREATMENT OF THE MILK SOLIDS.

Moisten with alcohol and disintegrate the mass; then boil with ether two or three times to extract the fat.

Evaporate the *ether-extract* over a water-bath at a moderate heat to expel the ether; transfer to the air-bath and increase the heat to 105° C. to expel any traces of water or alcohol. Weigh the residue, which will equal the FAT. If the first residue, after extracting the fat with ether, be heated to expel any ether and alcohol it may contain, and weighed, the difference in weight of the milk-solids and this weight will equal the *fat* extracted.

Heat the residue, after extracting the fat and evaporating to expel ether, with alcohol (95 per cent.), then add 25 c.c. of boiling water, and filter through a *weighed filter-paper;* filter a little at a time, keeping the remainder hot over a water-bath. When solution is all filtered, wash the casein on the filter-paper with a little boiling water. Add to filtrate five to ten drops of acetic acid, and evaporate to a small volume, by which means all the casein remaining in the filtrate is coagulated; filter through the same filter-paper, and wash the casein again on the filter-paper with hot water.

The filter-paper will then contain the casein and some insoluble salts. Heat in an air-bath until dry. The weight of the same, minus the weight of the filter-paper, will equal the casein and some insoluble salts; ignite and subtract the weight of ash. The remainder will equal the CASEIN.

Evaporate the filtrate from the casein over a water-bath, then heat in the air-bath to constant weight (note the weight). Ignite the dry mass and weigh (note the weight); subtract the last weight from the first, and the remaining weight will equal the MILK-SUGAR.

To determine the *inorganic salts* evaporate to dryness and ignite to constant weight about 5 grams of milk. The weight obtained will equal the inorganic salts.

The following very convenient method for the analysis of milk is adopted by Chandler:

Water is determined by evaporating a weighed portion of milk in a flat platinum dish (about half an inch deep and one and a half inches in diameter) at 212° F. The loss in weight is the WATER. The salts are determined by carefully incinerating the solid residue left after the evaporation of the water. For the determination of the other constituents a platinum dish is nearly filled with pure quartz-sand; the whole weighed; a small quantity of the milk is added, which is at once soaked up by the sand, and the whole again weighed to find the weight of milk taken. The whole is then dried at 212° F., the contents of the dish extracted with anhydrous ether, and again dried; the loss in the weight of sand, etc., indicates the percentage of BUTTER. The butter may be weighed directly by evaporating the ethereal solution in a weighed beaker. The residue, after removing the butter, is washed with warm water, to the first of which a few drops of acetic acid is added to remove the SUGAR. The difference between the original weight of the sand and of the sand and casein indicates the percentage of casein. A correction must be made in the weights of the sugar and casein on account of the salts, which are washed out with the sugar. By evaporating and igniting the sugar solution, the salts washed out will be determined; they must be deducted from the percentage of sugar; the remainder of the salts (ash) must be deducted from the casein.

ANALYSES OF MILK FROM DIFFERENT ANIMALS.

CONSTITUENTS.	*White Woman.* — TIDY.	*Colored Woman.* — MOTT.	*Cow (Average).* — 84 CHEMISTS.	*Mare.* — CAMERON.	*Goat.* — BESANEZ.	*Ewe.* — STAFANELLI.	*Sow.* — CAMERON.	*Canine.* — SZBOTIN.	*Ass.* — VŒLCKER.	*Camel.* — DRAGENDORFF.	*Hippopotamus.* — GUNNING.
Water	87.806	83.34	86.60	90.310	86.36	82.94	81.80	77.26	91.95	86.94	90.43
Milk-solids	12.194	13.66	13.40	9.690	13.64	17.06	18.20	22.74	8.05	13.06	9.57
	100.000	100.00	100.00	100.000	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Fat	4.021	4.03	3.86	1.055	4.36	6.97	6.00	10.64	0.11	2.90	4.51
Casein	3.523	3.32	4.68	1.953	3.36 1.30	5.49	5.30	5.20 3.97	1.82	3.67	4.40
Milk-sugar	4.265	5.71	4.18	6.285	4.00	3.63	6.07	2.49	6.08	5.78	
Inorganic Salts	0.285	0.61	0.68	0.397	0.62	0.97	0.83	0.44	0.34	0.66	0.11
Total	12.094	13.67	13.40	9.690	13.64	17.06	18.20	22.74	8.35	13.01	9.02

The following table contains the average composition of the products obtained from milk in making butter (Alex. Muller):

CONSTITUENTS.	NEW MILK.	SKIMMED MILK.	CREAM.	BUTTER-MILK.	BUTTER.†	BRINE.‡
Fat.................	4.00	0.55	35.00	1.67	85.00	0.00
Albuminoids*........	3.25	3.37	2.20	3.33	0.51	0.39
Milk-Sugar..........	4.50	4.66	3.05	4.61	0.70	3.84
Ash.................	0.75	0.78	0.50	0.77	0.12	0.86
Water...............	87.50	90.64	59.25	89.62	13.67	94.91
Total.........	100.00	100.00	100.00	100.00	100.00	100.00

* Casein and albumen. † Unsalted.

‡ Brine that separates on working after salting; salt not included.

The following table contains analyses of cheese by E. Hornig (1869):

CONSTITUENTS.	DUTCH CHEESE.	RAMADOUX CHEESE.		NEUF-CHATEL CHEESE.	GORGON-ZOLA CHEESE.	BRINGEN OF LIPTACE CHEESE.	SCHWERZ-ENBERG CHEESE.	LIMBURG CHEESE.
Water...............	38.63	56.60	51.21	57.64	36.72	34.08	59.28	49.34
Fatty Matters.......	20.14	17.05	9.16	20.31	33.69	28.04	10.44	20.63
Casein..............	34.90	18.76	33.60	18.51	25.67	23.23	24.09	24.26
Salts...............	6.17	6.78	6.01	3.51	3.71	5.58	6.17	5.45
Loss................	0.13	0.81	0.02	0.04	0.21	0.02	0.02	0.32
	100.00	100.00	100.00	100.00	100 00	100.00	100.00	100.00

The following analyses of cheese are given by Vœlcker:

CONSTITUENTS.	CHESHIRE.	STILTON.	OLD CHEDDAR.	DOUBLE GLOSTER.	SINGLE GLOSTER.	AMERICAN.
Water...........	32.59	20 27	30 32	32.44	28.10	27.29
Butter..........	32.51	43.98	35.53	30.17	33.68	35.41
Caseine.........	26.06	33.55	28.18	31.75	30.31	25.87
Sugar of Milk... Lactic Acid.....	4.53		1.66	1.22	3.72	6.21
Mineral Matter...	4.31	2.20	4.31	4.42	4.19	5.22
	100.00	100.00	100.00	100.00	100.00	100.00
Nitrogen.........	4.17	3.89	4 51	5.12	4.85	4.14
Common Salt.....	1.59	0.29	1.55	1.42	1.12	1.97

The composition of whey is as follows (Vœlcker):

Water	89.65
Butter	0.79
Casein	3.01
Milk-Sugar	5.72
Mineral Salts	0.83
	100.00

The following analyses are by Dr. E. Waller (made in January, 1875):

	American.	Eagle.	New York.	National.
Fat	16.29	14.36	14.28	13.97
Casein	17.26	15.07	13.96	14.02
Sugar	10.64	11.64	13.90	10.44
Salts	2.77	2.10	2.00	2.33
Water	53.04	56.83	55.86	59.24
	100.00	100.00	100.00	100.00

SUGARS AND SOME ALLIED BODIES.

(MILLER.)

VARIETY AND ORIGIN OF SUGAR.	PRINCIPAL PROPERTIES.
Sucrose, or cane-sugar, $C_{12}H_{22}O_{11}$; from sugar-cane.	Crystallizes in four or six-sided rhomboidal prisms, is very soluble in water, less so in diluted alcohol, sp. gr. 1.6, fuses at about 320° F. (160° C.), is not precipitated by subacetate of lead, but is so by an ammoniacal solution of acetate of lead, does not reduce an alkaline solution of potassio cupric tartrate on boiling, produces *right*-handed rotation = 73°.8, undergoes alcoholic fermentation with yeast, combines with alkalies, yields dextrose and levulose when boiled with dilute acids, with nitric acid yields saccharic and oxalic acids.
Inverted cane-sugar, $C_6H_{12}O_6$; from many recent fruits.	Is not crytallizable, is soluble in dilute alcohol, is not precipitated by subacetate of lead, reduces an alkaline solution of potassio-cupric tartrate by boiling, produces *left*-handed rotation = − 26° at 59° F. (15° C.), undergoes alcoholic fermentation with yeast, turns brown when treated with alkalies, is partially converted into grape-sugar by boiling with dilute acids.
Dextrose, or grape-sugar, $C_6H_{12}O_6,H_2O$; from dried fruits, or from starch, altered by acids.	Crystallizes in cubes or square tables, is less soluble in water than cane-sugar, but more soluble in alcohol, yields a precipitate with ammoniacal acetate of lead, reduces potassio-cupric tartrate and the salts of mercury, silver and gold when boiled with them, ferments readily with yeast, produces *right*-handed rotation = 57°.4, becomes brown when treated with alkalies, with nitric acid yields saccharic and oxalic acid.
Lactose, or sugar of milk, $C_{12}H_{22}O_{11},H_2O$; from whey of milk.	Crystallizes in four-sided prisms, is less soluble in water than grape-sugar, is nearly insoluble in alcohol and ether, is precipitated from its solutions by ammoniacal acetate of lead, reduces the salts of copper, silver, and mercury, when its alkaline solution is boiled with them, produces *right*-handed rotation = 56°.4, is not directly susceptible of alcoholic fermentation, is converted into galactose by boiling with dilute acids, yields mucic and oxalic acids with nitric acid.

VARIETY AND ORIGIN OF SUGAR.	PRINCIPAL PROPERTIES.
Trehalose, or mycose, $C_{12}H_{22}O_{11},2H_2O$ (Berthelot); Turkish manna, product of insect *Larinus nidificans.*	Crystallizes in brilliant rectangular octohedra or in rhombic prisms, produces *right*-handed rotation = 220°; if heated quickly it fuses at 212°, and at 266° (130° C.) loses H_2O and becomes solid; may be heated without decomposition to 410° (210° C.), when it melts again; loses its water of crystallization, is very soluble in water, and in hot alcohol, is sparingly soluble in cold alcohol and ether, is precipitated by ammoniacal acetate of lead, does not reduce potassio-cupric tartrate, ferments slowly and imperfectly with yeast, yields dextrose when heated with dilute acids, does not give mucic with nitric acid, but when heated with it yields saccharic and oxalic acids.
Melezitose, $C_{12}H_{22}O_{11},H_2O$ (Berthelot); from larch manna.	Crystallizes in short, hard, efflorescent rhombic prisms, is very soluble in water, sparingly soluble in alcohol, either hot or cold, insoluble in ether, has a sweetness about that of glucose, fuses at 280° (138° C.), is precipitated by ammoniacal acetate of lead, does not reduce the alkaline potassio-cupric tartrate, produces *right*-handed rotation = 94°.1, ferments with difficulty, yields dextrose when heated with dilute acids, gives no mucic acid with nitric acid.
Melitose, $C_{12}H_{24}O_{12}.2H_2O$ (Berthelot); from the *Eucalyptus.*	Crystallizes in slender prisms, is freely soluble in water, slightly soluble in alcohol, is feebly sweet, melts and loses water at 260° (127° C.), yields a precipitate with ammoniacal acetate of lead, does not reduce an alkaline solution of potassio-cupric tartrate, exerts *right*-handed rotation = 102°, undergoes alcoholic fermentation with yeast, at the same time half the sugar is separated in an unfermentable form as eucalin, furnishes mucic acid with nitric acid, is little affected by alkalies.
Eucalin, $C_6H_{12}O_6,H_2O$ (Berthelot); from fermentation of melitose.	Is not crystallizable, precipitates ammoniacal acetate of lead, and reduces the alkaline potassio-cupric tartrate when boiled with it, produces *right* handed rotation = about 50°, is not susceptible of alcoholic fermentation with yeast, becomes brown when treated with alkalies, is not altered by boiling with dilute acids.

Variety and Origin of Sugar.	Principal Properties.
Sorbin, $C_6H_{12}O_6$ (Pelouze); from berries of service tree, *Sorbus aucuparia*.	Crystallizes in octohedra with a rectangular base, is very soluble in water, nearly insoluble in alcohol, sp. gr. 1.65, is fusible without loss of weight, gives a white precipitate with ammoniacal acetate of lead, reduces the alkaline solution of potassio-cupric tartrate on heating it with it, occasions *left*-handed rotation $= -46^c.9$, is not fermentable with yeast, but with cheese and chalk slowly yields lactic and butyric acids and alcohol, becomes brown when treated with alkalies, yields a red solution with oil of vitriol, is converted into oxalic and a little racemic acid by nitric acid.
Inosin, $C_6H_{12}O_6,2H_2O$ (Scherer); from muscular tissue.	Crystallizes in radiated tufts, is soluble in water, insoluble in absolute alcohol and ether, loses water by heat, and fuses at 410° (210° C.), has no rotatory power on polarized light, does not reduce the alkaline potassio-cupric tartrate when boiled with it, is not susceptible of alcoholic fermentation, but with cheese and chalk yields lactic and butyric acids, is not altered by boiling with dilute acids or alkalies, forms a precipitate with ammoniacal acetate of lead.
Mannite, $C_6H_{14}O_6$; from the juice of *Fraxinus ornus*.	Crystallizes in silky anhydrous four-sided prisms, is soluble in water and alcohol, fuses at 320° (160° C.), gives a precipitate with ammoniacal acetate of lead, reduces the salts of silver or gold by heat, does not reduce the alkaline potassio-cupric tartrate when boiled with it, exerts no rotary power on polarized light, is not easily fermentable, with nitric acid yields saccharic and oxalic acids, is soluble without coloration in oil of vitriol, and in alkaline solutions.
Erythrite, $C_4H_{10}O_4$ (V. Luynes); from Roccella and other lichens.	Crystallizes in broad, voluminous crystals of the pyramidal system, is soluble in water and in alcohol, fuses at 248° (120° C.), has no rotatory power, gives no precipitate with ammoniacal acetate of lead, does not reduce the alkaline potassio-cupric tartrate, yields no mucic acid with nitric acid, is not fermentable.

Variety and Origin of Sugar.	Principal Properties.
Dulcite, $C_6H_{14}O_6$ (Laurent); origin unknown.	Crystallizes in brilliant prisms, is soluble in water and in alcohol, fuses at 356° (180° C.), gives no precipitate with acetate or subacetate of lead, does not reduce nitrate of silver or chloride of gold, produces no rotation on polarized light, is not susceptible of fermentation with yeast, is not affected by dilute alkalies, is converted into mucic acid by nitric acid.
Quercite, $C_6H_{12}O_5$; from acorns.	Crystallizes in transparent prisms, is soluble in water and dilute alcohol, is fusible at 420° (215°.5 C.), does not reduce the alkaline potassio-cupric tartrate, is not fermentable by yeast, is soluble without change of color in oil of vitriol and in the alkalies, yields oxalic acid with nitric acid.
Pinite, $C_6H_{12}O_5$ (Berthelot); from *Pinus lambertiana.*	Crystallizes slowly in hard, hemispherical radiated masses, has a very sweet taste, is very soluble in water, is sparingly soluble in alcohol, gives a precipitate with ammoniacal acetate of lead, does not reduce the alkaline potassio-cupric tartrate, sp. gr. 1.52, produces *right*-handed rotation, is not fermentable, fuses below 480° (249° C.), does not yield mucic with nitric acid.

CANE-SUGAR.

Cane-sugar, or sucrose, is the sugar of commerce, and is prepared from the sugar-cane, *Saccharum officinarum*,* which is a plant of the grass species; its stalk is round, knotted, and hollow, and the exterior of a greenish-yellow or blue with sometimes violet streaks.

It grows from 2.6 to 6.6 metres (8.4 to 22.5 ft.) high, and from 4 to 6 centimetres (1.6 to 2.4 inches) in thickness; the interior is cellular. The leaves grow to a length of 1.6 to 2 metres (5.2—6.6 feet), and are ribbed. The plant is grown from seed, and also cultivated from cuttings.

A hectare (2.471 acres English) of land yields of new sugar:

	By 15 Months' Cultivation.		In 1 Year.	
From Martinique	2,500 kilos	(5,510 lbs. Av.)	2,000 kilos	(4,408 lbs. Av.)
" Guadaloupe	3,000 "	(6,612 " ")	2,400 "	(5,289 " ")
" Mauritius	5,000 "	(11,020 " ")	4,000 "	(8,816 " ")
" Brazil	7,500 "	(16,530 " ")	6,000 "	(13,224 " ")

The sugar-cane yields 90 per cent. of juice, containing, according to Péligot, 18 to 20 parts of crystallized sugar. The following analyses are of the components of sugar-cane:

Composition of the Otaheite Cane by Payen:

Water	71.04
Cane-Sugar	18.00
Cellulose, lignite, pectine, and pectic acid	9.56
Albumen and other nitrogenous principles	0.55
Cerosine, wax, fats, resins, coloring matter, essential oils, etc.	0.37
Soluble salts	0.16
Insoluble salts	0.12
Silica	0.20
	100.00

	By PELIGOT. Martinique.	By DUPUY. Guadaloupe.	By ICERY. Mauritius.
Sugar	18.0	17.8	20.0
Water	72.1	72.0	69.0
Cellulose	9.9	9.8	10.0
Salts	—	0.4	0.7–1.2

---

* See Johnson's Cycl., Article "*Sugar*," by C. F. Chandler; also Wagner's Tech., p. 364.

Out of the 18 per cent. of the sugar found in the cane, as a rule not more than 8 per cent. of crystallized sugar can be realized.

The loss may be accounted for thus: 90 per cent. juice is expressed from the cane, from which only about 50 to 60 per cent. can be clarified from the straw, etc.; a fifth part is exhausted by refining; and finally, two-thirds of the sugar is obtained by boiling, while the rest goes to the molasses. The 18 per cent. sugar may be realized in the following manner:

In the refuse sometimes remains	6	per cent.
By skimming	2.5	" "
In the molasses	3.	" "
As raw sugar	6.5	" "
	18	per cent.

Cane-juice from the Canade la tierra in Cuba, when evaporated in vacuo at the atmospheric temperature, yields in 100 parts, according to M. Casacca:

Crystalline white sugar	20.94
Water	78.80
Mineral substances	0.14
Organic matter, different from sugar	0.12
	100.00

In 10 gallons of 231 cu. in. of cane-juice, making 8½° B., there are 5¾ ounces of salts, which consist of:

Potassic sulphate	17.840	grams.
Potassic sulphate	16.028	"
Potassic chloride	8.355	"
Potassic acetate	63.750	"
Calcic acetate	36.010	"
Gelatinous silica	15.270	"
Total	157.253	gr. = 5.57 oz. Av.

VARIETIES OF SUGAR.—European and American commerce deals with the following kinds of raw sugars:

1. *West Indian.*—Cuba, San Domingo or Hayti, Jamaica,

Porto-Rico, Martinique, Guadaloupe, St. Croix, St. Thomas, Havana.

2. *American.*—Rio Janeiro, Bahia, Surinam, Pernambuco.

3. *East Indian.*—Java, Manila, Bengal, Mauritius, Bourbon, Cochin-China, Siam, Canton.

Of late there has been a distinction between sugar cultivated by slave and that by free labor; the latter comes from Jamaica, Barbadoes, Demerara, Antigua, Trinidad, Dominica; the former from Cuba, Havana, Brazil, St. Croix, and Porto-Rico.

Besides the above-named sugar, American commerce deals with New Orleans, Mexico, Honolulu, and sometimes with Egyptian sugars.

According to method of preparation, raw sugars have received, besides the above, the following names: Melado, clay, muscovado, molasses, centrifugal, drone, and potted sugars.

The raw sugars come into market packed in hogsheads, tierces, barrels, bags, mats, baskets, and cheeroons.

In the French and English colonies sugar is exported in chests covered with fire-clay under the name of chest or tub sugar.

The mode of manufacture depends on the foreign constituents of sugar, all of which must be destroyed before the sugar can be refined. According to Mulder, we have in the following sugars from—

	JAVA. 10 Samples.	HAVANA. 6 Samples	SURINAM. 4 Samples.
Cane Sugar	98.6—83.1	97.0—87.3	92.3—85.4
Glucose	5.5— 0.3	3.7— 0.9	4.4— 1.6
Extractive matter, gum, etc.	3.5— 0.5	4.5— 0.4	2.1 – 1.1
Ash	1.9— 0.2	1.1— 0.0	1.4— 0.8
Water	6.3— 0.3	3.8— 0.9	6.9— 4.0

Molasses is produced by the long-continued heating of the cane-juice. It is used principally in the colonies for the manufacture of rum; it is soon converted to spirit, and then quickly becomes acetated.

West India molasses, according to Dr. Wallace, has the following composition:

Cane-sugar	47.0
Glucose	20.4
Extractive and coloring matter, etc	2.7
Salts (ash)	2.6
Water	27.3
	100.0
Specific gravity	1.36

Sugar from Beets.—Marggraf, in the year 1747, was the discoverer of sugar in beets, and suggested the manufacture of sugar from this source. The following are the principal sugar beets:

Quendlinburg beet is a slender, rose-colored root, and very sweet; it is matured fourteen days before any other kind.

Silesian beet is a pear-shaped root, white in the body and light-green on top; it does not yield as much sugar as the former, but as more beets can be grown on the same amount of ground, it produces more sugar. It is much cultivated in France and Germany.

Siberian beet is known as the *white-ribbed beet;* it is pear-shaped, with very light green ribbed leaves. Percentage of sugar in this beet is less than Silesian beet, although of greater weight.

The *French* or *Belgian beet* has small leaves and a slender and spiral root, yielding sugar.

The *Imperial beet* is slender, pear-shaped, very white, rich in sugar, but does not yield as well as Silesian beet.

The *King beet* is a biennial; in the first year the root is merely developed; in the second it bears seed.

ANALYSES OF SUGAR BEETS.*

NAME.	WATER.	ALBUMINOIDS.	SUGAR.	ORGANIC ACIDS, PECTIN, ETC.	CRUDE FIBRE.	ASH.	ANALYST.
Hohenheim	81.5	0.87	11.90	3.47	1.33	0.89	Wolff.
Mœckern	84.1	0.82	9.10	3.90	1.05	0.99	Ritthausen.
" 2 lbs	81.7	0.84	11.21	3.86	1.36	0.94	"
" ¾ "	79.5	0.90	12.07	5.09	1.52	0.88	"
Bickendorf, 1½ lbs	80.0	0.70	12.90	5.00	1.20	0.70	Grouven.
Slaudstadt, 2 lbs	80.0	0.68	13.37	5.21		0.74	Stöckhardt.
Lockwitz, 1½ "	79.0	0.65	13.32	5.58		0.60	"
Tharaud 1½ " manured	82.7	0.98	12.84	3.24		0.79	"
" 2 " "	81.8	1.16	10.15	5.77		1.12	"
" 3½ " "	82.1	1.14	9.25	6.36		1.15	"
" 4 " "	82.5	1.05	8.45	7.07		0.93	"
Silesia, manured	84.4	1.14	9.80	3.96		0.69	Bretschnieder.
" " with sodic nitrate	82.7	1.42	11.57	3.63		0.68	"
" " " calcic phos.	84.1	1.20	9.82	4.04		0.77	"
Average	81.5	0.95	11.5	3.7	1.3	0.85	

* From "How Crops Grow"—(Johnson).

The following analysis is more elaborate than the above, and is considered a fair average analysis of the sugar beet.*

	Per cent.
Water	82.30

(1.) *Insoluble Constituents.*

Cellulose	0.80
Pectose, pectase, pectic, and pectosic acids	0.30
Metarabic acid	
Fatty, waxy, and resinous bodies	
Albuminoids	
Pectates, parapectates, metapectates, pectosates, oxalates, and phosphates of magnesium, calcium, iron, and manganese	
Silica	

(2.) *Soluble Constituents.*

Cane-sugar	11.30
Glucose	—
Albumen, casein, etc.	1.50
Asparagine ($C_4H_8N_2O_3$)	—
Betaine ($C_5H_{11}NO_2$)	0.10
Carried forward	96.60

Brought forward	96.60
Pectine, parapectin, metapectin, and pectase	3.40
Gummy bodies	
Cromogene	
A yellow extractive body	
Parapectic, metapectic, aspartic, citric, and malic acids	
Pectates, parapectates, metapectates, citrates, malates, oxalates, aspartates, sulphates, phosphates, nitrates, and chlorides of potassium, sodium, rubidium, and ammonium	
Citrates, malates, asparates, sulphates, nitrates, and chlorides of magnesium, calcium, iron, and manganese	
Silica	
	100.00

Near Magdeburg, where the beet is extensively cultivated, the general results give:

The greatest sugar productions, as	13.3 per cent.
That from inferior beets	9.2 " "
The average beet yielding	11.3 " "

12¼ cwts. of beet yield on an average 1 cwt. of raw sugar.

THE ANALYSIS OF CANE-SUGAR.

Constituents.	Gay-Lussac and Thenard.	Berzelius.	Prout.	Ure.	Fownes.	Theoretical.
Oxygen	56.63	49.856	53.35	50.33	51.59	51.46
Carbon	42.47	43.265	39.99	43.38	41.98	42.11
Hydrogen	6.90	6.875	6.66	6.29	6.43	6.43

Formula for Sugar (sucrose), $C_{12}H_{22}O_{11}$.

SACCHARIMETRY.

There are several methods for determining the amount of saccharine matter contained in the various crude sugar productions; the following may be employed:

1. Mechanical,
2. Chemical, or
3. Physical Method.

---

* Taken from article on Sugar by C. F. Chandler—(Johnson's Cycl.).

THE MECHANICAL METHOD is applicable for determining the sugar in beets:

"The* middle part of the beet is cut in thin slices to the weight of 25 to 30 grams each and dried. From the difference in weight before and after drying, the quantity of water contained in the root is ascertained. The dry residue is pulverized, and then treated with boiling dilute alcohol of a specific gravity of 0.83. By this means the sugar is dissolved and the weight ascertained. The insoluble residue gives, after drying, the weight of the cellulose, proteine bodies and mineral constituents. If the alcoholic solution be placed in a vacuum over caustic lime, it gradually becomes more and more concentrated until, after standing about a day, the sugar, owing to its insolubility in absolute alcohol, may be collected in small colorless crystals, only absolute alcohol remaining. Good sugar-beets give 20 per cent. dry residue, the water amounting to 80 per cent. Of the 20 per cent., 13 per cent. is usually sugar, and the remaining 7 per cent. pectine, cellulose, proteine, and mineral substances. The higher the specific weight of the juice of the beet, the more sugar it contains. The juice of a good beet properly cultivated marks 8° and sometimes 9° B."

"CHEMICAL METHOD.—The chemical method is based on the following facts:

a. The known proportional solubility of calcic hydrate in cane-sugar.

b. The capability of a cane-sugar solution to reduce the hydroxides of copper to protoxides, the quantity reduced affording an estimate; and the conversion by acids of cane-sugar into inverted sugar (a mixture of levulose with dextrose or glucose).

c. The fermentation of sugar, giving rise to the formation of alcohol and carbonic acid, the amount of which can be ascertained, $4CO_2$ corresponding to one molecule of cane-sugar $C_{12}H_{22}H_{11}$.

---

* Wagner's Technology.

The first of these methods is that of determining the solubility of calcic hydrate in a cane-sugar solution. The fluid containing sugar is stirred with calcic hydrate, the quantity of which dissolved, estimated by titration with sulphuric acid, determines the quantity of sugar.

The second method is grounded on the researches of M. Trommer, who found—

(1.) That cane-sugar in an alkaline fluid does not reduce cupric oxide; but it becomes reduced if the sugar has previously been boiled with sulphuric or hydrochloric acid, the acid converting the cane into inverted sugar.

(2.) The quantity of the reduced protoxide is proportional to the quantity of sugar. Barreswil and Fehling give a test based on this law. An alkaline solution of cupric oxide is made by dissolving 40 grams of cupric sulphate in 160 grams of water, and adding a solution of 160 grams of neutral potassic tartrate in a little water, with 600 to 700 grams of sodic hydrate of a specific gravity 1.12. The mixture should be diluted to 1154.4 c.c. at 15°. A litre of this copper solution contains 34.65 grams of cupric sulphate, and requires for its reduction 5 grams of dextrose or levulose; or 10 atoms cupric sulphate (1247.5) are reduced by means of one atom of dextrose or levulose (180) to protoxide (34.65 : 5 = 1274.5 : 180 or 6.93 : 1), 10 c.c. of the copper solution corresponding also to 0.050 grams of dry dextrose or levulose. Mulder prefers a solution in which 1 part of cupric oxide corresponds to 0.552 parts of dextrose or levulose of the formula $C_6H_{12}O_6+H_2O$; by the use of this test-liquor, the amount of sugar can be ascertained with great accuracy. By another method 10 c.c. of this copper solution are heated with 40 c.c. of water, and placed in a sugar solution till all the cupric oxide is reduced. When this point is nearly reached, the precipitate becomes redder and forms more rapidly. Testing the filtrate with potassic ferrocyanide, will throw down a yellow precipitate if there be sugar in excess. The copper salts are instantaneously reduced by the sugar in corresponding quantities; long boiling is not necessary; 100 parts of dextrose or levulose correspond to 95 parts of cane-sugar."

Ferment Test.—"The third method, the ferment test, as it is generally termed, is grounded on the fact that a solution of sugar may be preserved for an indefinite period in an open or close vessel; but that if decomposing, azotized matter be accidentally or intentionally added, the sugar is converted first into dextrose or levulose, which, suffering vinous fermentation, is converted into alcohol with the evolution of carbonic acid:

$$\left.\begin{array}{l}\text{1 mol. of cane-sugar}\\(C_{12}H_{22}O_{11} = 342)\end{array}\right\}\begin{array}{c}\text{yields by}\\\text{fermentation}\end{array}\left\{\begin{array}{l}\text{4 mols. of carbonic acid} = 176,\\\text{4 mols. of alcohol} = 188.\end{array}\right.$$

The estimation of the quantity of carbonic acid is easily performed by means of the alkalimetric apparatus of Fresenius and Will. The fermentation being complete, the air is sucked out of the apparatus and the amount of carbonic acid estimated from its loss, which—

multiplied by $\frac{171}{88} = 1.9432$ gives the quantity of cane-sugar;
" " $\frac{180}{88} = 2.04545$ gives the quantity of dextrose."

IV. A mixture of one-third volume ether with two-thirds volume absolute alcohol. This is neither charged with acid nor saturated with sugar.

SCHEIBLER'S METHOD.

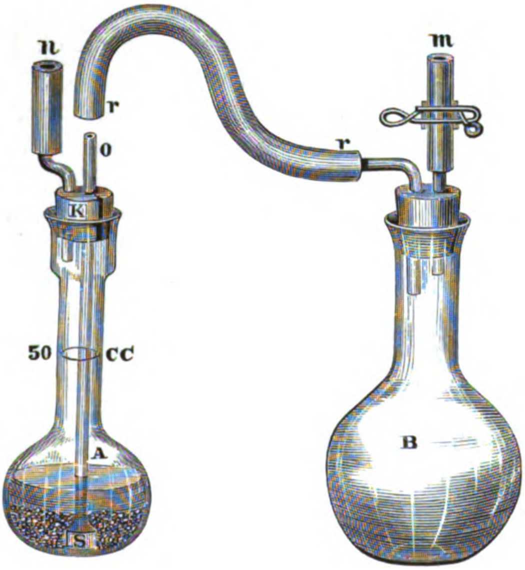
This method is founded on the principle of treating samples of sugar with saturated solution of sugar in alcohol; this solution dissolves and eliminates the impurities of the sample without in the least acting upon the crystallized portion. The necessary reagents for analysis are:

I. Alcohol of 85–86° mixed with acetic acid (50 c.c. to each litre of alcohol), and saturated with sugar. For this a good refined sugar is taken, which is powdered and introduced into the bottle; the above-mentioned solution is poured in, it is hermetically closed, and shaken frequently during several days.

II. Alcohol of about 92°.

III. Alcohol of about 96°. Alcohols II and III have no addition of acetic acid, but are saturated with sugar, as was the case with the first solution.

The apparatus required is shown in the figure.



It consists of a 50 c.c. flask; the neck of the flask is somewhat enlarged, as shown in the figure A. Through a rubber stopper K is inserted the glass filtering-tube OS. At the lower end of this tube is fastened a somewhat larger tube, and to this is fitted a felt-filter. There is also a flask B, in which a vacuum can be formed by means of suction. This flask is attached to A by means of the rubber tube P.

The operation is as follows: A normal quantity of sugar is weighed (26.048 grams if the Ventzke's polariscope is used, or 16.35 grams if the Duboscq) in the flask A. The stopper with the filter-tube is inserted in the flask.

Solution IV is now introduced into the flask and allowed to remain for fifteen or twenty minutes, during which time the water of the sugar, as also the small quantities of foreign substances, such as fatty bodies, alkaline salts, alkaline salts of fatty acids (butyric, valerianic, etc.), are dissolved, and the sugar is precipitated. The alcohol and ether is then withdrawn into the flask B by means of suction applied at *m*.

After this solution No. I is introduced, and then No. II, about 10 c.c. of each. This washing separates the absolute alcohol adhering to the sugar, which is finally saturated with solution II. After this latter has been drawn off by suction, solution No. I is introduced. The solution is left for fifteen to twenty minutes, sufficient time for the solution of all impurities of the raw sugar, the molasses, during which time the mass of sugar diminishes in volume and settles; the solution is then removed by suction the same as the others into the flask B. The filter-tube is now withdrawn, and any adhering sugar is washed into the flask; tri-plumbic acetate is added, then water, until the 50 c.c. mark is reached. The solution is then polarized. By this improved method it is claimed that great exactness can be obtained, much time spared, and less liability to loss than in the first method proposed by Scheibler. The operation occupies about two hours, and several analyses can be carried on at the same time.*

PHYSICAL METHOD.—M. Soleil has constructed an apparatus based upon the rotatory power of liquids, for analyzing saccharine substances, to which the name *saccharometer* is applied.

The following table shows the effect of sugars on polarized light:

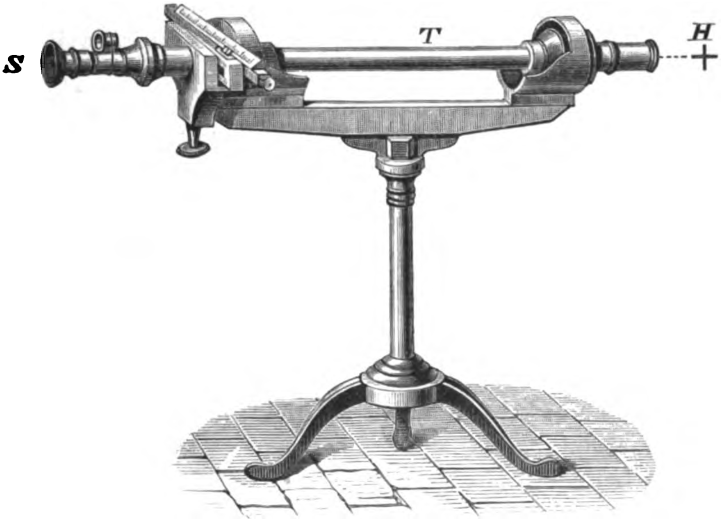
SUGARS.	FORMULÆ.	EFFECT ON POLARIZED LIGHT.
Cane-sugar (sucrose)	$C_{12}H_{22}O_{11}$	Right, 73°.8.
Melezitose (from Larch manna)	$C_{12}H_{22}O_{11}$	" 94°.1.
Mycose (from Turkish manna, product of an insect)	$C_{12}H_{22}O_{11}$	" 193°.0.
Melitose (from eucalyptus)	$C_{12}H_{24}O_{12}$	" 102°.0.
Dextrose (grape-sugar)	$C_6H_{12}O_6$	" 57°.4.
Malt-sugar (maltose)	$C_6H_{12}O_6$	" 172°.0.
Fruit-sugar (lævulose)	$C_6H_{12}O_6$	Left, 106°, at 13°.3C.
Eucalin (from fermentation of melitose)	$C_6H_{12}O_6$	Right, 50°.0.
Sorbin (from berries of the service tree)	$C_6H_{12}O_6$	Left, 46°.9.
Milk-sugar (lactose)	$C_6H_{12}O_6$	Right, 56°.4.
Galactose	$C_6H_{12}O_6$	" 83°.3.
Inverted sucrose (from honey and manna and some fruits)	$C_6H_{12}O_6$	Left, 28° at 14.12° C.

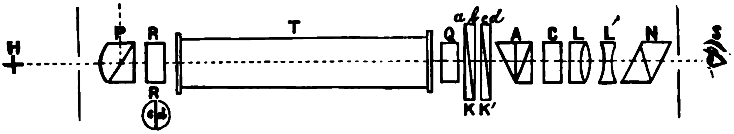
---

* For details for preserving solutions, etc., see Am. Chem., March 1873 and September 1873.

The above table, according to Berthelot, are the rotary powers of the different varieties of sugar, if equal weights of each are dissolved in an equal bulk of water; the quantity of each sugar is calculated for the formulæ annexed.

SOLEIL-DUBOSCQ SACCHAROMETER.





H,—Is a ray of light (Argand burner, gas-light is generally used).

P,—Is the polarizer, formed by two prisms, one of crown glass, the other of calc spar. The ordinary and extraordinary rays are polarized at right angles, the ordinary ray alone meets the eye. The principal division of the spar is in a vertical plane with the axis of the instrument.

R,—Two quartz plates of opposite rotating power cut perpendicular to axis (c and d) of instrument, having a thickness of 3.75 millimetres (or 7.50 m.m.), equal to a rotation of 90°, and gives a violet tint called the "tint of passage," or "transition tint."

T.—This is the tube made of copper or brass, which is sometimes tinned inside, with two glass plates for each end to close the tube *with*, so that it can hold the liquid to be analyzed.

Q.—This is a quartz plate 5.5 millimetres thick, having the property of right-handed rotation.

KK′.—This is a wedge of left-handed quartz; it is made by cutting a quartz plate with two parallel sides, obliquely, so that they will have the same angle. The scale of the instrument is attached to these parts: ab = cd = 4 millimetres.

A,—Is the analyzer. Formed in three parts: the first is a very small flint-glass prism, the second is a crown-glass prism, the third is a prism of calc spar.

C,—Is a plate of quartz.

LL′,—Is a Galilée Telescope.

N,—Is a nickel prism, which with C (quartz plate) produces the sensible tints.

S,—Is the eye of observer.

NOTE.—The Duboscq instrument, in comparison to the Ventzke, is best adapted for the examination of raw sugars, for the reason that only 16.35 grams are taken for analysis, whilst 26.048 grams are required for the Ventzke instrument. Some raw sugars are very dark-colored, and are difficult to decolorize; therefore, the least amount of sugar taken in a given quantity of water (100 c.c.), the easier will it be to decolorize the same.

THE ANALYSIS OF SUGAR BY MEANS OF THE OPTICAL SACCHAROMETER.

The analysis of sugar solutions by means of the optical saccharometer usually gives rise to one of the following problems:

(1.) "To determine* the quantity of pure sugar in the solution such as it is; or,

(2.) To determine the quantity of pure sugar in the solution, irrespective of the quantity of water in it; *i. e.*, the quantity of pure sugar in the substance as it would be if deprived of its water, or, more briefly, the quantity of sugar in the dry substance."

In the first case we must treat it as we would any other saccharine substance, as for example—

RAW SUGARS.

The raw sugar to be analyzed is first weighed: 16.35 grams are taken if a Soleil-Duboscq saccharometer is to be used, or 26.048 grams if a Ventzke-Soleil instrument is used. The sugar weighed is dissolved in a small beaker,† in about 60 c.c. of water, and then transferred to a small flask of 100 c.c. capacity, being careful to dissolve every particle of the sugar and transfer the same to the flask; where it is diluted to 90 c.c., after which 4 c.c. of a solution of common salt is added, and then 6 c.c. of tri-plumbic acetate, making in all 10 c.c. The flask is then agitated for a few moments, when the contents are filtered. If the filtered solution has a reddish color,‡ it may be filtered through *well-dried* bone-black, when the red color will disappear. If bone-black is not at hand, to 50 c.c. of the filtrate add 50 c.c. of water and filter if necessary, when a solution will be obtained which can be examined in the saccharometer.

---

* Amer. Chem., Oct., 1873. Article by P. Casamajor.

† It is only in cases of very dark sugars that the filtrate may sometimes be red; when red it cannot be used in the instrument.

‡ Nickel-plated copper-beakers will be found to be very useful, especially in the case of centrifugal sugars, which are difficult to dissolve.

The filtrate of a white or yellow color is now to be examined in the saccharometer. The tube of the instrument of 20 c.c. capacity, and 20 centimetres in length, is thoroughly washed out with the filtrate and then filled to overflowing, when the open end is covered by a round piece of glass, and the cap is put on. The tube is then put in the instrument and the solution examined. It is necessary to see that the zero (0) point on the scale of the instrument is correct; this is accomplished by means of a tube filled with pure water.

The color of the field best adapted to examine the solution depends on the sensitiveness of the eye. Experience has shown, though, that a yellow field is the most sensitive.

When once the tints of the two halves of the plate are exactly alike, the division of the scale corresponding to the vernier is read off, and the corresponding number gives the strength of the solution.

In the second case, that is,

TO DETERMINE THE QUANTITY OF PURE SUGAR IN A SOLUTION, IRRESPECTIVE OF THE QUANTITY OF WATER IN IT.

The following is the process of P. Casamajor:* Two cases may present themselves: either the solution is light-colored enough to be placed in the saccharometer, or it is dark and needs to be decolorized. Suppose a solution which, after dilution, its density falls between 5° and 15° Balling, is light-colored enough to go into the saccharometer. First place the areometer in the solution; suppose that it indicates 14°.3; next place in the solution a thermometer which will indicate say 27½° C., and note that the excess of 27½° over 17½° C. is 10°.

[NOTE.—The indications of the areometer are true: for the temperature of 17½° C. and for any other temperature, either higher or lower, we must consult the table for "correction of temperature," which is given on p. 482.]

It is necessary to turn now to the Table for Correction of Temperatures, and find the quantity to be added to the degrees Balling as $27\frac{1}{2}° > 17\frac{1}{2}° = +10$. Opposite 10 in the table is

---

* Amer. Chem., Nov. 1873, p. 161.

0.545, which we add to 14°.3 Balling = (14°.3 + 0.545 = 14°.845) 14°.84 comes nearest to 14.8 of the table marked Duboscq, and opposite to 14.8 is 1.043, and in the table marked Ventzke, 1.659.

Suppose a Ventzke instrument is used, and the solution indicates 43 per cent.; by multiplying 43% by 1.659 = 71.33% gives the quantity of pure sugar in the dry substance of the solution.

If the solution is too dark to be used in the saccharometer, it must be decolorized. The first step to be taken is to test the solution with the areometer and thermometer, and obtain the rectified degree Balling corresponding to 17½° C. Opposite to this degree Balling we find in the table the corresponding factor, which is written down for future use.

The solution is next clarified by adding the "sodic chloride solution" and tri-plumbic acetate. The total addition will be 10 per cent. of the volume of the sugar solution. If the solution is light, 5 per cent. will do. As this addition of liquid weakens the saccharimetric strength of the solution by 5 or 10 per cent., according to the quantity of decolorizer added, it must be compensated for by adding 5 or 10 per cent. to the factor written down. The solution, after being filtered, is finally placed in the tube of the saccharometer, and the indication of the instrument is multiplied by the factor obtained by adding 5 or 10 per cent. to the factor of the table.

NUMERICAL EXAMPLE.—Suppose we have a dark solution. After being diluted with water, it is tested by the areometer and thermometer, showing 11°.4 Balling, the temperature being 25½° C. The excess of 25½° over 17½° = 8. Opposite 8 in Table for Correction of Temperatures we find 0.436, which is added to 11°.4 Balling (11°.4 + 0.436 = 11.836). Suppose we have a Ventzke instrument, we find in the table marked Ventzke, opposite 11.8 (nearest 11.836), 2.107, which we write down. The solution being dark, we add 10 per cent. of clarifying solution, say 3 or 4 per cent. of sodic chloride, and the balance tri-plumbic acetate As this weakens the solution, we compensate for it by adding to the factor 2.107, 10 per cent. of its value = 0.2107, which gives 2.317. The solution, after being clarified by filtration is placed in the saccharometer, and then shows say 22½ per cent. By multiplying 2.317 by 22½, we obtain 52.1, which is the percentage of pure sugar in the dry substance of the solution.

TABLES FOR THE CORRECTION OF TEMPERATURES.

Difference between the temperature observed and 17½° C.	Quantity to be added or subtracted from degree Balling.
1	0.054
2	0.109
3	0.163
4	0.218
5	0.272
6	0.327
7	0.381
8	0.436
9	0.490
10	0.545
11	0.600
12	0.654
13	0.708
14	0.762
15	0.817

VENTZKE.

Table of factors, corresponding to degrees Balling, to be multiplied by the indication of the saccharometer.

Degree Balling.	Factor.	Degree Balling.	Factor.	Degree Balling.	Factor.	Degree Balling.	Factor.	Degree Balling.	Factor.
5.	5.107	7.	3.618	9.	2.792	11.	2.267	13.	1.902
5.1	5.013	7.1	3.568	9.1	2.762	11.1	2.246	13.1	1.887
5.2	4.920	7.2	3.519	9.2	2.731	11.2	2.225	13.2	1.873
5.3	4.826	7.3	3.470	9.3	2.700	11.3	2.204	13.3	1.858
5.4	4.733	7.4	3.420	9.4	2.670	11.4	2.184	13.4	1.844
5.5	4.639	7.5	3.371	9.5	2.640	11.5	2.163	13.5	1.829
5.6	4.559	7.6	3.328	9.6	2.612	11.6	2.144	13.6	1.815
5.7	4.479	7.7	3.284	9.7	2.585	11.7	2.125	13.7	1.801
5.8	4.399	7.8	3.240	9.8	2.558	11.8	2.107	13.8	1.787
5.9	4.319	7.9	3.197	9.9	2.530	11.9	2.088	13.9	1.773
6.	4.239	8.	3.154	10.	2.503	12.	2.069	14.	1.759
6.1	4.171	8.1	3.116	10.1	2.478	12.1	2.052	14.1	1.746
6.2	4.103	8.2	3.078	10.2	2.453	12.2	2.034	14.2	1.733
6.3	4.035	8.3	3.039	10.3	2.428	12.3	2.016	14.3	1.721
6.4	3.968	8.4	3.001	10.4	2.403	12.4	2.000	14.4	1.708
6.5	3.900	8.5	2.963	10.5	2.378	12.5	1.982	14.5	1.695
6.6	3.844	8.6	2.929	10.6	2.356	12.6	1.966	14.6	1.683
6.7	3.787	8.7	2.895	10.7	2.334	12.7	1.950	14.7	1.671
6.8	3.730	8.8	2.860	10.8	2.311	12.8	1.934	14.8	1.659
6.9	3.674	8.9	2.826	10.9	2.289	12.9	1.918	14.9	1.648
								15.	1.636

DUBOSCQ.

Table of factors, corresponding to degrees Balling, to be multiplied by the indication of the saccharometer.

Degree Balling.	Factor.	Degree Balling.	Factor.	Degree Balling.	Factor.	Degree Balling.	Factor.	Degree Balling.	Factor.
5.	3.206	7.	2.271	9.	1.753	11.	1.423	13.	1.194
5.1	3.151	7.1	2.240	9.1	1.734	11.1	1.410	13.1	1.185
5.2	3.097	7.2	2.207	9.2	1.714	11.2	1.397	13.2	1.176
5.3	3.042	7.3	2.176	9.3	1.695	11.3	1.384	13.3	1.166
5.4	2.988	7.4	2.147	9.4	1.676	11.4	1.371	13.4	1.157
5.5	2.933	7.5	2.116	9.5	1.657	11.5	1.358	13.5	1.148
5.6	2.879	7.6	2.088	9.6	1.640	11.6	1.346	13.6	1.139
5.7	2.824	7.7	2.061	9.7	1.622	11.7	1.334	13.7	1.130
5.8	2.770	7.8	2.034	9.8	1.605	11.8	1.323	13.8	1.122
5.9	2.715	7.9	2.007	9.9	1.588	11.9	1.311	13.9	1.113
6.	2.661	8.	1.980	10.	1.571	12.	1.299	14.	1.104
6.1	2.622	8.1	1.955	10.1	1.555	12.1	1.288	14.1	1.096
6.2	2.583	8.2	1.931	10.2	1.540	12.2	1.277	14.2	1.088
6.3	2.544	8.3	1.906	10.3	1.524	12.3	1.266	14.3	1.080
6.4	2.505	8.4	1.882	10.4	1.508	12.4	1.255	14.4	1.072
6.5	2.466	8.5	1.860	10.5	1.493	12.5	1.244	14.5	1.064
6.6	2.427	8.6	1.839	10.6	1.479	12.6	1.234	14.6	1.056
6.7	2.388	8.7	1.817	10.7	1.465	12.7	1.224	14.7	1.049
6.8	2.349	8.8	1.796	10.8	1.451	12.8	1.214	14.8	1.043
6.9	2.310	8.9	1.774	10.9	1.437	12.9	1.204	14.9	1.034
								15.	1.027

DETERMINATION OF THE WATER IN SUGAR.

There are two methods which can be employed:

(1.) By drying the sugar near the point of caramelization; *i. e.*, 120° to 130°, the loss in weight will equal the water. The operation requires about two hours.

(2.) By means of the "water areometer." The following is a description of the process of P. Casamajor:

To determine the amount of water in sugar: Take 16.35 grams of the sugar to be tested, which dissolve, so that the solution shall occupy 100 c.c. without adding tri-plumbic acetate or any other decolorizing agent.

After shaking up thoroughly, so as to have a uniform liquid, pour some of it into a glass cylinder; put an areometer into the solution and note the division to which it sinks; also note the temperature of the solution. The indications of the areometer show the quantity (provisional) of water in the sugar tested, if the temperature is 17½° C. If the temperature is not 17½° C, corrections are to be made by means of the following table:

Degrees Celsius, above or below 17½ C.	Quantity to add when below and to subtract when above 17½ C.
1	0.36
2	0.71
3	1.07
4	1.44
5	1.80
6	2.15
7	2.50
8	2.87
9	3.12
10	3.48
11	3.84
12	4.20
13	4.55
14	4.81
15	5.16
16	5.52

Suppose you have the indication of your areometer 2.50 and that of the thermometer 23½° C. Then 23½ − 17½ = 6°. Opposite 6° you find 2.15. The amount of water is

$$\begin{array}{r} 2.50 \\ -\ 2.15 \\ \hline \end{array}$$

Provisional, 0.35 per cent.

If the areometer indicates 2.50 and the thermometer 14° C; the difference 17½° − 14° = 3½°, to which correspond 1.25, average of

$$\begin{array}{r} 1.07 \\ \underline{1.44} \\ 2\overline{)2.51} \\ 1.25 \end{array}$$

2.50 + 1.25 = 3.75 per cent. (provisional).

There is another correction to be made which relates to the salts contained in the sugar. Suppose we have a sugar giving in the saccharometer 85 per cent.; the water areometer, after correction for temperature, giving 4 per cent. The sugar may be provisionally put down:

Saccharimetric ...	85 per cent.	Provisional.
Water............	4 "	
Impurities........	11 "	

Casamajor found, by comparing a large number of tests in which he determined the ashes, that $\frac{1}{20}$ of the impurities in cane-sugar and $\frac{1}{10}$ in beet-sugar should be added to the water as found above, to correct the error due to salts.

Thus, in the above example, $\frac{11}{20} = 0.55$, which, when added to 4, makes 4.55 per cent.; therefore, we have—

Saccharimetric	85	per cent.
Water	4.55	"
Impurities	10.45	"
	100.00	

By the above process the amount of water may be determined very rapidly.

If it is desirous to determine the quantity of sugar, using the same solution, add to it 5 or 10 per cent. of decolorizing material, and to the result of the saccharometer add 5 or 10 per cent. to counteract for the dilution.

DETERMINATION OF THE SCALE OF THE WATER AREOMETER.

The 0 point is obtained by dissolving 16.35 grams of pure, dry sugar in water, so that the solution will occupy 100 c.c. at 17½° C. The next point to be determined is 10 per cent., which is easily obtained by taking 90 c.c. of the above solution and diluting with pure water up to 100 c.c. This second solution at 17½° C. corresponds to a sugar having 10 per cent. of water. Having obtained the 0 point, as also the 10 per cent. on the instrument, the space may be divided equally between these two points for the percentages. The points obtained thereby are not strictly correct, but the error committed is only a theoretical one, and is not appreciable on such an instrument.

The different points give the true percentage of water in a sample of sugar at 17½° C., after allowing for the correction due to salts mentioned above. At any other temperature, correction must be made as above.

DETERMINATION OF THE ASH IN SUGARS.

Weigh out 9 grams of the sugar, to be examined in a platinum-dish, and add four drops of sulphuric acid, diluted in about 2 centimeters of water. The platinum-dish is gently heated at first to prevent bubbling over, and finally heated strongly to incinerate the carbon. The result is the same as taking 10 grams and deducting a tenth.*

---

* The reason for deducting one-tenth is to counterbalance the additional weight due to the conversion of the sugar-salts into sulphate; it is entirely a conventional matter.

Assaying.

ASSAY OF IRON ORES.

DIRECTIONS FOR SELECTING SAMPLES FOR ANALYSIS.

Several fragments should be selected from different parts of the vein or bed, amounting in the aggregate to fifty or sixty pounds. Or when the ore has been mined and is lying in heaps, several shovels-full of ore, coarse and fine, should be obtained, so as to procure a fair average of the whole; it is also better to select from different parts of the pile—a keg-full in all is sufficient. A few ounces, or even less, is all that is actually required for the analysis, but it is better to pulverize a large quantity together, and the portion analyzed is a much better representation of the mine than a single fragment can be.

PREPARING THE SAMPLE FOR ANALYSIS.

"Break up in an iron mortar forty or fifty pounds of the ore, into pieces that will pass through a tin sieve with half-inch holes. Thoroughly mix the fine and the coarse. Now break up about ten pounds of average quality, so that it will pass through a sieve made of tin with quarter-inch holes. *Mix well*, take one pound of this, and pulverize in iron mortar, until it will pass through a sieve of 60 meshes to the linear inch. *Mix well*, take out about 50 grams, pulverize in agate mortar, pass through muslin bolting-cloth, and put into a small bottle, tightly corked, for analysis and special determinations. Any portion of this taken for ASSAY or for QUALITATIVE or QUANTITATIVE ANALYSIS, must be pulverized to an impalpable powder in an agate mortar."

In the assay of IRON ORES it is necessary to slag off from the iron all the impurities, so that the iron will be set free in a pure state. The formula for the slag must be $= K_2O_3.SiO_2 + 2(3KO.SiO_2)$.

Its approximate percentage composition is:

Silica	38	or about	2½ parts.
R_2O_3 (Alumina)	15		1 part.
RO (CaO, MgO, etc.)	47		3 parts.

CHARGES FOR ORES OF UNKNOWN COMPOSITION.

	1.	2.	3.	
Silica	2.5	1.	4.0	grams.
Lime	2.5	4.	1.5	"
Ore	10.	10.	10.	"

It is necessary to make two assays of the ore, using first charge 1, then charge 2, etc.

TO CALCULATE THE CHARGE WHEN THE COMPOSITION OF THE ORE IS KNOWN.

The ore contains—	Per cent.	10 grams of ore contain—	Required to form slag.	Difference to be added.
Silica	1.65	0.165	2.50	2.335
Alumina	1.94	0.194	1.00	0.806
CaO, MgO, etc.	4.51	0.451	3.00	2.549

Kaolin is used as a means to furnish alumina, and kaolin is ($Al_2O_3\ \frac{1}{2}\ .\ SiO_2\ \frac{1}{2}$). Now, since 0.806 alumina must be added to charge to form the proper slag, twice as much kaolin must be used, as only one-half of the kaolin is alumina. Therefore, $.806 \times 2 = 1.612$ grams of kaolin to be added. But in adding 1.612 grams of kaolin, 0.806 gram of SiO_2 is added because half of the kaolin is SiO_2. Therefore 0.806 grams must be subtracted from the amount of SiO_2 to be added. 2.335 grams − 0.806 grams = 1.529 grams SiO_2 to be added.

The charge is therefore:

Ore	10.	grams.
Silica	1.529	grams.
Kaolin	1.612	"
Lime	2.549	"

The above example was where the ore did not contain sufficient SiO_2 to form the required slag. The following is an example of an ore containing too much SiO_2:

The ore contains—	Per cent.	10 grams of ore contain—	Required.	To be added.
Silica	25.96	2.596	2.50	0.096
Alumina	6.92	0.692	1.00	0.308
CaO, MgO, etc.	7.59	0.759	3.00	2.241

To add 0.308 of Al_2O_3, twice 0.308 or 0.616 of kaolin must be added. In adding 0.616 kaolin, 0.308 SiO_2 is added. Therefore, since there is already 0.096 SiO_2 too much, there will be 0.096 + 0.308 or 0.404 SiO_2 too much, and this amount must be treated so that it will form a slag.

Constituents.	Excess.	Required.	Difference to be added.
Silica	0.404	2.50	2.096
Alumina	—	1.00	1.000
CaO, MgO, etc.	—	3.00	3.000

Now in adding 1.000 gram of Al_2O_3 two grams of kaolin must be added, and in adding two grams of kaolin one gram of SiO_2 is added; therefore this amount of SiO_2 must be subtracted from the amount of SiO_2 necessary to add, which is 2.096; $\therefore 2.096 - 1.000 = 1.096$.

The charge is therefore:

Ore	10 grams.
Silica	1.096 grams.
Kaolin	$0.616 + 2.000 = 2.616$ grams.
Lime	$2.241 + 3.000 = 5.241$ "

To add SiO_2, ground quartz is used. Ores containing titanium require the addition of fluor-spar, 0.5 to 10 grams, according to the amount of titanium that is present.

PREPARING THE CRUCIBLE.

The crucible used is a Hessian crucible. They are filled with *brasque.* Brasque in this case is four parts of pulverized charcoal to one part of molasses. This is thoroughly kneaded until a ball of it, made in the hands, resists to a sensible degree an attempt to pull it apart.

The crucibles are packed full by driving the brasque in with a mallet; a conical-shaped cavity of sufficient size for the charge is cut out of the brasque with a knife, and the cavity on the inside polished with a strong glass tube. The crucible is then dried by a fire (must not be heated too high).

PREPARING CHARGE.

The charge is weighed out and thoroughly mixed on glazed paper, then put into the crucible. The top of the conical cavity is then covered with a piece of charcoal, and then the whole top of the crucible is covered with a coating of fire-clay (fire-clay with one-fourth to one-half part of fine sand and a little hair, thoroughly kneaded). The outside of the crucible is also covered with fire-clay (very thin coating), and then the crucible is luted on a fire-brick and thoroughly dried before putting it into the furnace. The fire should be kept up in the furnace between four and 5 hours, with anthracite coal.

Duplicate assays should not vary more than 0.3–0.4 of one per cent.

The button should be gray or grayish-white, the grain fine, or tolerably so. PHOSPHORUS in the ore makes the button *cold-short*—hard, brittle, and a white metal. SULPHUR makes the button strong reticulated—mottled structure, and *red-short.*

MANGANESE gives a button with a smooth surface, hard and non-graphitic; it presents a white crystalline fracture. The slag obtained has an amethyst color, or yellow, green, and brown when manganese is present in excess.

CHROMIUM gives a smooth button, "well fused, with a brilliant crystalline fracture, and tin-white color; at other times it is white and only half-fused, or it may even form a spongy mass of a clear gray color, according to the quantity of chromium contained in the iron. The slag is dark and resinous, surrounded with a thin metallic coating."

"TITANIUM gives a button with a smooth surface; has a deep gray fracture, dull and crystalline, and adheres strongly to the slag. The button is sometimes covered with the nitro-cyanide of titanium with its characteristic copper color. The slag is resinous, black, and scoriaceous, curiously wrinkled on the outside, and covered with metallic pellicles of nitro-cyanide of titanium with its characteristic copper color; sometimes the slag is vitreous and of a bluish tint."

The following is a comparison between the results obtained by analysis and fire-assay, by Ricketts:*

Ore.	Iron by Analysis.	By Fire Assay.		
Magnetite	68.35 per cent.	69.6	71.2	71.3 per cent.
Hematite	44.50 " "	44.6	46.0	48.6 " "
Limonite	44.20 " "	44.3	44.6	45.2 " "

---

* "Notes on Assaying," Ricketts, p. 89.

ASSAY OF GOLD AND SILVER.*

The assay of gold and silver will comprise: I. Assay of Ores; II. Assay of Alloys.

I. ASSAY OF ORES.

PREPARATION OF THE SAMPLE.

It is essential, in the first place, to obtain a fair average sample of the ore, otherwise the results of the assay may be commercially worthless. Selection must be left to the judgment of the assayer. The sample must be dried, if necessary; care being taken not to roast it. It must then be pounded in an iron mortar, and passed through a sieve of eighty meshes to the linear inch. If any native metal, in the form of scales or filaments, remain upon the sieve, take the weight, separately, of what has passed through and of what is left upon the sieve. The latter must be assayed according to "Assay of Alloys," and the result referred to the *whole amount* of ore. It is essential that the *whole of the sample*, except the malleable portion, be passed through the sieve. Mix thoroughly the sifted ore.

The *collection of the gold and silver* in a button of metallic lead is effected in a crucible, or in a scorifier, whence arise two methods of assay: I. Crucible Assay; II. Scorification Assay.

The crucible assay is applicable to all ores; the latter is limited, practically, by the small size of scorifiers, to the richer ores.

I. CRUCIBLE ASSAY.

An ore of gold and silver is composed of precious metal, gangue, and oxides, sulphides, etc., of foreign metals.

To collect the precious metals in a button of lead, the ore is mixed with litharge, suitable fluxes, an oxidizing or a reducing agent, and fused in a Hessian crucible. Litharge is reduced to metallic lead; the latter seizes upon the precious metals and collects in a button at the bottom of the crucible, while the foreign materials form, with the fluxes, a fusible slag above the lead button.

---

* See Amer. Chem., 1870—Articles by T. M. Blossom, E.M.

The crucible is broken when cold, and the malleable button detached from the slag by hammering on an anvil. The following are the necessary reagents:

REAGENTS.

Litharge,
Nitre,
Charcoal,
Silica,
Carbonate of Ammonia,
Carbonate of Soda or of Potash,
Argol (crude bitartrate of potash),
Borax Glass,
Common Salt.

The reagents must be finely pulverized and dried, and kept in closed vessels.

Borax should be fused to a glass and pulverized.

PRELIMINARY ASSAYS OF REAGENTS.

Ordinary commercial litharge always contains silver; so it becomes necessary to determine in each new lot the amount of silver contained, for deduction from the silver found in the regular assay of an ore.

There must also be determined, beforehand, the reducing powers of argol and charcoal, and the oxidizing power of nitre. This necessity arises from the impurity of the reagents. By reducing power is meant the amount of metallic lead that one gram of the reagent will reduce from litharge; and by oxidizing power, the amount of metallic lead that one gram of nitre will oxidize. The following are the charges for the preliminary assay:

I. REDUCING POWER.

ARGOL.		CHARCOAL.	
Argol	2 grams.	Charcoal	1 gram.
Litharge	2 A.T.*	Litharge	2 A.T.
Carb. Soda	½ A.T.	Carb. Soda	½ A.T.
Salt to	Cover.	Salt	Cover.

---

[*] A.T. means ASSAY TON. It is obtained as follows:

1 Av. lb. contains 7000 grains = 16 Av. oz. 1 oz. = 437½ grains.

1 Troy lb. contains 5760 grains = 12 oz. Troy. 1 Troy oz. contains 480 grains.

OXIDIZING POWER.

Nitre	3 grams.
Charcoal	1 gram.
Litharge	2 A.T.
Carb. Soda	⅓ A.T.
Salt	Cover.

SILVER IN LITHARGE.

Litharge	4 A.T.
Carb. Soda	2 A.T.
Charcoal	1 gram.
Salt	Cover.

It is necessary to know the reducing power of the ore to be assayed; therefore a PRELIMINARY ASSAY is made.

CHARGE.

Ore	2 grams.
Litharge	25 "
Carb. Soda	10 "
Salt	Cover.

The reducing power of an ore is due to the presence of sulphur, arsenic, antimony, zinc, etc., but generally sulphur contained in the pyrites, etc. It is necessary, if possible, to determine from the mineralogical composition of the ore to be assayed, if it is rich or poor. If rich, ½ A.T., or ⅓, ⅕, $\frac{1}{10}$ A.T., is taken. If the ore is poor, 1 A.T. or 2 A.T. is taken.

From the preliminary assay of reagents we have found:

One gram of nitre will oxidize 5.4 grams of lead (about).

One gram of charcoal will reduce 24 grams of lead (about).

And from the preliminary assay of the ore we found that 2 grams of ore gave a button of lead weighing 3 grams.

METHOD OF CALCULATING CHARGES.

EXAMPLE.—Ore pretty rich.

½ A.T. will be taken of the ore.

Reducing power found 2 grams of ore = 3 grams of lead.

$$\therefore \quad 2 \text{ grams} = 3 \text{ grams Pb.}$$

$$\therefore \quad 1 \text{ gram} = 1.5 \text{ grams Pb.}$$

---

1 ton contains 2000 lbs. (2240). 2000 lbs. × 7000 gr. = 14000000 grains in one ton.

14000000 ÷ 480 = 29166⅔ Troy ounces in a ton of 2000 lbs.

0.001 gram = 1 milligram = 1 *Assay Ounce.*

29166⅔ ÷ 1000 = 29.166⅔ grams = 1 ASSAY TON = 1 A.T.

1 A.T. is taken as 30 grams for convenience. ½ A.T. of ore taken.

$$\therefore \quad 30 \div 2 = 15; \quad 15 \times 1.5 = 22.5 \text{ grams.}$$

A cupel should not be made to hold a button weighing more than 18 grams; and this button, 22.5 grams, is too large; it must be reduced by oxidation.

$$22.5 - 18 = 4.5 \text{ grams too large.}$$

Oxidizing power of nitre = 5.4.

$$\therefore \quad 4.5 \text{ grams} \div 5.4 \text{ grams} = .83 \text{ grams nitre required.}$$

The charge is therefore:

Ore	½ A.T.
Litharge	1 "
Carb. Soda	½ "
Nitre	.83 grams.
Salt	Cover.

In the above charge we see that 1 A.T. of litharge and ½ A.T. were taken. The rule is to take *twice as much litharge as ore*, and *the same amount of carbonate of soda as ore*. The salt cover is used, as its name implies, to cover the charge in the crucible. It also serves to wash down the sides of the crucible, if the charge boils up.

The above charge is put into a Hessian crucible, and the latter put into the furnace, covered over, on top of a brick laid on the bottom. The crucible is left in the furnace equal times to and from fusion. That is, if it takes ten minutes to promote fusion of the charge (the knowledge of which may be obtained by lifting the cover off the crucible and looking in), the crucible is left in the furnace ten minutes longer.

The above ore treated was a rich ore; the following will be a poor ore:

EXAMPLE.—Ore is poor. 1 A.T. must be taken. Reducing power of ore, 2 grams of ore = .35 gram of lead.

$$2 = .35; \quad \therefore \quad 1 = .175.$$

1 A.T. = 30 grams. ∴ 30 × .175 = 5.25 grams.

Button wanted must weigh 18 grams.

∴ 18 — 5.25 = 12.75 grams too small.

1 gram charcoal = 24 grams Pb.

∴ 24 ÷ 12.75 = ½ gram (about) of charcoal must be added to charge.

The charge, then, is:

Ore	1 A.T.
Litharge	2 "
Carb. Soda	1 "
Charcoal	½ gram.
Salt	Cover.

ORES TO BE ROASTED.

Ores containing a large amount of sulphur or arsenic, antimony or zinc, should always be roasted.

ROASTING THE ORE.

The ore may be roasted in a cast-iron pan, a common spider, over the crucible furnace. There ought to be a hood over the furnace to carry off the fumes. The pan should be covered with chalk on the inside; an even coating may be made with chalk paste, then dried over the fire. The coating prevents a loss of ore.

The weighed sample of ore must be spread over the pan and stirred, while heated with a bent wire until all fumes are driven off.

Ores roasted have no reducing power; then enough charcoal must be added to reduce from the lead a button weighing 18 grams. 1 gram charcoal = 24 grams lead. For 18 grams, therefore, .555 gram of charcoal must be added.

II. SCORIFICATION ASSAY.

The reagents necessary for a scorification assay are *test-lead* and *borax glass*. The ore is mixed with these, put into a scorifier, and fused in a muffle.

The following table exhibits the proportions found by experience to be best adapted to the different gangues. The proportions are referred to *one part* of ore:

Character of Gangue.	Parts Test-lead.	Parts Borax.
Quartzose	8	—
Basic (Fe_2O_3, Al_2O_3, CaO, etc.)	8	0.25—1.00
Galena	5—6	0.15
Arsenical	16	0.10—0.50
Antimonial	16	0.10—1.00
Fahlerz	12—16	0.10—0.15
Iron pyrites	10—15	0.10—0.20
Blende	10—15	0.10—0.20

No preliminary roasting of ore is required. The scorifier is gently heated at first, and then highly heated, until the button of lead on the surface of the charge has disappeared, when it is taken out of the muffle.

Charge of ore is generally $\frac{1}{3}$, $\frac{1}{6}$, or $\frac{1}{10}$ of an assay ton.

CALCULATING CHARGE.

Example.—Suppose the ore is rich (take $\frac{1}{3}$ A.T.) and gangue antimonial. 1 A.T. = 30; $\frac{1}{3}$ A.T. = 10.

We see by table, for ores having antimonial gangue, use 16 parts of test-lead and 0.10–1.00 of borax = .5 (average). Therefore, 16 × 10 = 160 Pb, and .5 × 10 = 5 of borax.

Charge is therefore:

Ore	$\frac{1}{3}$ A.T.
Test-lead	160 grams.
Borax	5 "

GALENA—SPECIAL METHOD.

It is best and most convenient always to make a scorification assay of galena. If, however, it be desirable for any reason to make a crucible assay, a CHARGE of nitre, 20 grams per assay ton of ore used, and the same weight of carbonate of soda as of ore used.

CUPELLATION.

The lead button to be cupelled must be malleable, and the proper size for the cupel, about 12 to 15 grams. The cupel is made of bone-ash, and weighs 18 grams; it absorbs the scoriæ, leaving a pure bead of precious metal. The cupel must be carefully dried before use, and must be free from cracks, which would cause a loss of precious metal. The bottom of the muffle should be covered with sand, to prevent injury to it by upsetting a cupel.

Before introducing the button to be cupelled, the muffle, as also the cupel, should be at a reddish-white heat. The button melts, and gradually diminishes in size by oxidation and absorption. When the bead becomes dull, then bright, resembling precious metal, the cupel must be withdrawn, but very gradually, to the front of the muffle, where it must be covered over with an inverted cupel, and then the whole is withdrawn and placed one side to cool. The beads of gold and silver, when cold, is removed from the cupel, washed and weighed. (The balance used for weighing must weigh down to one-tenth of a milligram.)

INQUARTATION AND PARTING.

The separation of gold from silver is called parting. To dissolve the bead in nitric acid, the silver must be 2.5–3 times the amount of gold.

N.B.—The assayer must judge from the color of the bead if there is enough silver present; if not, he must add some to it by fusion with a blowpipe. This addition of silver is best done on charcoal.

The inquartated bead is flattened on the anvil, and treated in a porcelain capsule with nitric acid, 1.16 sp. gr. (21° B.). It is heated a little, until all the silver is dissolved from the button, when, if gold is present, it will be left as a brown powder, undissolved. (Acid must be free from all traces of chlorine.) The gold residue is thoroughly washed with distilled water, detached by the knife, transferred to a cornet of lead, and cupelled. The gold bead obtained is weighed, and the ASSAY IS COMPLETED. It remains only to calculate the results.

CALCULATION OF RESULTS.*

Every milligram of precious metal obtained *per assay ton of ore* corresponds to ounces in the ton of 2000 lbs. Av.

EXAMPLE.—Suppose that the sample presented for assay gave, on being pulverized and passed through the sieve of 80 meshes to linear inch, the following weights:

A.	Sifted ore..................	1458.32 grams.
B.	Scales of metal.............	40.75 "
C.	Total	1499.07 "

It being known from the mineralogical composition of the sample that it was a rich ore, $\frac{1}{3}$ A.T. was taken for an assay of the sifted portion (A). The residue of metallic scales, etc. (B), was scorified with test-lead, and yielded a button weighing 60.35 grams. This button was rolled out, and two average samples of 10 grams each were cupelled.

The following results were obtained from the complete assays:

A.—SIFTED ORE—CRUCIBLE ASSAY.

One-third assay ton, 9.722 grams yielded:

	1.	2.	Average.
Au + Ag................	0.19355	0.19275	0.19315
Au (by parting)..........	0.00025	0.00025	0.00025
Ag...............	0.19330	0.19250	0.19290

---

* See Amer. Chem., 1870—Article by Blossom.

.	1.	2.	Average.
Ag	0.19330	0.19250	0.19290
Ag in litharge*	0.00067	0.00067	0.00067
Ag in ore	0.19263	0.19183	0.19223

B.—METALLIC SCALES.

10 grams of the scorified button yielded:

	1.	2.	Average.
Au + Ag	5.0625	5.0620	5.0622
Au (by parting)	0.0020	0.0020	0.0020
Ag	5.0605	5.0600	5.0602
Ag in test-lead	None.	None.	None.

A. Sifted ore (in all) .... $1458.32 \times \frac{0.19213}{9.722} = 28.819$ Ag.

B. Metallic scales (in all) $40.75 = \frac{5.0602}{10} \times 60.35 = 30.538$ Ag.

Total ore........... 1499.07 .... 59.357, Total Ag.

$$1 \text{ A.T.} = 29.166666. \quad \therefore \quad 29166.66 = \text{milligrams in 1 A.T.}$$

$$29166.66 \times \frac{59.357}{1499.07} = 1154.71 \text{ oz. per 2000 lb.}$$

A. Sifted ore............ $1458.32 \times \frac{0.00025}{9.722} = 0.0375$ Au.

B. Metallic scales......... $40.75 = \frac{0.002}{10} \times 60.35 = 0.0121$ Au.

C. Total................. 1499.07 0.0496 T'l Au.

$$29166.66 \times \frac{0.0496}{1499.07} = 0.97 \text{ oz. per 2000 lbs.}$$

Result per 2000 lbs. Ore.

Silver	1154.71 oz.	@ $ 1.29	$1,489.58
Gold	0.97 oz.	@ $20.67	$ 20.04
Total bullion	1155.97 oz.		$1,509.62

---

* The litharge yielded one milligram of silver per assay ton, and two-thirds assay ton of it was employed.

ASSAY OF ALLOYS.

I. SILVER COIN AND BULLION.

The form of assay used for silver coin and bullion is that known as Gay-Lussac's Wet Method, which consists in determining the fineness of the alloy by the quantity of a standard solution of common salt necessary to precipitate, fully and exactly, the silver contained in a known weight of alloy.

Process embraces two steps:

A, Preliminary Assay, and B, Assay Proper. The latter requires for its conduction the preparation of three solutions, called *Normal Salt*, *Decime Salt*, and *Decime Silver*.

Normal Salt Solution.—This is a solution of common salt of such a strength that 100 c. c. will exactly precipitate one gram of silver. It is prepared as follows: Make a concentrated solution of salt in water; take 10 c.c. and evaporate to dryness in a weighed porcelain capsule, and weigh; the increase of weight will equal the amount of salt in 10 c.c.; multiply this result by 10, and it will equal the amount of salt in 100 c.c. of solution. Suppose that 100 c.c. of the concentrated salt solution contains 35 grams of salt. Suppose 45 litres of the normal salt solution is required. If the salt were pure:

$$\overset{\text{At. Wt. Ag.}}{108} : \overset{\text{At. Wt. NaCl}}{58.5} :: 45 \times 10 : x = 243.75 \text{ grams} =$$

weight of pure salt required. But on evaporation of 100 c.c. of solution, only 35 grams of salt were obtained; therefore, pure salt $(243.75 \div 35) \times 100 = 696.29$ = number of cubic cent. salt solution required for 45 litres of water. Since in adding the salt solution we also add 696.29 c.c. of water, therefore, 45 litres — 696.29 c.c., or 44 litres 304 c.c. of water must be added.

Decime Salt Solution.—This is a solution of common salt only one-tenth the strength of the former; *i.e.*, 100 c. c. will exactly precipitate 0.1 gram, 1 c.c. will precipitate 1 milligram of silver. The solution is made by diluting the *normal salt solution* with 8 parts of pure water.

Decime Silver Solution.—Dissolve 1 gram of pure silver in nitric acid, and dilute to a litre; 1 c.c. of the solution will contain 1 milligram of pure silver.

The *decime silver solution* is equivalent to the *decime salt solution*; *i.e.*, if mixed in equal quantities, they will mutually suffer complete decomposition.

The *normal salt solution*, after being prepared, is tested and accurately standardized. In three bottles of 250 c.c. capacity (8 oz.), 1 gram of silver is dissolved (in each) in nitric acid, and the whole largely diluted with water; then 100 c.c. of *normal salt solution* is allowed to pass into the bottle, when chloride of silver is precipitated; the bottle, being closed by a well-fitting glass-stopper, is shaken for quite a while; if the solution is clear on standing, the *normal solution* is of the right strength, unless, by adding some of the decime salt solution, a precipitate is produced; add 2 thousandths of the *decime salt solution*, agitate as before, and when solution becomes clear, add again 2 thousandths decime salt, and repeat the operation until a precipitate fails to appear. Suppose there have been added 16 thousandths. The last two produced no precipitate and are not counted. The two preceding thousandths were only needed in part, so that the acting thousandths were above 12 and below 14 = 13 in number. Thus, 1013 parts of normal solution are required to precipitate 1 gram of silver, while only 1000 parts or 100 c.c. should be required. The solution is too weak, and the quantity of salt solution to be added may be found by considering that 696.29 c.c. have produced a standard of only 1000–13 or 987 thousandths. It remains to provide for the 13 thousandths. The additional quantity of salt solution required is found as follows:

987 : 696.29 :: 13 : x = 9.2 c.c. of *concentrated solution* to

be added. After this is added, the solution is tested the same as before.

A.—PRELIMINARY ASSAY.

Weigh out one gram of the *alloy* and wrap it in a sheet of lead (one sheet of lead about two inches square, weighing $\frac{17}{100}$ ounces, or 5.287 grams), and cupel in the ordinary manner. Suppose a button of *silver* is obtained weighing 0.8695 grams; then—

$$\overset{\text{Gram.}}{1} : 0.8695 :: 1000 : x = 869.5 = \text{approximate fineness.}$$

This must be corrected for the unavoidable losses of a fire-assay (Table from Mitchell). The corrections are given in thousandths, and are in all cases to be added to the standards of cupellation.

TABLE OF CORRECTIONS FOR LOSS IN CUPELLATION.

STANDARD.	CORRECTION.	STANDARD.	CORRECTION.	STANDARD.	CORRECTION.
998.97	1.03	645.29	4.71	297.40	2.60
973.24	1.76	620.30	4.70	272.42	2.58
947.50	2.50	595.32	4.68	247.44	2.56
921.75	3.25	570.32	4.68	222.45	2.55
896.00	4.00	545.32	4.68	197.47	2.55
870.93	4.07	520.32	4 68	173.88	2.12
845.85	4.13	495.32	4.68	148.30	1.70
820.78	4.22	470.50	4.50	123.71	1.29
795.70	4.30	445.69	4.31	99.12	0.88
770.59	4.41	420.87	4.13	74.34	0.66
745.38	4.52	396.05	3.95	49.56	0.44
720.36	4.64	371.39	3.61	27.78	0.22
695.25	4.75	346.73	3.27		
670.27	4.73	322.06	2.94		

The number in the column of standards next nearest to 869.5 is 870.93, and the corresponding correction is 4.07; adding this to 869.5 we obtain 873.57 for the true approximate fineness.

B.—ASSAY PROPER.

Take such a weight of the alloy as will contain one gram of pure silver. This is found from the approximate fineness by the following proportions:

$$873.57 : 1000 :: 1 : x = 1.145 \text{ grams.}$$

Put this amount in an 8 oz. stoppered bottle and dissolve it in nitric acid. Add 100 c.c. of *normal salt solution*, and proceed the same as in testing normal salt solution until the decime salt fails to give a precipitate. Suppose six thousandth of the decime salt solution were added; the last gave no precipitate, so that more than 4 and less than 5 or 4.5 thousandths are required. Add 1.5 thousandths of *decime silver* solution; this will decompose 1.5 thousandths of the decime salt, which was added in excess; it is known that 4 thousandths decime salt were wholly required; the fifth gave a precipitate, but was only required in part; the 1.5 thousandth decime silver added will decompose 1.5 thousandths decime salt; add now 0.5 thousandths decime silver; if a precipitate is produced, between 4 and 4.5 or 4.25 thousandths decime salts were required. If no precipitate was found on the addition of the 0.5 decime silver solution, 4.5 would thus be proved correct. Suppose, however, that a precipitate had been obtained, the number of thousandth normal salt solution would be 1000 (100 c.c.)* + 4.25 decime = 1004.25; *i. e.*, the weight of alloy taken contained exactly 1004.25 milligrams, *equal to* 1.00425 grams of fine silver. The fineness is given by the following proportion:

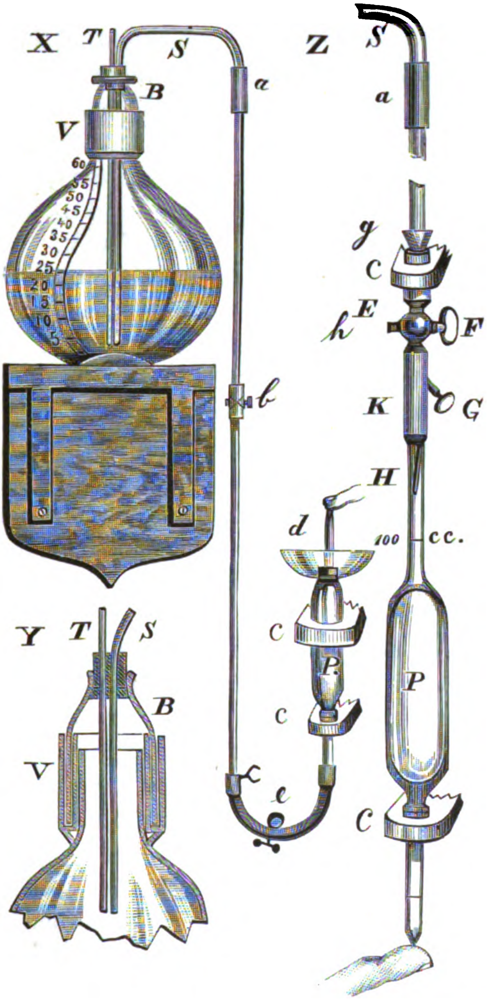
$$1.145 : 1.00425 :: 1000 : x = 877.07 \text{ (fineness).}$$

The pieces of apparatus peculiar and most essential to the assay of silver coin and bullion are the reservoir for contain-

---

* For sake of convenience the pipette of 100 c.c. was divided into 1000 parts.

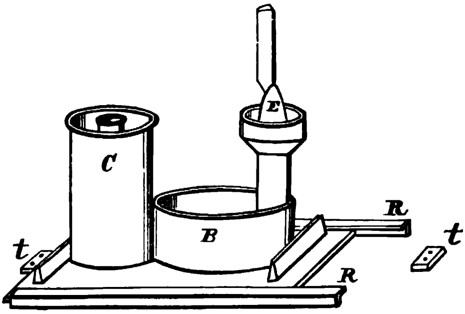
ing, and the pipette with its connections for measuring the normal solution.



A common glass carboy is a very suitable vessel for a reservoir, and is easily obtained and adapted to its purpose. The following figure will show the method of arranging and connecting it with a simple measuring-apparatus. The carboy will hold about 60 litres, or 15–16 gallons. It has a paper scale affixed to it, which is graduated by adding, successively, a known number of litres of water until the carboy is filled, and marking, after each addition, the height of the liquid.

B and V are parts of an hydraulic valve. B is a bell, or cover of glass, through which the tubes pass, being fitted by means of a cork. V is the neck of sheet-iron, about four inches deep. The valve is closed with mercury, which should fill the neck to about one-third of its height. An enlarged section of the valve and tubes is shown at Y. The tube T and the siphon S reach nearly to the bottom of the carboy; the former admits air to the carboy, and as no air can pass out by the tube, evaporation is effectually prevented. The siphon is jointed with rubber-tubing at "a," and has a stop-cock at "b." It is furnished, at the lower end, with a piece of rubber-tubing of sufficient length for connecting it with the lower end of the pipette P; the latter is supported by the brackets "cc," which are themselves affixed to the wall of the room, or to an upright standard. The upper extremity of the pipette passes through a vessel, "d," designed to catch the liquid running over from the former.

The method of using the apparatus is, to attach the tube to the pipette, as shown in the figure; open the pinch-cock "e," and allow the normal solution to flow upwards into the pipette until the latter overflows. Stow the flow and close the pipette with the finger, as shown; upon removing the rubber-tube, and wiping off with a sponge any of the solution adhering to the outside of the pipette below, the latter is ready to deliver exactly 100 c.c. of liquid into the bottle placed to receive it. The method of measuring the normal solution is employed at the United States Assay Office in New York; it certainly has the merit of being simple and expeditious. We have shown at Z the form of apparatus in use for the same purpose at the School of Mines, New York. By this arrangement the pipette is filled from above. EE are two sockets, separated by a stop-cock, F. The upper one, which is screwed inside, is connected by means of a cork "g," with the siphon S, which conducts the normal solution. The lower socket is cemented to the pipette, and is furnished with a conical air-tap, G. Below the air-tap G, and soldered to the socket, is a very narrow silver tube H, conducting the solution into the pipette, and allowing the escape of displaced air by the air-tap. The cock F is provided with a thumb-screw "h," by means of which it is adjusted on its seat; "cc" are brackets for the support of the pipette and tube. To use the apparatus: open the air-tap G, and close the lower orifice of the pipette with the finger; open the cock F, and allow the solution to fill the pipette above the 100 c.c. mark, then close the cock and air-tap. The finger may now be removed, and the solution lowered to the 100 c.c. mark by allowing air to enter slowly through the tap G. When the liquid reaches the proper level, close the tap and remove with a sponge any of the solution adhering to the outside of the pipette, which is now ready, on opening the air-tap, to deliver exactly 100 c.c. of the normal solution. To facilitate the last part of the operation we employ the following contrivance:



C is a cylinder of tin plate to receive the assay bottle. m is a sponge enveloped in linen and forced into a tube of tin plate, terminated above by a cup, open below, so that the liquid may run into the vessel B, on which the tube is soldered. The whole of this apparatus is affixed to a sheet of tin plate, movable in two slots, R R. The extent of this movement is determined by two stops, t t, so placed that when the base of the apparatus abuts against one of them, the pipette will be in contact with the sponge, and that, when it strikes the other, the orifice of the pipette will be directly over the centre of the neck of the bottle. The sponge is placed in contact with the pipette immediately after removing the finger.

The precipitated chloride of silver must be exposed to the light as little as possible. Sunlight converts the chloride into a subchloride, liberating chlorine, and thus vitiates the results. This is avoided by placing the bottle in a cylinder of tin plate when about to agitate the solution, and by keeping it, at other times, in some receptacle which will shut out the light. We employ for this purpose a table with a double top; the upper is pierced with holes, along its length, for the reception of the bottles, which, when resting on the lower, hardly project above the top. The table is also provided at the back with a blackboard and means for draining the bottles. On the blackboard are recorded the additions of salt and of silver solution; the former are designated by a + sign, and the latter by a — sign.

The action of sunlight may be prevented by windows of yellow glass, which exclude the chemical rays.

In the foregoing description it has been assumed that the temperature of the normal solution remains the same as that at which it was standardized. Such is not the case in practice, for the temperature varies constantly. At a higher temperature the pipette will contain less salt, and at a lower temperature more salt; consequently the standard of the bullion would be fixed too high in the former and too low in the latter case. It is convenient to standardize the normal solution for a temperature of 20° C. A simple calculation will give the following table of corrections to be made in the estimated standard of bullion, when the temperature of the normal solution is other than that at which it was standardized, or 20° C. The correction is given in milligrams or thousandths, and when positive is added to, and when negative subtracted from, the estimated standard.

CORRECTIONS

FOR ESTIMATED STANDARD OF BULLION CORRESPONDING TO DIFFERENT TEMPERATURES OF THE NORMAL SALT SOLUTION.

Cent. Deg.	Correction.	Cent. Deg.	Correction.	Cent. Deg.	Correction.
10	+0.8	15	+0.6	20	0.0
11	+0.8	16	+0.5	21	−0.2
12	+0.8	17	+0.4	22	−0.4
13	+0.7	18	+0.3	23	−0.6
14	+0.7	19	+0.1	24	−0.8

It is not necessary for the normal solution to have a temperature of 20° C. when it is standardized. Suppose it be 15° C.; from the above table, +0.6 is the correction for 15° C.; *i. e.*, 100 c.c. of a solution standardized at 20° C. will precipitate, at 15° C., 1000.6 milligrams of pure silver. The solution is therefore made of the latter strength, and corrected for a temperature of 20° C.

GOLD COIN AND BULLION.

The assay of gold coin and bullion comprises two determinations: (*a*), of copper or base metal, and (*b*), of gold. The difference between the sum of these two and the total weight of bullion represents the amount of silver.

A.—BASE METAL DETERMINATION.

If the alloy contain no more than 20 thousandths of copper, weigh out 0.500 grams, and cupel with half a sheet of lead.

If it contain more than 20 thousandths of copper, cupel 0.250 grams of the alloy with a whole sheet of lead.

If a large amount of silver be present, cupel 0.500 grams with a whole sheet of lead. The copper is scorified and carried into the cupel, leaving a button of gold (and silver, if there is any). A check assay is made with every set of assays. A proof alloy containing 850 parts of gold, 12 parts copper, and

38 parts silver, may be employed. This ought to lose by cupellation just the 12 parts of copper. It may lose more or less, and, according to the difference one way or the other, we correct the regular assays which have been made under the *same conditions*. Suppose the check assay yielded 11.8 thousandths copper; 0.2 thousandths have been retained, and the proportion of copper in *each of the regular assays* must be increased by that amount.

If the check assay had yielded 12.2 thousandths as the proportion of copper, it would be known that 00.2 thousandths of silver were lost, and the proportion of copper obtained in each of the regular assays would be diminished to this extent.

B.—GOLD PARTING.

Add to 0.5 gram of alloy enough pure silver so that the silver will be twice as much as the gold in its composition.

The assayer can tell by the touchstone about how much silver was originally present. Wrap the alloy .5 gram and silver in a sheet of lead and cupel. If the alloy be above 950 fine, add say 0.005 grams of rolled copper, to toughen the cornet. This addition should be made in the fine gold proof.

The button from cupellation is flattened by the hammer on an anvil. It is then heated to redness in a clay annealing cup placed in the muffle, when it is removed. When cold, it is passed between the rolls of a small flatting-mill. When rolled sufficiently thin, the ribbon is again annealed and wound into a cornet or spiral round a small glass rod.

PARTING.

The cornet is next subjected to the action of nitric acid in a glass matrass of about three ounces capacity. Pure acid, absolutely free from chlorine, is added at different intervals and heat applied. Acids of two different degrees of strength are employed.

The first has a specific gravity 1.16 (21° Baumé); the second a specific gravity of 1.26 (32° Baumé). First pour on acid, 21° B. and heat for ten minutes; replace this by acid 32° B. and boil ten minutes; decant and make a second boiling with acid of the same strength, 32° B. Finally, the cornet is washed with distilled water, the flask is filled completely with water, a porcelain capsule is placed over the neck, and the whole inverted. The cornet falls gently through the water into the capsule, the flask is removed, the water decanted and the cornet dried, and annealed in the muffle.

The weight of this cornet gives the total amount of gold in the sample assayed.

The gold, copper, and silver are reported in thousandths as in the assay of silver bullion.

NATIVE METAL AND ALLOYS.

Rough metal in scales, etc., is left on the sieve during pulverization of ores. The assay of the above material consists, ordinarily, of scorification, cupellation, and parting. The quantity of test lead for scorification would vary in every case; but an appreciation of what has been said already concerning scorification will enable the assayer to judge of the proper quantity.[*]

FINENESS OF ALL GOLD AND SILVER COINED IN THE UNITED STATES.

GOLD.

DATE OF ISSUE.	$20.	$10.	$5.	$3.	$2.50.	$1.	FINENESS IN THOUSANDTHS.
1792	—	270	135	—	67.5	—	916⅔
1834	—	258	129	—	64.5	—	899-9-40
1837	—	258	129	—	64.5	—	900
1849	516	258	129	—	64.5	25.8	900
1853	516	258	120	77.4	64.5	25.8	900
1878	516	258	120	77.4	64.5	25.8	900

---

[*] See Author's Preface.

SILVER.

Date of Issue.	Dollar.	Half-Dollar.	Quarter.	Dime.	Half-Dime.	Three-cent Piece.	Fineness in Thousandths.
1792	416	208	104	416.10	208–10	—	892–4–10
1837	$412\frac{1}{2}$	$206\frac{1}{4}$	$103\frac{1}{8}$	$41\frac{1}{4}$	$20\frac{5}{8}$	—	900
1851	$412\frac{1}{2}$	$206\frac{1}{4}$	$108\frac{1}{8}$	$41\frac{1}{4}$	$20\frac{5}{8}$	* $12\frac{3}{8}$	900
1853	$412\frac{1}{2}$	192	96	382–5	19–1–5	11.52	900
1873	420 †‡	192-9-10	‡ 962–5	‡ 383–5	‡193–10	—	900

* The three-cent piece of 1851 was to be only 750 fine.
† Twelve and a half grams.
‡ Nearly.

ASSAY OF LEAD ORES.

The ore is first properly ground, when 10 grams of it are taken for one assay; this is mixed with 25 grams of black flux or its substitute (10 grams of Na_2CO_3 to 3 grams of flour) on a piece of glazed paper; this is put into a Hessian crucible. Three wire loops, after being sandpapered, are put in so that they cross each other on top, and the charge is covered with salt. It is then introduced into the fire and covered, where it is left equal times to and from fusion. That is, if it takes twenty-six minutes to fuse the charge, leave it in six minutes longer; then remove it from the fire, and set it aside to cool. When perfectly cool, the crucible is broken, the button is hammered on an anvil into a cube and weighed. The weight will equal, when multiplied by 10 ($\frac{100}{10}$), the percentage of lead in the ore. Three assays of each ore ought to be made, and the average will equal the true percentage if the results of all are about the same. The above method, I have found, gives better results than any other yet known.

ASSAY OF TIN ORES.

Ten grams of the pulverized ore is mixed thoroughly on glazed paper with 10 grams of cyanide of potassium (KCy). This is introduced into a crucible (Hessian crucible) lined with chalk and covered with salt. The crucible is then introduced into a very hot fire and covered over. If it takes ten minutes to fusion, leave the crucible in ten minutes longer; then take out and set one side to cool. When cold, crack crucible and weigh button, its weight multiplied by 10 will equal the percentage of tin in the ore. Three assays of each ore ought to be made, and the average will equal the true percentage, if the results are about alike in each.

The crucible may be lined by a paste of chalk; then dried.

ASSAY OF ANTIMONY.

Ten grams of the pulverized ore is mixed thoroughly on a sheet of glazed paper with 30 grams of potassium cyanide (KCy), and introduced into a (Hessian) crucible and covered with salt. The crucible is then introduced into a very quick fire, covered over and left in for eight minutes, when it is taken out and put one side to cool. When cold, the crucible is cracked and the button taken out and weighed. It is better to do duplicate assays. The weight of the button multiplied by 10 will equal the percentage.

PLATINUM.

The assay of platinum may be performed as follows:

*Fusion with lead.**—Weigh and pulverize the sample as finely as possible, and sift; the metallic residue will contain most of the metal sought for. Weigh the residue and siftings separately.

1. Siftings.—Charge 20 grams in a small crucible with

Litharge	50	**grams.**
Borax glass	15	"
Soda	30	"
Charcoal	1	"

---

* Taken from "Notes on Assaying." (Ricketts.)

Part of the soda should be mixed with the charge, and part used as cover. The proportion of fluxes may be varied to suit the gangue, so as to render the slag as fusible as possible.

The litharge is reduced by the charcoal, and alloys with the platinum and foreign metals, save osm-iridium, which will be found principally under the lead-button. The lead-button is then broken out, scorified with a little borax glass, if too large, and cupelled at as high a temperature as possible in an ordinary bone-ash cupel until it solidifies. The residue will be platinum, with a little silver, gold, etc. It may be purified by fusing in a crucible of cut lime, which is heated by coal-gas, the combustion being supported by a current of oxygen.

The lead retained in the unpurified button is about one-eighth to one-quarter of its weight.

2. Residue.—Fuse directly in a scorifier with pure lead and borax glass, cupelling the whole or a weighed portion of the resulting button if it be too large, as in 1.

Remarks.—In place of the method used for the siftings, pure galena and iron wire might be employed, as in the assay for lead; other fluxes being added to suit.

In the charge given for siftings, twenty to thirty grams of granulated lead in addition to the litharge can be used with advantage. Instead of cupelling the lead-button containing the platinum alone, add five or six times the weight of the platinum in silver. This gives a result free from lead. The silver can afterwards be deducted in the calculation of the platinum.

Chemistry of Man.

ANALYSIS OF A MAN.

(By Prof. Miller.)

A man 5 feet 8 inches high, weighing 154 pounds.

	lbs.	oz.	grs.
Oxygen	111	0	0
Hydrogen	14	0	0
Carbon	21	0	0
Nitrogen	3	10	0
Inorganic elements in the ash:			
Phosphorus	1	2	88
Calcium	2	0	0
Sulphur	0	0	219
Chlorine	0	2	47
1 ounce = 437 grains.			
Sodium	0	2	116
Iron	0	0	100
Potassium	0	0	290
Magnesium	0	0	12
Silica	0	0	2
Total	154	0	0

The quantity of the substances found in a human body weighing 154 lbs.:

	lbs.	oz.	grs.
Water	111	0	0
Gelatin	15	0	0
Albumen	4	3	0
Fibrine	4	4	0
Fat	12	0	0
Ashes	7	9	0
Total	154	0	0

THE BLOOD.

The blood is one of the principal fluids of the body which is intended for its nutrition, and exists in two states:

Blood	Arterial blood—bright-red or scarlet.
	Vein blood—dark-red or purple.

Blood has a clammy feel, salt to the taste, slightly alkaline, and has a specific gravity of about 1.055; is viscid, drying rapidly.

When blood is allowed to coagulate, the fibrine entangles the globules, and forms a clot and a fluid:

Blood	Plasma or Liquor Sanguinis.
	Serum.

The plasma consists of:

Plasma	Fibrine.
	Blood-cells or corpuscles.

The serum:

Serum	Albumen.
	Water.
	Salts.

The fibrine only becomes solid on allowing the blood to coagulate, as it is held in solution in the blood.

ANALYSIS OF BLOOD.

(By M. Gorrup Besanez.)

	1st spec.	2d spec.
Water	796.93	783.63
Solid matters	203.07	216.37
Fibrine	1.95	1.56
Corpuscles	103.28	115.12
Albumen	70.75	62.74
Extractive matter and salts	27.14	36.94

COMPARISON OF THE ARTERIAL AND VENOUS BLOOD.

(BY MM. POGGIALE AND MARCHAL.)

	MAN. Arterial Blood in 1000 parts.		MAN. Venous Blood in 1000 parts.
Water	822.46	....	818.39
Solid matter	177.54	....	181.59
Fibrine	6.17	....	6.08
Albumen	66.03	....	61.87
Fatty matter	1.10	....	1.20
Globules	97.46	....	106.05
Sodic chloride	3.15	....	3.29
Soluble salts	2.10	....	2.19
Calcic phosphate	0.79	....	0.76
Ferric oxide	0.63	....	0.58
Loss	0.11	....	0.09
Total	1000.00	....	1000.00

MEAN COMPOSITION OF MALE AND FEMALE VENOUS BLOOD.

(BY BACQUEREL AND RODIER.)

	Male.		Female.
Density of defibrinated blood	1060.00	....	1017.50
Density of serum	1028.00	....	1027.40
Water	779.00	....	791.10
Fibrine	2.20	....	2.20
Fatty matters	1.60	....	1.62
Serolin	0.02	....	0.02
Phosphorized fat	0.49	....	0.46
Cholesterin	0.09	....	0.09
Saponified fat	1.00	....	1.04
Albumen	69.40	....	70.50
Blood-corpuscles	141.10	....	127.20
Extractive matters and salts	6.80	....	7.40
Sodic Chloride	3.10	....	3.90
Other soluble salts	2.50	....	2.90
Earthy phosphates	0.33	....	0.35
Iron	0.57	....	0.54

COMPOSITION OF THE ASH OF HUMAN BLOOD.

(By Enderlin.)

Trisodic phosphate	22.100	83.746	Soluble Salts.
Sodic chloride	54.769		
Potassic chloride	4.416		
Potassic sulphate	2.461		
Calcic phosphate	3.636	15.175	Insoluble Salts.
Magnesic phosphate	0.769		
Ferrous oxide and ferrous phosphate	10.770		
	98.921		

BLOOD GLOBULES.

Blood-globules are often called *blood-corpuscles* or blood-disks. There are two kinds: red and white. The red globules are round, having a concave center, raised on the edge; their diameter varies between $\frac{1}{4000}$ and $\frac{1}{2800}$ of an inch; average, about $\frac{1}{3500}$ of an inch. There are from three to four hundred times as many red globules as white (Harley.) Fifty times as many (Todd and Bowman). The white globules are much larger than the red globules, and they have a granular surface. Their diameter is about $\frac{1}{2500}$ of an inch.

DIAMETER OF RED GLOBULES.

(By Mr. Gulliver.)

In the Ape	$\frac{1}{3400}$ of an inch.	In the Cat	$\frac{1}{4400}$ of an inch.
" " Horse	$\frac{1}{4600}$ " " "	" " Fox	$\frac{1}{4100}$ " " "
" " Ox	$\frac{1}{4200}$ " " "	" " Wolf	$\frac{1}{3600}$ " " "
" " Sheep	$\frac{1}{5300}$ " " "	" " Elephant	$\frac{1}{2700}$ " " "
" " Goat	$\frac{1}{6300}$ " " "	" " Red-deer	$\frac{1}{5000}$ " " "
" " Dog	$\frac{1}{3500}$ " " "	" " Musk-deer	$\frac{1}{12000}$ " " "

The amount of blood in proportion to the entire weight of a body is as 1 : 8. So that a man weighing 145 lbs. contains on the average 18 lbs. of blood.

ANALYSIS OF BLOOD-CORPUSCLES AND OF LIQUOR SANGUINIS OR PLASMA.

(By Lehman.)

	Blood Corpuscles.		Liquor Sanguinis.
Water	688.00		902.90
Solid constituents	312.00		97.10
Specific gravity	1.0885		1.021
Hæmatin	16.75	Fibrin.	4.05
Hæmato crystallin	241.07	Albumen.	78.84
Cell membranes	41.15		—
Fat	2.31		1.72
Extractive matter	2.60		3.94
Mineral substances (exclusive of iron).	8.12		8.55
Chlorine	1.686		3.644
Acid sulphuric	0.066		0.115
Acid phosphoric	1.134		0.191
Potassium	3.328		0.323
Sodium	1.052		3.341
Oxygen	0.667		0.403
Calcic phosphate	0.114		0.311
Magnesic phosphate	0.073		0.222

DETECTION OF HUMAN BLOOD BY THE MICROSCOPE.

The crystals which form in blood under certain circumstances, and when treated by certain reagents, affords a means of detecting human blood from other blood.

Blood { may form Hæmatin crystals.
" " Hæmatoidin crystals.
" " Hæmin "

"**Hæmatin crystals** found in normal blood, particularly in the spleen, may be obtained by agitating the blood with water or ether, so that the blood corpuscles are ruptured and their contents crystallized." (See drawing below.)

"**Hæmatoidin crystals** are found in old clots." (See below.)

"**Hæmin crystals** may be made by mixing dried blood with equal quantity of common salt, and boiling it with a few drops of glacial acetic acid till the whole has dissolved. A drop of the mixture on the slide will show the crystals on cooling."

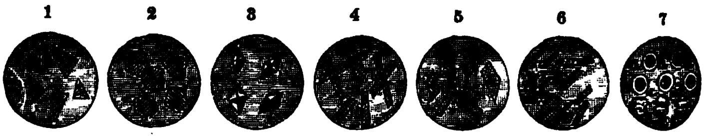


Figure 1 represents the crystals from blood of a guinea-pig (trihedral).
" 2 " " " " " " " squirrel (pentagonal).
" 3 " " " " " " " rat and mouse (octahedral).
" 4 " " " " human blood (hæmatin crystals).
" 5 " " " " " " (hæmatoidin crystals).
" 6 " " " " " " (hæmin crystals).
" 7 *a* represents *red corpuscles*, and *b* represents *white corpuscles*.

MUCUS.

Mucus is prepared in the follicles or glandulæ with which nearly all the mucous membranes are provided.

"Mucus is a clear colorless fluid which is poured out in large or small quantity on the surface of the mucous membranes. It is distinguished from other secretions by its viscidity, which is its most marked physical property, and which depends on the presence of a peculiar animal matter, known under the name of mucosine. When mixed with other animal fluids, this viscidity is so great that the mucus has nearly a semi-solid or gelatinous consistency."

Mucus is very smooth and slippery (slimy) to the touch, and this property enables it to protect the mucous membrane from injury, and facilitates the passage of foreign substances.

The following is an analysis of the pulmonary mucus, that is, the fluid secreted by the follicles of the trachea and bronchial tubes:

(By Nasse.)

Water	955.520
Solid constituents	44.480
Mucin, with a little albumen	23.754
Water extract	8.006
Alcohol extract	1.810
Fat	2.887
Sodic chloride	5.825
" sulphate	0.400

Sodic carbonate	0.198
" phosphate	0.080
Potassic phosphate, with trace of iron	0.974
" carbonate	0.291
Silica, and potassic sulphate	0.255

Mucus, when viewed under the microscope (200 diameters), is seen to consist of granular oval corpuscles and epithelial scales, and a watery fluid. This fluid, if examined under a more powerful magnifier, is seen to consist of minute molecular particles, which have not been studied as yet. The average diameter of the mucous-corpuscles is about $\frac{1}{2000}$ of an inch; they vary considerably.

SEBACEOUS MATTER.

Sebaceous matter is produced in the human subject in three forms: first, by the sebaceous glands of the skin; second, by the ceruminous glands of the external auditory meatus; and third, by the meibomian glands of the eyelid.

Sebaceous matter is characteristic by containing a very large proportion of fatty or oily ingredients.

COMPOSITION OF THE SEBACEOUS MATTER OF THE SKIN.

(By Esenbeck.)

Animal substances	358
Fatty matters	368
Calcic phosphate	200
" carbonate	21
Magnesic carbonate	16
Sodic chloride, acetate, etc.	37
	1000

PERSPIRATION.

Perspiration is a clear-colored watery liquid, with a distinctly acid reaction, and a specific gravity of 1.003 or 1.004. Lavoisier and Seguin found that in 24 hours about 13.500 gr., or nearly two pounds avoirdupois of perspiration was given out of a healthy person. It appears that the lungs exhale during the same time over 8000 grains; so that from the lungs and skin combined the watery exhalations amount on the average to rather more than three pounds per day. The amount of perspiration discharged during violent exercise has been known to rise as high as 5000 or 6000 grains per hour. Southwood Smith found that the laborers employed in heated gasworks lost by both cutaneous and pulmonary exhalation as much as 3½ pounds weight in less than an hour.

COMPOSITION OF PERSPIRATION.*

Water	995.50
Sodic chloride	2.23
Potassic chloride	0.24
Sodic and potassic sulphate	0.01
Sodium and potassium united to organic acids	2.02
	1000.00

TEARS.

This secretion is a clear, alkaline, watery fluid, containing an organic substance similar to albumen, and saline matters consisting for the most part of sodic chloride. The following is its composition:

COMPOSITION OF TEARS.

(*Taken from* ROBIN, *Leçon sur les Humeurs.*)

Water	982.0
Albuminous matter	5.0
Sodic chloride	13.0
Other mineral salts	.2
	1000.2

MILK.

The fluid secreted by the mammary glands of women (as in the case of all animals), near the end of utero-gestation during

---

* This analysis and the above remarks are taken from different parts of an article on Perspiration, in Dalton's Physiology.

a period which varies considerably and has not been accurately determined, as also the fluid secreted for a few days after delivery, is called *colostrum.*

Flint describes the colostrum secreted before delivery as a thickish, stringy fluid, which bears little resemblance to perfectly-formed milk.

The colostrum after delivery the author has always found to be a light yellowish, opaque, alkaline fluid, having, as Flint says, "a mucilaginous consistence."

The following table contains an analysis of the colostrum of a white and colored woman:

CONSTITUENTS.	COLOSTRUM WHITE WOMAN. *Average.* (TIDY.)	COLOSTRUM COLORED WOMAN. (MOTT.)
Water	84.077	85.01
Solids	15.923	14.99
	100.000	100.00
Fat	5.781	4.31
Casein	3.228	3.22
Albumen		.88
Milk-sugar	6.513	6.05
Mineral salt	0.335	0.53
	15.923	14.99

From observations, microscopical and otherwise, the author has come to the conclusion that on the eighth or tenth day after delivery all the characters of the colostrum disappear, and the secretion becomes normal, that is to say, healthy milk. In some very rare cases, though, a few colostrum corpuscles and masses of agglutinated milk-globules may be discovered after the tenth day, but such cases are very rare.

The following table contains analyses of pure healthy woman's milk:

CONSTITUENTS.	*White Woman's Milk. Average, 89 Anal.* (VERNOIS and BECQUEREL).	*White Woman's Milk. Average, 14 Anal.* (TIDY).	*Colored Woman's Milk. Average, 12 Anal.* (MOTT).
Water	88.908	87.806	86.34
Milk solids	11.092	12.193	13.66
	100.000	100.000	100.00
Fat	2.666	4.021	4.03
Casein	3.924	3.523	3.32
Milk-sugar	4.364	4.265	5.71
Inorganic salts	0.138	0.285	0.60
	11.092	12.193	13.66

Human milk is white, bluish-white, and more rarely yellowish-white opaque fluid, having a slight odor, sweetish taste, and possessing an alkaline reaction. Its specific gravity varies between 1.02561 — 1.04648 (Vernois and Becquerel). Its average specific gravity, according to Simon, is 1.032. The average specific gravity of colored woman's milk is 1.0223.

If a drop of milk be examined under the microscope, myriads of beautifully formed globules of various sizes will be seen suspended in a clear liquid. These globules are known as milk-globules, are of a slight yellow color, dark around the edges, and exhibit a pearly gloss. The diameter of the human milk-globule is not larger than $\frac{1}{2000}$ of an inch, and most of them are about $\frac{1}{10000}$ of an inch. The colostrum-corpuscles spoken of above are somewhat larger; their diameter varies between $\frac{1}{7500}$ to $\frac{1}{500}$ of an inch; these corpuscles always make their appearance in the milk, when it is in an unhealthy condition. It is to the envelopes which surround the milk-globules that the opaque and white appearance of milk is due. These envelopes are translucent, and (but to no great extent) refract light.

When the milk is allowed to stand for some time, most of the milk-globules, owing to their low specific gravity, rise to the surface and form a thick, fatty, yellowish-white stratum, to which the name cream has been given. The fluid below the layer of cream has necessarily become poorer in fat; it has a more bluish-white color, and its specific gravity is increased. If this fluid be allowed to stand still longer, the casein which it contains is precipitated, or curdled, that is to say rendered insoluble; at the same time the fluid becomes acid or sour. The acidity is due to the *lactic* acid which has been formed; the lactose or milk-sugar merely having undergone a molecular change. This natural coagulation of milk is due to the growth and development of fungus plants; the lactic acid is not necessary for its progress; the casein undergoes a change similar to the change from soluble silica to insoluble silica.

SALIVA.

"Human saliva, as it is obtained directly from the buccal cavity, is a colorless, slightly viscid and alkaline fluid, with a specific gravity of 1.005. When first discharged it is frothy and opaline, holding in suspension minute whitish flocculi." —(Dalton's Human Physiology.)

COMPOSITION OF SALIVA.

(BY BIDDER AND SCHMIDT.)

Water	995.16
Organic matter	1.34
Potassic sulphocyanide	0.06
Magnesic, sodic and calcic phosphate	.98
Sodic and potassic chlorides	.84
Mixture of epithelium	1.62
	1000.00

The sediment that deposits from human saliva consists of buccal and glandular epithelium, with granular matter and oil-globules.

COMPOSITION OF HUMAN PAROTID SALIVA.

(By Prof. Maurice Perkins.)

Water	983.308
Organic matter precipitated by alcohol	7.252
Substances destructible by heat, but not precipitated by alcohol or acids	4.810
Sodic sulphocyanide	0.330
Calcic phosphate	0.240
Potassic chloride	0.900
Sodic chloride and sodic carbonate	3.060
	1000.000

Saliva required for mastication of 19* ounces of bread = 4572 grains.
" " " " 16* " meat = 3360 "
Secreted in intervals of meals = 12232 "
Total quantity in 24 hours = 20164 "

Or rather less than three pounds additional (Dalton).

GASTRIC JUICE.

The gastric juice should be drawn about fifteen minutes after feeding, separated by filtration from accidental impurities. Its specific gravity is 1.010. Becomes opalescent on boiling, owing to the coagulation of its organic ingredients.

The following is the composition of gastric juice of the dog, based on a comparison of various analyses by Lehmann, Bidder and Schmidt, and other observers.—(Dalton's Physiology, p. 126.)

---

* Allowance for a man in full health.

COMPOSITION OF GASTRIC JUICE.

Water	975.00
Organic matter	15.00
Lactic acid*	4.78
Sodic chloride	1.70
Potassic chloride	1.08
Calcic chloride	0.20
Ammonic chloride	0.65
Calcic phosphate	1.48
Magnesic phosphate	0.06
Iron	0.05
	1000.00

PANCREATIC JUICE.

Pancreatic juice is a clear, colorless, somewhat viscid fluid, having a specific gravity of 1.008 to 1.010, and a distinctly alkaline reaction.

COMPOSITION OF PANCREATIC JUICE.

(By Bidder and Schmidt.)

Water		900.76
Organic matter (pancreatine)		90.38
Sodic chloride		7.36
Soda, free		0.32
Sodic phosphate		0.45
" sulphate		0.10
Potassic sulphate		0.02
Combinations of	Calcic oxide	0.54
	Magnesic oxide	0.05
	Ferrous oxide	0.02
		1000.00

---

* Lehmann finds lactic and hydrochloric acid; more of the former than of the latter. Bidder and Schmidt find, in place of lactic acid, in most of their analyses hydrochloric. Fownes states that "hydrochloric, lactic, butyric, propionic, and acetic acids are present," and gives the sp. gr. 1.002. "It contains two albuminous substances, one insoluble in water and absolute alcohol, the other soluble in water but precipitated by alcohol, tannin, mercuric chloride and lead salts. This is pepsin. In the gastric juice of man it exists to the amount of 0.319 per cent. When the gastric juice has the greatest solvent power, 100 parts of fluid are saturated by 1.25 parts of potash. The gastric juice dissolves the albuminous substances taken as

"The albuminous substance resembles ptyalin, together with leucine, guanine, xanthine, and inosite. The pancreatic juice has three distinct actions—first, on starch; secondly, on fat; and thirdly, on albuminous matter.

"Starch is converted into sugar more energetically by the pancreatic fluid than by the saliva. Fat is changed into fatty acids and glycerine at a temperature of 35° C.; and boiled albumen and fibrin are quickly dissolved at the same temperature, while the alkalescence distinctly remains."

INTESTINAL JUICE.

The intestinal juice is "colorless and glassy in appearance, viscid and mucous in consistency, and has a distinct alkaline reaction. It has the property, when pure, as well as when mixed with other secretions, of rapidly converting starch into sugar at the temperature of the living body."—(Dalton's Physiology.) Frerichs found from 2.2 to 2.6 of solid constituents in the intestinal juice, in which the parts soluble in water amounted to 0.87%, the fat 0.195%, and the ash 0.84%. Lehmann only found 2.156% of solid constituents.

BILE.

The bile is very readily obtained from the gall-bladder. It is a "somewhat viscid and glutinous fluid, varying in color and specific gravity according to the species of animals from which it is obtained. Human bile is of a dark golden-brown color, ox bile of a greenish yellow, pig's bile of a nearly clear yellow, and dog's bile of a deep brown. Specific gravity of human bile, 1.018; that of ox bile, 1.024; that of pig's bile, 1.030 to 1.036." The bile is distinctly alkaline, and miscible in water in all proportions.

The following is an analysis of the bile of an ox, based on the calculations of Berzelius, Frerichs, and Lehmann (Dalton's Physiology, p. 162):

---

food, and slightly changes their reaction. Thus, albumen, fibrin, casein, legumin, gluten, and chondrin, give rise to as many different peptones."

COMPOSITION OF OX BILE.

Water	880.00
Sodic glyko-cholate	90.00
" tauro-cholate	
Biliverdin	13.42
Fats	
Sodic and potassic oleates, palmitate, and stearate	
Cholesterin	
Sodic chloride	15.24
" phosphate	
Calcic phosphate	
Magnesic phosphate	
Sodic and potassic carbonate	
Mucus of the gall-bladder	1.34
	1000.00

COMPOSITION OF HUMAN BILE.

(By Gorup-Besaney.)

Water	823—908
Solid matter	177— 92
Bile-acids with alkali	108— 56
Fat and cholesterin	47— 40
Mucus and coloring matter	24— 15
Ash	11— 6

The bile is formed or prepared by the liver from venous instead of arterial blood. The most important constituent in the bile is sodic glyko-cholate and tauro-cholate, which substances were discovered in ox bile by Streeker, in 1848. Both these salts are freely soluble in water, and if plumbic acetate be added to the solution, plumbic glyko-cholate is precipitated, which may be filtered off; then if plumbic subacetate be added, a precipitate of plumbic tauro-cholate is produced, which may also be filtered off. The above-named salts, sodic glyko-cholate ($NaC_{26}NO_6$) and sodic tauro-cholate ($Na_2C_{52}H_{90}N_2S_2O_{15}$), only exist in ox bile; the similar compounds in human bile, when in a water solution, are precipitated by plumbic acetate and plumbic subacetate, but, after adding the first of the above reagents, if to the filtrate plumbic subacetate be added, no precipitate is produced. The entire biliary ingredients of human bile are therefore precipitated by both or either of the salts of lead.

"The principal coloring matter of the bile is called *Bilirubin* or *Cholipyrrhin.* When dry it is reddish-brown and uncrystallizable, insoluble in water, more soluble in alcohol, which it colors yellow, and most soluble in caustic alkali. On the addition of nitric acid to the yellow alkaline solution, a change ensues. The color passes through green, blue, violet, and red; after some time, the liquid again turns yellow, probably in consequence of a gradual process of oxidation.

"Another coloring matter of bile is called *Biliverdin.* It is dark-green, amorphous, without taste or smell, insoluble in water, slightly soluble in alcohol, but soluble in ether."

PETTENKOFER'S TEST.

Add to the watery solution of the bile or of the biliary substances, one drop of a solution of sugar in water (1 pt. of sugar to 4 pts. of water); then add sulphuric acid, drop by drop; a white precipitate forms (which is abundant in case of an ox, less in a dog), which dissolves in excess of acid. The acid is added until the solution assumes a somewhat syrupy consistency and an opalescent look, owing to the development of minute bubbles of air. A red color begins to show itself at the bottom of the mixture, and afterwards spreads until the whole fluid is a clear, bright cherry red. This color gradually changes to a lake, and finally to a deep, rich opaque purple. Add now three or four volumes of water to the mixture; a copious precipitate forms, and falls down; the color is destroyed.

The red color obtained cannot be relied upon as proof of the presence of biliary matter, but if the *purple color* is obtained, the presence of biliary matter may be considered proved.

If the biliary matter is present in only small quantities in the solution to be tested, the red color will not show itself for seven or eight minutes, nor the *purple* under twenty or twenty-five minutes.

In delicate reactions "evaporate the suspected fluid to dryness, extract the dry residue with absolute alcohol, precipitate this solution with ether, and dissolve the ether precipitate in water before applying the test. In this manner, all foreign substances which might do harm will be eliminated, and the test will succeed without difficulty.

Draper states that if the average results obtained by Bidder and Schmidt from the cat and dog be applied to the human subject, in an adult man weighing 140 pounds, the daily quantity of the bile will be certainly not less than 16.940 grains, or very nearly 2½ pounds avoirdupois.

The bile is not an active agent in digestion; it might be supposed it was, as it pours into the intestines in the greatest abundance immediately after a hearty meal; this is because the intestinal fluids are themselves present at that time in greatest abundance, and therefore can act upon and decompose the greatest quantity of bile.

CHYLE.

This is an opaque, milky, and feebly alkaline fluid, which varies considerably.

"It is nothing more than the lymph which is constantly absorbed by the lymphatic system everywhere, with the addition of more or less fatty ingredients taken up from the intestines during the digestion of food."

ANALYSIS OF THE CHYLE OF AN ASS.

(BY DR. REES.)

Water	902.37
Albumen	35.16
Fibrin	3.70
Spirit extract	3.32
Water extract	12.33
Fat	36.01
Saline matter	7.11
	1000.00

ANALYSIS OF THE CHYLE OF A HORSE.

(FOWNES' CHEMISTRY.)

Water	91.00 to	96.00 per cent.
Fixed constituents	9.00	4.00
Nuclei and cells	Variable.	
Fibrin	0.19	0.7
Albumen	1.93	4.34
Fat	1.89	0.53
Extractive matter free from salts	7.27	8.34
Soluble salts	7.49	6.78
Insoluble	about 2.00	

The chyle approximates in composition and properties to the blood.

LYMPH.

The lymph is an "opalescent or nearly transparent alkaline fluid, usually of a light amber color and having a specific gravity of 1.022. Its analysis shows a remarkable similarity in constitution between it and the plasma of the blood."

ANALYSIS OF LYMPH.

(BY LASSAIGNE.)

Water	964.0
Fibrin	000.9
Albumen	28.2
Fat	0.4
Sodic chloride	5.0
Sodic carbonate " phosphate " sulphate	1.2
Calcic phosphate	0.5
	998.22

ANALYSIS OF THE LYMPH OF AN ASS.

(By Dr. REES.)

Water	965.36
Albumen	12.00
Fibrin	1.20
Spirit-extract	2.40
Water-extract	13.19
Fat	Trace.
Saline matter	5.85
	1000.00

The following table gives the quantity of fluids secreted and reabsorbed during twenty-four hours, calculated for a man weighing 140 pounds:

(DRAPER'S PHYSIOLOGY, p. 325.)

Saliva	20.164 grains,	or	2.880 pounds.
Gastric juice	98.000 "	"	14.000 "
Bile	16.940 "	"	2.420 "
Pancreatic juice	13.104 "	"	1.872 "
Lymph	27.048 "	"	3.864 "
			25.036 pounds.

"A little over twenty-five pounds of the animal fluids transude through the internal membranes, and are restored to the blood by reabsorption in the course of a single day. It is by this process that the natural constitution of the parts, though constantly changing, is still maintained in its normal condition by the movement of the circulating fluids, and the incessant renovation of their nutritious materials."

BONES.

"At the age of twenty-one years the weight of the skeleton is to that of the whole body as 10.5 to 100 in man, and as 8.5 to 100 in woman, the weight of the body being about 125 or 130 pounds. Bones are constructed of organic matter called *Ossein*, which yields gelatin on boiling, and is made stiff by insoluble earthy salts, of which calcic phosphate [$Ca_3(PO_4)_2$] is the most abundant. The proportion of earthy and animal matter vary very much with the *kind* of bone and with the age of the individual, as will be seen in the following table, in which the corresponding bones of an adult and of a still-born child are compared."—(Fownes' Chemistry.)

BONES.	ADULT.		STILL-BORN.	
	Inorganic Matter.	Organic Matter.	Inorganic Matter.	Organic Matter.
Femur	62.49	37.51	57.51	42.49
Humerus	63.02	36.98	58.08	41.92
Radius	60.51	39.49	56.90	44.10
Os temporum	63.50	36.50	55.90	44.10
Costa	57.49	42.51	53.75	46.25

"The bones of the adult are constantly richer in earthy salts than those of the infant."

The following complete comparative analysis of human and ox bones is due to Berzelius:

	Human Bones.	Ox Bones.
Animal matter soluble by boiling	32.17	33.30
Vascular substance	1.13	
Calcic phosphate with a little calcic fluoride	53.04	57.35
Calcic carbonate	11.30	3.85
Magnesic phosphate	1.16	2.05
Soda and sodic chloride	1.20	3.45
	100.00	100.00

The following is another analysis of bones by Berzelius:

Organic matter:	Gelatin and blood-vessels	33.30
Inorganic and Earthy matter.	Calcic phosphate	51.04
	" carbonate	11.30
	" fluoride	2 00
	Magnesic phosphate	1.16
	Soda and sodic chloride	1.20
		100.00

Some chemists add to this about one per cent. of fat.

TEETH

Have a very similar composition, but contain less organic matter; their texture is much more solid and compact. The enamel does not contain more than 2 to 3.5 per cent. of animal matter, but contains about 81 to 88 per cent. of calcic phosphate, with about 7 to 8 per cent. calcic carbonate and more calcic fluoride than the bones contain.

ANALYSIS OF THE GRAY AND WHITE MATTER OF THE BRAIN.

(By Lassaigne.)

	Gray.	White.
Water	85.2	73.0
Albuminous matter	7.5	9.9
Colorless fat	1.0	13.9
Red fat	3.7	0.9
Osmazome and Lactates	1.4	1.0
Phosphates	1.2	1.3
	106.0	100.0

"It appears from this analysis that the cerebral substance consists of albumen dissolved in water, combined with fatty matters and salts. The fatty matter, according to Fremy, consists of cerebric acid, which is most abundant, cholesterin, oleophosphoric acid, and olein, margarin,* and traces of their acids. The same analyst states that the fat contained in the brain is confined almost exclusively to the white substance, and that its color becomes lost when the fatty matters are removed. According to Vauquelin, the cord contains a larger proportion of fat than the brain; and according to L'Heritier, the nerves contain more albumen and more soft fat than the brain."—(Gray's Anatomy, p. 60, 1870.)

PUS.

There is a number of different substances that are included under the name of pus. The normal secretion is known as *true* or *genuine pus*, the other substances as *spurious* or *false pus.* True pus is the natural secretion of a wounded or otherwise injured surface. It is a creamy, white, or yellowish opaque liquid, having a specific gravity of 1.030 or 1.033.

When viewed under the microscope, it is seen to consist of minute granular corpuscles similar to those in mucus, and serum surrounding them. The diameter of the corpuscles vary considerably, but are about $\frac{1}{2000}$ of an inch in diameter. Pus is neutral to test-paper, although in some rare cases it is either acid or alkaline.

Blue pus sometimes forms on the bandages on which the pus has been discharged. If this be treated with water and agitated with chloroform, a blue crystalline coloring matter (pyocyanin) may be obtained (Fordos).

---

* Margarin is composed of palmitin and stearin.

COMPOSITION OF PUS.

(By Dr. Wright.)

	Pus from a Vomica.	Pus from a Psoas Abscess.	Pus from a Mammary Abscess.
Water	894.4	885.2	879.4
Fatty matter	17.5	28.8	26.5
Cholesterin	5.4		
Mucus	11.2	6.1	—
Albumen	68.5	63.7	83.6
Sodic, potassic, and calcic lactates, carbonates, and phosphates	9.7	13.5	8.9
Iron	A trace.	—	—
Loss	3.3	2.7	1.6
	1000.0	1000.0	1000.0

URINE.

The urine is a clear, amber-colored, watery fluid, possessing when warm an aromatic odor, which disappears upon cooling.

The specific gravity of urine varies. *Urina potus* has a specific gravity varying from 1.003 to 1.009; this urine is light-yellow in color, and is passed after drinking much water. *Urina chyli* has a specific gravity about 1.030; this is passed after the digestion of a full meal. *Urina sanguinis* possesses the average specific gravity 1.015–1.025; this is passed immediately after a night's rest. The average density of the whole urine passed by a man in 24 hours (which varies between 20 and 50 fluid-ounces) is usually from 1.015 to 1.020.

The urine is usually acid to test-paper, but the urine passed shortly after eating is often neutral, or even alkaline, becoming again gradually more and more acid up to the time the next meal is taken (according to Dr. Bence Jones). The acidity of urine is due mostly to mono-sodic orthophosphate (NaH_2PO_4). If the urine is to be examined chemically, it is best to take a sample of all the urine passed in twenty-four hours.*

The following analysis of urine is by Lehmann:

---

* See Scheme for the Analysis of Urine.

COMPOSITION OF THE URINE.

Water	937.682	
Urea	31.450	62.318 solid matter.
Uric acid	1.021	
Lactic acid	1.496	
Water and alcohol extractives	10.680	
Lactates	1.897	
Sodic and ammonic chlorides	3.646	
Alkaline phosphates	7.314	
Sodic phosphate	3.765	
Magnesic and calcic phosphate	1.132	
Mucus	0.112	
	1000.195	

HELLER'S ANALYSIS OF URINE.

PHYSICAL PROPERTIES.

Color.	
Odor.	
Reaction.	Litmus. Turmeric.
Sp. Gr.	Urinometer.
Sediment.	

NORMAL CONSTITUENTS.

Urophæin.	Ur. gtt. 10 + H_2SO_4 oz. ss.	Brown color.
Uroxanthin.	Ur. gtt. 30 + HCl oz. ss.	Amethyst color.
Urea.	Ur. gtt. + HNO_3 gtt.	Nit. Urea Crystals.
Uric Acid.	Ur. + $\frac{1}{8}$HCl + 24 hrs.	Ppt. $\bar{U}$. Crystals
Chlorides.	Ur. + HNO_3 + ($AgNO_3$ + 8Aq.)	Clumpy white ppt.
Sulphates.	Ur. + (Sat. Sol. $BaCl_2$ + $\frac{1}{8}$HCl).	Ppt. within hour.
Earthy Phos.	Ur. + $NH_4(OH)$ in excess.	" " "
Alk. Phos.	Ur. — Earthy Phos. ppt. by $NH_4(OH)$; filt. and add (Sat. Sol. $MgSO_4$ + HCl) made Alk. by $NH_4(OH)$.	Precipitate.

ABNORMAL CONSTITUENTS.

Albumen.	Heat or HNO_3.	Coagulates.
Bile.	Ur. spread on plate + HNO_3 gtt.	Prismatic rings.
Blood Corpuscles.	By microscope.	
Pus Corpuscles.	" "	
Iodine.	Ur. + HNO_3 + Starch.	Blue color.
Sugar.	Ur. + $\frac{1}{3}$ Liquor Potassæ. Boil and let cool.	Brown color.
Urerythrin.	Ur. + $\bar{A}$ + Pb$\bar{A}$.	Fawn ppt.

HUMAN EXCREMENT.

The following are the constituents of human excrement:

Excretin* ($C_{78}H_{156}O_2S$).
Excretolic acid.
Peculiar red coloring matter.
Calcic palmitate and stearate.
Magnesic " " "
Butyric acid.
Taurin.
Calcic phosphate.
Magnesic and ammonic phosphate.
Potassic phosphate.
Insoluble and undigested matters derived from the food.

SUBSTANCE ABSORBED AND DISCHARGED.

The following table gives approximately what is absorbed and discharged during 24 hrs. by a healthy *adult* human subject.

ABSORBED DURING 24 HOURS.†		DISCHARGED DURING 24 HOURS.	
Oxygen	1.470 lbs.	Carbonic acid	1.630 lbs.
Water	4.535 "	Aqueous vapor	1.155 "
Albuminous matter	.805 "	Perspiration	1.930 "
Starch	.660 "	Water of the urine	2.020 "
Fat	.220 "	Urea and salts	.137 "
Salts	.040 "	Fæces	.358 "
	7.230 "		7.230 "

"Rather more than seven pounds, therefore, are absorbed and discharged daily by the healthy *adult* human subject; and for a man having the average weight of 140 pounds, a quantity of material equal to the weight of the entire body

---

* Dr. Marcet estimates the average amount of excretin in each evacuation at about 2.8 grams. In the fæces of an infant, cholesterin was found, but no excretin. The fæces of a man with a diseased pancreas contained a large proportion of sodic bistearate.—(Bowman's Med. Chem., p. 168.)

STERCORINE was found to be an ingredient of the human fæces by Prof. A. Flint, Jr. (Am. Jour. Med. Science, Oct. 1862), and was obtained by him in proportions varying from .0007 to .003 of the whole mass of the fæces.

† Dalton's Human Physiology, p. 370.

thus passes through the system in the course of twenty days."

ANALYSIS OF HUMAN SEMEN.

(By Vauquelin.)

Water	90 parts.
Mucus	6 "
Calcic phosphate	3 "
Sodic phosphate	1 "
	100 "

"To examine the semen* in a pure state, it must be taken from the vasa efferentia of an animal recently dead, and whose death has been produced from intention or accident, but not from disease.

"The seminal fluid, or semen, which it is the function of the testicles to secrete, is always, when evacuated, mixed with the secretions of the vesiculæ seminales and prostate gland, and mucus of the urethra; floating in it are also to be found a greater or less number of epithelial scales.

"The secretions, however, which enter into the composition of the ejaculated fluid, have a relative proportion to each other; that of the vesiculæ seminales amounting to about four-sevenths; that of the testicles and vasa deferentia to about one-seventh; while the remaining portion consists of the products of the prostate gland, mucus of the urethra, etc.

"The † *semen* is a thick, whitish fluid, having a peculiar odor. It consists of a fluid portion called the *liquor seminis*, and solid particles termed seminal granules and spermatozoa.

"The *seminal granules* are round corpuscles, measuring $\frac{1}{4000}$th of an inch in diameter.

"The *spermotozoa* are the essential agents of impregnation, or rather the elements which mix with the elements of the egg or ovum, by which process fecundation is effected. They

---

* Dr. H. J. Jordan. Lecture on the Generative Organs.

† Sexual Physiology by R. T. Trall, p. 22.

are minute, elongated particles, with an oval extremity or body, and a long, slender filament. They move in an undulatory manner, and are supposed by many physiologists to be animalcules.

"The ovum is exceedingly minute, measuring from $\frac{1}{240}$th to 120th of an inch in diameter, consisting externally of a transparent envelope, the *zona pellucida* or vitelline membrane, and internally of the yelk or *vitellus*, a small vesicular body; imbedded in the substance of the yelk, is the germinal vesicle, and this contains a minute substance called the *germinal spot.* The germinal vesicle is a fine, transparent membrane, about $\frac{1}{700}$th of an inch in thickness; the germinal spot is opaque, of a yellow color, and measures $\frac{1}{3600}$th to $\frac{1}{2400}$th of an inch.

"The *ovisacs* contain the ova, and are termed graafrein vesicles. They vary in number from ten to twenty; in size they vary from that of a pin's head to that of a pea."

Miscellaneous Department.

CLASSIFICATION OF THE ELEMENTS.*

(BY MENDELEJEFF.)

The relations between the atomic weights of the elementary bodies and their physical and chemical characters, have been further developed by Mendelejeff in an elaborate paper (Ann. Ch. Pharm. Suppl., viii, 133–229).

Mendelejeff points out that when the elements are arranged according to the order of their atomic weights, from H = 1 to U = 240, the relations between their properties and their atomic weights exhibit the form of a periodic function. If, for example, the fourteen elements whose atomic weights lie between 7 and 36 be thus arranged:

Li = 7; G = 94; B = 11; C = 12; N = 14; O = 16; F = 19.
Na = 23; Mg = 24; Al = 27.3; Si = 28; P = 31; S = 32; Cl = 35.5,

it is seen at once that the characters of these elements vary gradually and regularly as their atomic weights increase, and that this variation is periodical, *i. e.*, varies in the two series in the same manner, so that the corresponding members of these series are analogous to one another; Na and Li; Mg and G; Al and B; Si and C; S and O, etc., forming similarly constituted compounds, or, in other words, possessing equal atomicity or combining capacity. Moreover, the combining capacity of the elements in each series increases regularly with the atomic weight, the first members forming monochlorides, the second dichlorides, the third trichlorides, etc., or corresponding oxides or oxychlorides.

---

* From Watt's Dic. Chem., 2 Suppl.

The physical characters of the elements and their corresponding compounds likewise exhibit remarkable regularity when thus arranged, as may be seen with regard to the specific gravities and atomic volumes of the elements in the second series above given:

	Na	Mg	Al	Si	P	S	Cl
Sp. gr......	0.97	1.75	2.67	2.49	1.84	2.06	1.33
At. volume .	24	14	10	11	16	16	27

	Na_2O	MgO_2	Al_2O_3	SiO_2	P_2O_5	S_2O_6	Cl_2O_7
Sp. gr......	2.8	3.7	4.0	2.6	2.7	1.9	(?)
At. volume .	22	22	25	45	55	82	(?)

Most of the other elements may likewise be arranged in groups of seven, the members of which exhibit similar relations, *e. g.*:

	Ag	Cd	In	Sn	Sb	Te	I
At. weight..	108	112	113	118	122	125 (?)	127
Sp. gr......	10.5	8.6	7.4	7.2	6.7	6.2	4.9

Such a group of seven elements is called by Mendelejeff, a *small period or series.*

The elements which can be thus seriated are contained in the first seven columns of the table on page 547, those in the same column having equal combining capacity, and therefore forming oxides of corresponding composition.

On comparing the several series in this table, it will be observed that the corresponding members of an even, and of the following uneven series (the fourth and fifth, for example) differ from one another in character much more than the corresponding members of two even or two uneven series (*e. g.*, the fourth and sixth, or the fifth and seventh); thus, calcium resembles strontium much more than it resembles zinc. The members of the even series are not so distinctly metalloidal as those of the uneven series; and the last members of the even series resemble in many respects (in their lower oxides, etc.) the first members of the uneven series. Thus, chromium and manganese in their basic oxides are analogous to copper

TABLE I.

SERIES.	GROUP I. — R_2O	GROUP II. — RO	GROUP III. — R_2O_3	GROUP IV. RH_4 RO_2	GROUP V. RH_3 R_2O_5	GROUP VI. RH_2 RO_3	GROUP VII. RH R_2O_7	GROUP VIII. — RO_4
1....	H = 1							
2....	Li = 7	G = 9.4	B = 11	C = 12	N = 14	O = 16	F = 19	
3....	Na = 23	Mg = 24	Al = 27.3	Si = 28	P = 31	S = 32	Cl = 35.5	
4....	K = 39	Ca = 40	— = 44	Ti = 48	V = 51	Cr = 52	Mn = 55	Fe = 56, Co = 59, Ni = 59, Cu = 63.
5....	(Cu = 63)	Zn = 65	— = 68	— = 72	As = 75	Se = 78	Br = 80	
6....	Rb = 85	Sr = 87	(?) Yt = 88	Zr = 90	Nb = 94	Mo = 96	— = 100	Ru = 104, Rh = 104, Pd = 106, Ag = 108.
7....	(Ag = 108)	Cd = 112	In = 113	Sn = 118	Sb = 122	Te = 125	J = 127	
8....	Cs = 133	Ba = 137	(?) Di = 138	(?) Ce = 140	—	—	—	— — — —
9....	(—)	—	—	—	—	—	—	
10....	—	—	(?) Er = 178	(?) La = 180	Ta = 182	W = 184	—	Os = 195, Ir = 197, Pt = 198, Au = 199.
11....	(Au = 199)	Hg = 200	Tl = 204	Pb = 207	Bi = 208	—	—	
12....	—	—	—	Th = 231	—	U = 240	—	— — — —

and zinc. On the other hand, strongly marked differences exist between the last members of the uneven series (haloids) and the first members of the following even series (alkali-metals). Now, between the last members of the even series and the first members of the uneven series there occur, according to the order of the atomic weights, *all* those elements which cannot be included in the small periods. Thus, between Cr and Mn on the one hand, and Cu and Zn on the other, there come the elements Fe, Co, Ni, forming the following transition series:

Cr = 52; Mn = 55; Fe = 56; Co = 59; Ni = 59; Cu = 63; Zn = 65.

In like manner, after the sixth series follow the metals Ru, Rh, Pd; and after the tenth, O_3, Ir, Pt. These two series of seven terms each, together with the three intervening members, form a *long period* of seventeen members.

As these intermediate members are not included in either of the seven groups of short period, they form a group of themselves (the eighth), some of the members of which, viz., Os and Ru, are capable of forming oxides of the form RO_4 or R_2O_8. This group contains nine metals, viz.:

Fe = 56;	Ni = 59;	Co = 59.
Ru = 104;	Rh = 104;	Pd = 106.
Os = 198; (?)	Ir = 195; (?)	Pt = 197.

These metals resemble one another in many respects:

(1.) They are all of gray color and difficult of fusion; the fusibility increases from Fe to Co and Ni, just as in the following series Ru, Rh, Pd, and Os, Ir, Pt. (2.) They possess in a high degree the power of condensing and giving passage to gases, as seen especially in nickel, palladium, iron, and platinum. (3.) Their highest oxides are bases, or acids of little energy, which are easily reduced to lower oxides of more decided basic character. (4.) They form stable double cyanides with the alkali-metals. Fe, Ru, and Os form analogous compounds K_4RCy_6; Co, Rh, Ir form salts having the general formula K_3RCy_6; Ni, Pd, Pt form salts having the composition K_2RCy_4. (5.) All these metals form stable metallammonium salts, resembling one another in many of their characters. Thus, rhodium and iridium form salts analogous in composition to the roseocobaltic salts $RX_3.5NH_3$. (6.) Some of the compounds of these metals, especially those of the higher degrees of combination, are distinguished by characteristic colors.

The metals Cu, Ag, Au are also, on account of analogous behavior, included in the eighth group; although, according to the constitution of their lower oxides, they may also be included in the first group.

The arrangement of the elements in the order of their atomic weights, and the composition of the short and long periods, is more clearly seen in Table II, in which the periods form vertical columns:

Typical Elements.							
			K = 39	Rb = 85	Cs = 133	—	—
			Ca = 40	Sr = 87	Ba = 137	—	—
			—	?Yt = 88?	?Di = 138?	Er = 178?	—
			Ti = 48?	Zr = 90	Ce = 140?	?La = 180?	Th = 231
			V = 51	Nb = 94	—	Ta = 182	—
			Cr = 52	Mo = 96	—	W = 184	U = 240
			Mn = 55	—	—	—	—
			Fe = 56	Ru = 104	—	Os = 195?	—
			Co = 59	Rh = 104	—	Ir = 197	—
			Ni = 59	Pd = 106	—	Pt = 198?	—
H = 1	Li = 7	Na = 23	Cu = 63	Ag = 108	—	Au = 199?	—
	G = 9.4	Mg = 24	Zn = 65	Cd = 112	—	Hg = 200	—
	B = 11	Al = 27.3	—	In = 113	—	Tl = 204	—
	C = 12	Si = 28	—	Sn = 118	—	Pb = 207	—
	N = 14	P = 31	As = 75	Sb = 122	—	Bi = 208	—
	O = 16	S = 32	Se = 78	Te = 125?	—	—	—
	F = 19	Cl = 35.5	Br = 80	J = 127	—	—	—

In the members of the even series (Table I), the metallic or basic character predominates, whereas the corresponding members of the uneven series rather exhibit acid properties. Thus there is a decided difference between V, Nb, Ta, from the even series of the fifth group, and P, As, Sb, Bi, from the uneven series whose highest oxides have a similar constitution R_2O_5, the former yielding less powerful acids than the latter. The members of the even series do not, so far as is known, yield volatile compounds with hydrogen or the alcohol-radicles, like the corresponding members of the uneven series; thus all attempts to prepare the compound $Ti(C_2H_5)_4$ from $TiCl_4$ have been unsuccessful, in spite of the great resemblance between $TiCl_4$, $SiCl_4$, and $SnCl_4$.

The position of the second series seems at first sight to be inconsistent with the general division of the elements into even and uneven series; for most of the members of this series possess acid properties, form compounds with hydrogen and the alcohol-radicles, and some of them are gaseous—in all which characters they rather resemble the elements of the uneven series. It must, however, be observed, with regard to this series: (1) That it does not include an eighth group, like the other uneven series; (2) That the atomic weights of the elements included in it differ from those of the corresponding elements of the following series by only 16, whereas in all the other series this difference ranges from 24 to 28. The difference between the atomic weights of successive even series is generally about 46, but in the elements of the second and fourth series it is only 32–36.

	Li	G	B	C	N	O	F	Na	Mg	Al	Si	P	S	C
	K	Ca	—	Ti	V	Cr	Mn	Cu	Zn	—	—	As	Se	Br
Diff.	32	31	—	36	37	36	36	40	41	—	—	44	46	45

These peculiarities explain the apparent anomalies above mentioned, and, moreover, afford additional evidence of the dependence of the properties of the elements on their atomic weights. To make the elements of the second series analogous in character to those of the fourth, their atomic weights should indeed be smaller than they actually are. Similar anomalies may also be observed in comparison of Na with Ca, and of Mg with Zn, but they disappear in cases of P and As, S and Se, Cl and Br, where the differences in the atomic weights conform to the general rule.

In consequence of the peculiar properties of the elements of the second series, Mendelejeff designates them as *typical elements*, to which category, also, belong hydrogen, and likewise sodium and magnesium, for the reason just stated. These typical elements may indeed be regarded as analogous to the lowest members of homologous series (H_2O and CH_4O, for example), which, as is well known, do not exhibit all the properties of the higher homologues.

The preceding considerations likewise explain the isolated position of hydrogen, the element possessing the lowest atomic weight. According to the form of its salifiable oxide H_2O, and of the salts HX, it belongs to the first group; its nearest analogue is Na, which likewise belongs to an uneven series of the first group. More remote analogues of hydrogen are Cu, Ag, and Au.

Mendelejeff also develops several applications of the law of periodicity, viz.: (1.) To the classification of the elements. (2.) To the determination of the atomic weights of elements whose properties are but little known. (3.) To the determination of the properties of hitherto unknown elements; those, namely, which might be expected to occupy the blank spaces in the preceding tables. (4.) To the correction of the values of atomic weights. (5.) To the completion of our knowledge of the combination-forms of chemical compounds.

For the details of these applications, we must refer to the original paper.

NOTE.—Mendelejeff places the new element Gallium between Aluminum and Indium, Group III (see Table I). Gallium was discovered by M. Lecog Boisbaudran in 1875. Gallium forms an oxide Ga_2O_3. See p. 5.

CHRONOLOGICAL TABLE

OF DEFUNCT ELEMENTS, WITH REFERENCE TO ORIGINAL PAPERS.

(By H. Carrington Bolton, Ph.D.[*])

Note.—Articles referring to the decease of the element are marked by an asterisk.

Date.	Element.	Discoverer.	Reference.
1777..	Edelerde............	Bergmann...	
1780..	Hydrosiderum.......	Meyer.......	Schrift, Geo. Nat. Fr. Berlin, ii, 334; iii, 380.
1784..	Saturnum...........	Mounet......	Journ. de Phys., xxviii.
1788..	Diamantspatherde...	Klaproth....	Beschäft, Ges. Nat. Fr. Berlin, viii, St. 4.
1790..	Australia............	Wedgwood..	Seherer's Allg. Journal, 1790.
1799..	Nameless earth	Fernandez...	Scherer's Allg. J.
1800..	Agusteride..........	Trommsdorff	Scherer's Allg. J., iv. 312. *Gehlen's N. J., i, 445, and v.
1801..	Pneum-alkali......	Hahnemann.	Scherer's Allg. J., v.
1801..	Erythromium or Panchromium.	Del Ris......	Annales des Mines (1), iv. *Ann. Chem. Phys. (2), liii, 268. *Pogg. Ann., xxi, 49.
1808..	Silenium............	Proust.......	Journ. de Phys., lv, 297 and 457. *Gilbert Ann., xiii, 127.
1805..	Niccolanum.........	Richter......	Gilbert Ann., xix, 377.
1805..	Andronia .... Thelike	Winterl. . .	Gehlen's J., iv. Gilbert Ann., xx, 430. *Gehlen's J. (2), iii, 336.
1810..	Junonium...........	Thompson ..	Phil. Mag. (1), xxxvi, 278. Gilbert Ann., xlii, 115. Gilbert Ann., xliv, 113.
1815..	Thorium	Berzelius....	Schweigg. J., xxi, 15. *Pogg. Ann., iv, 145.
1818..	Vestium or Sirium..	Von Vest....	Gilb. Ann., lix, 95 and 387. *Trommsd., J., iii, 1, 292. *Gilb. Ann., lxii, 80.
1818.	Wodanium..........	Lampadius..	Gilb. Ann., lx, 99. *Gilb. Ann., lxiv, 338.
1820..	Crodonium..........	Trommsdorff	Gilb. Ann., lxv, 208. *Gilb. Ann., lxvi, 290.
1821..	Apyre...............	Brugnatelli..	Gilb. Ann., lxvii, 335.
1828..	Ruthenium..........	Osann.......	Pogg., xiii, xiv.
1828..	Pluranium...........	Osann.......	Pogg., xiii, 291.
1828..	Polinium.......	Osann.......	Pogg., xiv, 352.

---

[*] Am. Chem., July, 1870, p. 1.

CHRONOLOGICAL TABLE OF DEFUNCT ELEMENTS—(Continued).

DATE.	ELEMENT.	DISCOVERER.	REFERENCE.
1836..	Donium............	Richardson..	Ann. Chem. Pharm., xix, 154. *Ann. Chem. Pharm., xxiii, 239.
1836..	Treenium..........	Boase.......	Thompson's Records General Science, iv, 20. Chem. Centr., 1836, 616.
1843..	Terbium............	Mosander...	Ann. Chem. Pharm., xlviii, 220. *Ann. Chem. Pharm., cxxxi, 179, and cxxxvii, 1.
1845..	Norium............	Ivanberg....	Berzelius, Jahresb., xxv, 149. *Journ. pr. Chem., lvii, 145; and xcvii, 321.
1846..	Pelopium...........	H. Rose.....	Pogg. Ann., lxix, 115. *Pogg. Ann., xc, 456.
1846..	Ilmenium...........	Herrmann..	Journ. pr. Chem., xxxviii, 109; and xl, 457. *Pogg., Ann., lxxiii, 449.
1850..	Aridium............	Ullgren.....	Journ. pr. Chem., lii, 442. Ann. Chem. Pharm., lxxvi, 239. *Ann. Chem. Pharm., lxxxviii, 264.
1851..	Donarium...........	Bergemann,.	Ann. Chem. Pharm., lxxx, 267. *Ann. Chem. Pharm., lxxxiv, 287.
1852..	Thallium............	Owen.......	Am. J. Sci. (2), xiii, 420. *Am. J. Sci. (2), xvi, 95; xvii, 130.
1853..	Nameless metal of platinum group.	Genth.......	Am. J. Sci. (2), xv, 246.
1854..	Nameless earth in zircons.	Sjögren......	Journ. pr. Chem., lv. 298. *Journ. pr. Chem., lvii, 145.
1857..	Sulphurium........	Jones.......	Mining Journ., July 14, 1857. *Chem. News, vii, 263.
1860..	Dianum............	Von Kobell..	Ann. Chem. Pharm., cxxxvi, 299.
1861..	Nameless earth of calcium group.	Dupré.......	Phil. Mag. (4), xxi, 86. Chem. News, iii, 129.
1862..	Wasium..........	Bahr........	Pogg. Ann., cxix, 572. *Journ. pr. Chem., xci, 316. *Compte's Rendus, lvii.
1863..	Nameless metal of platinum group.	Chandler....	Am. J. Sci. (2), xxxiii, 351.
1864..	Nameless earth in zircons.	Nylander....	Acta Universit. Lundensis, 1864.
1864..	Nameless earth in limestones.	Bischoff.....	Pogg. Ann., cxxii, 646.
1869..	Jargonium..........	Sorby.......	Chem. News (Am. Repr.), iv, 231. *Chem. News (Am. Repr.). Apr., 1870.
1869..	Nameless earth......	Loew........	Annals N. Y. Lyc. Nat. Hist., ix, 211.

PRICE OF METALS.*

(*Arranged by* H. C. Bolton, Ph.D.)†

Metal	State.	Value in Gold per lb. Avoir.	Price in Gold per Gram.	Authority.
Vanadium	Cryst. fused	$4792.40	$10.80	S.
Rubidium	Wire	3261.60	7.20	S.
Calcium	Electrolytic	2446.20	5.40	S.
Tantalum	Pure	2446.20	5.40	S.
Cerium	Fused globules	2446.20	5.40	S.
Lithium	Globules	2228.76	4.92	S.
Lithium	Wire	2935.44	6.48	S.
Erbium	Fused	1671.57	3.96	S.
Didymium	"	1630.08	3.60	S.
Strontium	Electrolytic	1576.44	3 48	S.
Indium	Pure	1522.08	3.36	T.
Ruthenium	—	1304.64	2.88	T.
Columbium	Fused	1250.28	2.76	S.
Rhodium	—	1032.84	2.28	T.
Barium	Electrolytic	924.12	2.04	S.
Thallium	—	738.39	1.63	T.
Osmium	—	652.32	1.44	T.
Palladium	—	498.30	1.10	T.
Iridium	—	466.59	1.03	T.
Uranium	—	434.88	.96	T.
Gold	—	299.72	—	—
Titanium	Fused	239.80	.52	—
Tellurium	"	196.20	.43	—
Chromium	"	196.20	.43	—
Platinum	"	122.31	.27	—
Manganese	"	108.72	.24	T.
Molybdenum	—	54.34	.12	T.
Magnesium	Wire and tape	45 30	.10	T.
Potassium	Globules	22.65	.05	T.
Silver	—	18.60	—	—
Aluminium	Bar	16.30	.036	S.
Cobalt	Cubes	12.68	.028	S.
Nickel	"	3.80	.008	T.
Cadmium	—	3.26	.007	T.
Sodium	—	3.26	.007	T.
Bismuth	Crude	1.95	.0043	S.
Mercury	—	1.00	—	—
Antimony	—	.36	—	T.
Tin	—	.25	Prices taken from recent quotations.	
Copper	—	.22		
Arsenic	—	.15		
Zinc	—	.10		
Lead	—	.06		
Iron	—	.01½		

---

* S. and T. annexed to the price per gram stands for Schuchardt and Trommsdorff, respectively, and indicates the source of the data.

† Am. Chem., June, 1875.

TABLE I.*

Composition of the Ash of Agricultural Plants and Products giving the Average of all trustworthy Analyses published up to August, 1865, by Professor Emil Wolff, of the Royal Academy of Agriculture, at Hohenheim, Wirtemberg.†

No.	Substance.	No. of Analyses.	Per cent of Ash.	Potash.	Soda.	Magnesia.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Silica.	Chlorine.
	I.—MEADOW HAY AND GRASSES.										
1	Meadow hay	13	7.78	25.6	7.0	4.9	11.6	6.2	5.1	29.6	8.0
2	Young grass	1	9.32	56.2	1.8	2.8	10.7	10.5	4.0	10.3	2.0
3	Dead ripe hay	1	7.73	7.6	2.9	3.4	12.9	4.4	0.7	63.1	5.7
4	Rye grass in flower	4	7.10	24.9	4.2	2.1	7.5	7.8	3.8	39.6	5.4
5	Timothy	3	7.01	28.8	2.7	3.7	9.4	10.8	3.9	35.6	5.0
6	Other sweet grasses	39	7.27	33.0	1.8	2.6	5.5	7.8	4.4	37.6	4.1
7	Oats, heading out	6	9.46	41.7	4.4	3.5	7.0	8.8	3.4	27.9	4.4
8	" in flower	7	7.23	39.0	3.8	3.2	6.7	8.3	2.7	33.2	4.0
9	Barley, heading out	5	8.98	38.5	1.7	2.9	7.0	10.1	2.9	31.2	5.6
10	" in flower	5	7.04	26.2	0.6	3.1	6.0	9.8	2.9	48.0	3.5
11	Winter wheat, heading out	2	9.73	34.7	1.9	1.5	4.9	7.4	2.8	41.9	5.8
12	" " in flower	3	6.99	25.7	0.5	2.2	3.1	7.3	1.9	56.3	2.8
13	Winter rye, heading out	1	5.42	38.6	0.8	3.1	7.4	14.7	1.6	32.0	..
14	Green cereals, light	5	7.20	29.6	1.5	3.9	6.6	9.1	4.1	41.4	4.3
15	" " heavy	5	9.21	35.6	3.4	4.7	8.3	8.1	4.8	30.0	5.6
16	Hungarian millet, green (*Panicum germ.*)	2	7.23	37.4	..	8.0	10.8	5.4	3.6	29.1	6.4
	II.—CLOVER AND FODDER PLANTS.										
17	Red clover	56	6.72	34.5	1.6	12.2	34.0	9.9	3.0	2.7	3.7
	a. 15-25 per cent potash	15	6.01	20.8	1.9	18.2	39.7	9.4	3.3	1.2	5.4
	b. 25-35 " "	23	6.74	29.8	1.6	11.8	35.6	10.6	3.0	2.7	2.9
	c. 35-50 " "	18	7.19	46.3	1.4	7.8	27.3	9.2	2.2	2.5	3.2
18	White clover	2	7.16	17.5	7.8	10.0	32.2	14.1	8.8	4.5	3.2
19	Lucern	7	7.14	25.3	1.1	5.8	48.0	8.5	6.1	2.0	1.9
20	Esparsette	2	5.39	39.4	1.7	5.8	32.2	10.4	3.3	4.0	3.0
21	Swedish clover	2	5.53	33.8	1.5	15.8	31.9	10.1	4.0	1.2	2.8
22	*Anthyllis vulneraria*	1	5.60	10.8	4.5	4.6	68.9	7.0	1.6	2.9	0.2
23	Green vetches	2	8.74	42.1	2.9	6.8	26.3	12.8	3.7	1.8	3.1
24	Green pea, in flower	1	7.40	40.8	0.2	8.2	28.7	13.2	3.5	2.6	1.8
25	Green rape, young	5	8.97	32.3	3.8	4.5	23.1	8.7	16.3	3.2	7.6

---

* The following eleven tables have been taken from "How Crops Grow," by Johnson.

† From Professor Wolff's *Mittlere Zusammensetzung der Asche, aller land- und forstwirthschaftlichen wichtigen Stoffe*, Stuttgart, 1865. The above table, being more complete, and in most particulars more exact, than the author's means of reference enable him to construct, and being moreover likely to be the basis of calculations by agricultural chemists abroad for some years to come, has been reproduced here literally. The references and important explanations accompanying the original, want of space precludes quoting. In the table, oxide of iron, an ingredient normally present to the extent of less than one per cent., is omitted. Chlorine is often omitted, not because absent from the plant, but from uncertainty as to its amount. Carbonic acid is also excluded in all cases for the sake of uniformity and facility of comparison.

Composition of the Ash of Agricultural Plants and Products.

No.	Substance.	No. of Analyses.	Per cent of Ash.	Potash.	Soda.	Magnesia.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Silica.	Chlorine.
	III.—ROOT CROPS.										
26	Potatoes	31	3.74	59.8	1.6	4.5	2.3	19.1	6.6	2.3	2.8
27	Artichokes	1	5.16	65.4	...	2.7	3.5	16.0	3.2	...	2.4
28	Beets	15	6.86	53.1	14.8	5.1	4.6	9.6	3.3	3.5	6.6
29	Sugar-beets	44	4.35	49.4	9.6	8.9	6.3	14.8	4.7	3.5	2.0
30	Turnips	15	8.28	39.3	11.4	3.9	10.4	13.8	14.3	2.4	4.1
31	Turnips*	2	7.20	50.6	3.8	2.1	13.4	17.4	6.0	1.1	6.4
32	Ruta-bagas	2	7.68	51.2	6.7	2.6	9.7	15.3	8.4	0.5	5.1
33	Carrots	10	6.27	36.7	22.1	5.3	10.7	12.5	6.4	2.0	3.2
34	Chiccory	7	5.21	40.4	7.7	6.8	8.7	14.5	9.2	6.1	3.7
35	Sugar beet-heads †	1	4.03	29.6	24.4	11.0	9.1	12.8	7.6	2.0	0.5
	IV.—LEAVES AND STEMS OF ROOT CROPS.										
36	Potatoes, August	8	8.92	14.5	2.7	16.8	39.0	6.1	5.6	8.0	4.6
37	" October	1	5.12	6.3	0.8	22.6	46.2	5.5	5.5	4.2	3.0
38	Beets	6	15.96	29.1	21.0	9.7	11.4	5.1	7.4	4.8	11.3
39	Sugar-beets	7	17.49	22.1	16.8	18.3	19.7	7.4	8.0	3.1	5.7
40	Turnips	16	13.68	22.9	7.8	4.5	32.4	8.9	9.9	3.8	8.2
41	Kohl-rabi	1	16.87	14.4	3.9	4.0	33.3	10.4	11.7	10.5	3.9
42	Carrots	7	13.57	14.1	23.1	4.6	33.0	4.7	7.9	5.6	7.1
43	Chiccory	1	12.46	60.0	0.7	3.2	14.3	9.0	9.0	1.0	1.7
44	Cabbage	2	10.81	48.6	3.9	3.8	15.3	15.8	8.5	1.2	2.5
45	Cabbage-stalk	1	6.46	43.9	5.5	4.1	11.3	20.9	11.8	1.1	1.3
	V.—REFUSE AND MANUFACTURED PRODUCTS.										
46	Sugar-beet cake	7	3.15	36.6	8.4	5.6	25.3	10.2	3.9	6.2	4.8
	a. Common cake	2	3.03	25.0	12.7	...	27.2	12.9	5.8	...	13.0
	b. Residue of maceration	2	3.53	35.3	9.4	11.8	27.3	6.0	2.3	...	0.9
	c. Residue from centrifugal machine	1	3.11	45.5	9.8	..	25.3	13.0	6.5	...	...
47	Beet molasses	3	11.28	71.1	10.5	0.4	6.0	0.5	2.1	0.7	10.1
48	Molasses slump‡	1	19.02	89.8		0.9		0.1	1.7	..	1.6
49	Raw beet sugar	1	1.43	33.3	28.0	...	8.5	...	22.9	0.9	5.8
50	Potato slump‡	1	11.10	46.3	6.6	8.8	6.2	20.0	7.3	3.4	2.1
51	Potato fiber§	4	0.99	15.6	...	7.6	47.8	23.9	...	3.1	1.3
52	Potato juice ‖	2	23.45	69.5	...	3.5	1.0	16.3	3.6	0.1	7.5
53	Potato skins¶	3	9.59	72.0	0 7	6.7	9.6	3.4	0.4	2.7	2.1
54	Fine wheat flour	1	0.47	36.0	0.9	8.2	2.8	52.0	...	...	...
55	Rye flour	1	1.97	38.4	1.8	8.0	1.0	48.3	...	...	...
56	Barley flour	1	2.33	28.8	2.5	13.5	2.8	47 3	3.1	...	...
57	Barley dust**	1	5.62	18.9	1.4	7.7	2.5	28.9	...	20.0	. .
58	Maize meal	1	....	28.8	3.5	14.9	6.8	45.0	...	...	...
59	Millet meal	1	1.35	19.7	2.8	25.8	...	47.3	2.7	...	...
60	Buckwheat grits	2	0.72	25.4	5.9	12.9	2.8	48.1	1.7	...	1.6
61	Wheat bran	1	6.43	24.0	0.6	16.8	4.7	51.8	...	1.1	...
62	Rye bran	1	8.22	27.0	1.3	15.8	3.5	47.9	...	...	...
63	Brewer's grains	2	5.17	4.2	0.8	10.1	11.6	38.0	0.8	32.2	...
64	Malt	1	2.78	17.3	...	8.4	3.8	36.5	...	33.2	...
65	Malt sprouts	1	6.56	34.9	...	1.4	1.5	21.0	6.3	29.5	...
66	Wine grounds	1	4.60	53.4	0.5	3.2	15.5	15.5	7.8	...	0.5
67	Grape skins	2	4.04	49.4	2.2	6.1	13.0	20.8	4.4	3.5	0.6
68	Beer	1	...	37.5	7.8	4.9	2.2	32.7	...	10.2	...

---

* White turnips in the original, but apparently no special kind.

† Probably the crowns of the roots, removed in sugar-making.

‡ The residue after fermenting and distilling off the spirit.

§ Refuse of starch manufacture.

‖ Undiluted.

¶ From boiled potatoes.

** Refuse in making barley grits.

COMPOSITION OF THE ASH OF AGRICULTURAL PLANTS AND PRODUCTS.

V.—REFUSE AND MANUFACTURED PRODUCTS.

No.	Substance.	No. of Analyses.	Per cent of Ash.	Potash.	Soda.	Magnesia.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Silica.	Chlorine.
69	Grape must	6	...	62.8	0.9	5.6	4.9	17.7	6.5	1.3	0.6
70	Rape cake	2	6.59	24.8	0.1	11.5	10.9	36.9	3.3	8.7	0.2
71	Linseed cake	1	6.24	23.8	1.4	15.9	8.6	35.2	3.4	6.5	0.6
72	Poppy cake	1	10.60	20.8	4.5	4.8	28.1	37.8	2.0	4.8	...
73	Walnut cake	1	5.86	33.1	...	12.2	6.7	43.8	1.2	1.6	0.2
74	Cotton-seed cake	1	6.95	35.4	...	4.3	4.6	48.8	1.1	4.0	...

VI.—STRAW.

No.	Substance.	No. of Analyses.	Per cent of Ash.	Potash.	Soda.	Magnesia.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Silica.	Chlorine.
75	Winter wheat	12	4.96	11.5	2.9	2.6	6.2	5.4	2.9	66.8	...
76	Winter rye	6	4.81	18.7	3.3	3.1	7.7	4.7	1.9	58.1	...
77	Winter spelt	2	5.56	11.2	0.4	0.9	4.8	6.8	1.8	71.4	...
78	Summer rye	3	5.55	23.4	...	2.8	8.9	6.5	2.6	55.9	...
79	Barley	17	5.10	21.6	4.5	2.4	7.6	4.8	3.7	53.8	...
80	Oats	6	5.12	22.0	5.8	4.0	8.2	4.2	3.5	48.7	...
81	Maize	1	5.49	35.8	1.2	5.5	10.5	8.1	5.2	38.0	...
82	Peas	21	5.74	21.8	5.3	7.7	37.9	7.8	5.6	5.7	6.1
83	Field bean	4	7.12	44.4	3.3	7.8	23.1	7.0	0.2	5.4	13.8
84	Garden bean	5	6.06	37.1	6.0	5.2	27.4	7.8	3.6	4.7	5.2
85	Buckwheat	6	6.15	46.6	2.2	8.6	18.4	11.9	5.8	5.5	7.7
86	Rape	12	4.58	25.6	10.3	5.7	26.5	7.0	7.1	6.7	12.4
87	Poppy	1	7.86	38.0	1.3	6.5	30.2	8.5	5.1	11.4	2.5

VII.—CHAFF, ETC.

No.	Substance.	No. of Analyses.	Per cent of Ash.	Potash.	Soda.	Magnesia.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Silica.	Chlorine.
88	Wheat	1	10.73	9.1	1.8	1.3	1.9	4.3	...	81.2	...
89	Spelt	2	9.50	9.5	0.8	2.5	2.4	7.3	2.3	74.2	...
90	Barley	1	14.23	7.7	0.9	1.8	10.4	2.0	3.0	70.8	...
91	Oats	1	9.22	13.1	4.8	2.6	8.9	0.8	2.5	59.9	...
92	Maize cobs	1	0.56	47.1	1.2	4.1	3.4	4.4	1.9	26.4	...
93	Flax-seed hulls	1	6.62	31.1	4.3	2.8	29.6	2.8	4.8	17.2	6.1

VIII.—TEXTILE PLANTS, ETC.

No.	Substance.	No. of Analyses.	Per cent of Ash.	Potash.	Soda.	Magnesia.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Silica.	Chlorine.
94	Flax straw	8	3.71	36.9	5.1	7.1	22.8	11.5	5.8	6.0	4.0
95	Rotted flax stems	2	2.40	9.0	4.8	5.4	51.4	5.9	3.1	18.8	...
96	Flax fiber	3	0.67	3.3	3.2	5.4	68.6	10.8	2.7	6.2	0.4
97	Entire flax plant	2	4.30	34.2	4.8	9.0	15.5	28.0	4.9	2.6	5.9
98	Entire hemp plant	2	4.60	18.8	3.2	9.6	43.4	11.6	2.8	7.6	2.5
99	Entire hop plant	1	9.87	26.2	3.8	5.8	16.0	12.1	5.4	21.5	4.6
100	Hops	12	6.80	37.3	2.2	5.5	16.9	15.1	2.6	15.4	3.4
101	Tobacco	7	24.08	27.4	3.7	10.5	37.0	3.6	3.9	9.6	4.5

IX.—LITTER.

No.	Substance.	No. of Analyses.	Per cent of Ash.	Potash.	Soda.	Magnesia.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Silica.	Chlorine.
102	Heath	8	4.51	13.2	5.3	8.4	18.8	5.1	4.4	35.2	2.1
103	Broom (*Spartium*)	2	2.25	36.5	2.5	12.4	17.1	8.6	2.5	10.3	2.7
104	Fern (*Aspidium*)	5	7.01	42.8	4.5	7.7	14.0	9.7	5.1	6.1	10.2
105	Scouring rush (*Equisetum*)	2	23.77	13.2	0.5	2.3	12.5	2.0	6.3	53.8	5.7
106	Sea-weed (*Fucus*)	8	14.39	14.5	24.0	9.5	13.9	3.1	24.0	1.7	10.1
107	Beech leaves in autumn	6	6.75	5.2	0.6	6.0	44.9	4.2	3.7	33.9	0.4
108	Oak " " "	1	4.90	3.5	0.6	4.0	48.6	8.1	4.4	30.9	...
109	Fir " (*Pinus sylvestris*)	1	1.40	10.1	....	9.9	41.4	16.4	4.4	13.1	4.4
110	Red pine leaves (*Pinus picea*)	1	5.82	1.5	....	2.3	15.2	8.2	2.8	70.1	...
111	Reed (*Arundo phrag*)	1	4.69	8.6	0.2	1.2	5.9	2.0	2.8	71.5	...
112	Down grass (*Psamma arearia*)	1	.....	29.8	4.0	3.8	16.5	7.2	3.6	18.5	...
113	Sedge (*Carex*)	11	8.08	33.2	7.3	4.2	5.3	6.7	3.3	31.5	5.6
114	Rush (*Juncus*)	7	5.30	36.6	6.6	6.4	9.5	6.4	8.7	10.9	14.2
115	Bulrush (*Scirpus*)	2	3.65	9.7	10.3	3.0	7.2	6.5	5.6	43.8	...

Composition of the Ash of Agricultural Plants and Products.

X.—GRAINS AND SEEDS OF AGRICULTURAL PLANTS.

No.	Substance.	No. of Analyses	Per cent of Ash.	Potash.	Soda.	Magnesia.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Silica.	Chlorine.
116	Wheat	78	2.07	31.1	3.5	12.2	3.1	46.2	2.4	1.7	.....
117	Rye	14	2.08	30.9	1.8	10.9	2.7	47.5	2.3	1.5	.....
118	Barley	34	2.55	21.9	2.8	8.3	2.5	32.8	2.3	27.2	.....
119	Oats	20	3.07	15.9	3.8	7.3	3.8	20.7	1.6	46.4	.....
120	Spelt with husk	2	4.20	17.3	1.8	5.8	2.6	20.0	2.6	44.0	.....
121	Maize	8	1.42	27.0	1.5	14.6	2.7	44.7	1.1	2.2	....
122	Rice with husk	3	7.84	18.4	4.5	8.6	5.1	47.2	0.6	0.6	.....
123	" husked	3	0.39	23.3	4.8	13.4	2.9	51.0	0,6	3.0	.....
124	Millet with husk	2	4.49	11.9	1.0	8.4	1.0	23.4	0.2	52.3	.....
125	" husked	1	1.42	18.9	5.8	18.6	.....	53.6	1.5	.....	...
126	Sorghum	1	1.86	20.8	3.3	14.8	1.3	50.9	.....	7.5	...
127	Buckwheat	2	1.07	23.1	6.2	13.4	3.3	48.0	2.1	.....	1.7
128	Rape seed	15	4.24	23.5	1.1	12.2	13.8	43.9	3.6	1.1	0.3
129	Flax "	3	3.65	32.2	1.8	13.2	8.4	40.4	1.1	1.1	0.1
130	Hemp "	2	5.48	20.1	0.8	5.6	23.5	36.3	0.2	11.8	0.1
131	Poppy "	1	6.12	13.6	1.0	9.5	35.4	31.4	1.9	3.2	4.4
132	Madia "	1	.....	9.5	11.2	15.4	7.7	55.0	.....	.....	.....
133	Mustard "	3	4.30	15.9	5.8	10.2	18.8	39.0	4.7	2.4	0.4
134	Beet "	1	5.66	18.7	17.3	18.9	15.6	15.5	4.2	2.1	9.4
135	Turnip "	1	3.98	21.9	1.2	8.7	17.4	40.2	7.1	0.7	.....
136	Carrot "	1	8.50	19.1	4.8	6.7	33.8	15.8	5.6	5.3	3.3
137	Peas	30	2.81	40.4	3.7	8.0	4.2	36.3	3.5	0.9	2.3
138	Vetches	1	2.40	30.6	10.6	8.5	4.8	38.1	4.1	2.0	1.1
139	Field beans	6	3.45	40.5	1.2	6.7	5.2	39.2	5.1	1.2	2.9
140	Garden beans	9	3.06	44.1	2.9	7.5	7.7	30.4	3.8	0.8	0.9
141	Lentils	1	2.06	27.8	9.9	2.0	5.1	29.1	.....	1.1	3.3
142	Lupines	1	.....	33.5	17.8	6.2	7.8	25.5	6.3	0.9	1.3
143	Clover seed	3	4.11	37.3	0.6	12.2	6.2	33.5	4.7	2.4	1.3
144	Esparsette seed	1	4.47	28.6	2.8	6.6	31.6	23.9	3.2	0.8	1.1

XI.—FRUITS AND SEEDS OF TREES, Etc.

No.	Substance.	No. of Analyses	Per cent of Ash.	Potash.	Soda.	Magnesia.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Silica.	Chlorine.
145	Grape seeds	2	2.81	28.6	.....	8.6	33.9	24.0	2.5	1.1	0.3
146	Alder	2	5.14	37.6	1.6	8.0	30.7	13.0	3.4	3.2	0.1
147	White pine	1	.....	21.8	7.1	16.8	1.5	39.7	.....	11.7	0.3
148	Red pine	1	.....	22.4	1.8	15.1	1.9	46.0	....	10.4	...
149	Beech nuts	1	3.30	22.8	10.0	11.6	24.5	20.8	2.2	1.9	0.5
150	Acorns	2	.....	64.5	0.7	5.4	7.0	16.2	2.8	1.1	1.7
151	Horse-chestnut	2	2.36	58.9	.....	0.5	11.6	22.4	1.4	0.2	6.4
152	" green husk	2	4.38	76.4	.....	1.0	10.0	6.3	1.4	0.6	5.5
153	Apple, entire fruit	1	.....	35.7	26.1	8.8	4.1	13.6	6.1	4.3	.....
154	Pear, " "	1	.....	54.7	8.5	5.2	8.0	15.3	5.7	1.5	.....
155	Cherry, " "	1	.....	51.9	2.2	5.5	7.5	16.0	5.1	9.0	1.1
156	Plum, " "	1	.....	59.2	0.5	5.5	10.0	15.1	3.8	2.4	.....

XII.—LEAVES OF TREES.

No.	Substance.	No. of Analyses	Per cent of Ash.	Potash.	Soda.	Magnesia.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Silica.	Chlorine.
157	Mulberry	3	8.53	19.6	.....	5.4	25.7	10.2	0.5	33.5	0.1
158	Horse-chestnut, spring	2	7.17	38.8	.....	8.9	21.3	23.4	6.0	2.9	3.3
159	" autumn	1	7.52	19.6	.....	7.8	40.5	8.2	1.7	13.9	4.1
160	Walnut, spring	1	7.72	42.7	.....	4.6	26.9	21.1	2.6	1.2	0.5
161	" autumn	1	7.01	26.6	.....	9.8	53.7	4.0	2.7	2.0	0.3
162	Beech, summer	2	4.83	18.5	1.8	8.6	36.5	7.8	3.1	15.2	1.2
163	" autumn	6	6.75	5.2	0.6	6.0	44.9	4.2	3.7	33.9	0.4
164	Oak, summer	1	4.60	33.1	.....	13.5	26.1	12.2	2.7	4.4	0.1
165	" autumn	1	4.90	3.5	0.6	4.0	48.6	8.1	4.4	30.9	.....
166	Fir, autumn	1	1.40	10.1	.....	9.9	41.4	16.4	4.4	12.1	4.4
167	Red pine, autumn	1	5.82	1.5	....	2.3	15.2	8.2	2.8	70.1	.....

COMPOSITION OF THE ASH OF AGRICULTURAL PLANTS AND PRODUCTS.

No.	SUBSTANCE.	No. of Analyses.	Per cent of Ash.	Potash.	Soda.	Magnesia.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Silica.	Chlorine.
	XIII.—WOOD.										
168	Grape	8	2.75	29.8	6.7	6.8	37.8	12.9	2.7	0.8	0.8
169	Mulberry	1	1.60	6.5	14.3	5.7	57.3	2.2	10.8	8.6	4.2
170	Birch	2	0.31	11.6	5.8	8.9	60.0	8.5	0.8	4.8	0.6
171	Beech, body-wood	2	0.65	16.1	8.4	10.8	56.4	5.8	1.0	4.7	0.1
172	" small wood	1	1.05	15.2	2.1	16.8	45.8	11.6	0.7	6.7	0.1
173	" brush	1	1.45	14.1	2.2	10 8	48.0	12.3	1.2	9.8	0.1
174	Oak, body-wood	2	.....	10.0	3.6	4.8	73.5	5.5	1.4	1.1	0.2
175	" small branches with bark	1	.....	19.8	.....	7.5	54.0	9.3	1.6	8.1	.....
176	Horse-chestnut twigs, autumn	1	3.31	19.4	.....	5.2	51.0	21.7	.....	0.7	1.4
177	Walnut twigs, autumn	1	2.99	15.3	.....	8.1	55.9	12.2	3.2	2.9	0.3
178	Poplar, young twigs	5	.....	14,0	0.4	7.5	58.4	13.1	1.5	2.0	0.1
179	Willow, " "	1	.....	11 4	5.6	10.1	50.8	16.4	3.1	0.7	0.6
180	Elm. " "	1	.....	24.1	2.1	10.0	37.9	9.6	5.4	6.2	6.7
181	Elm, body-wood	1	.....	21.9	13.7	7.7	47.3	3.3	1.3	3.1	.....
182	Linden	1	.....	35.8	6.0	4.2	29.9	4.9	5.3	5.8	1.5
183	Apple tree	2	1.29	12.0	1.6	5.7	71.0	4.6	2.9	1.3	0.2
184	Red pine	1	0.25	5.2	26.8	6.2	47.9	5.1	3.0	2.0	4.0
185	White pine	2	0.28	15.3	9.9	5.9	50.1	5.5	3.0	6.0	0.2
186	Fir	6	0.31	11.8	4.6	9.1	50.1	5.8	2.3	15.0	0.4
187	Larch	1	0.32	15.3	7.7	24.5	27.1	3.6	1.7	3.6	0.6
	XIV.—BARK.										
188	Birch	2	1.33	3.8	5.4	8.2	45.6	7.3	1.8	20.1	1.3
189	Beech	1	.....	14.7	0.4	0.2	57.9	0.4	1.8	18.0	.....
190	Horse-chestnut, young, autumn	1	6.57	24.2	.....	4.0	61.3	7.0	1.1	1.1	1.2
191	Walnut " "	1	6.40	11.6	.....	10.6	70.1	5.9	0.2	0.7	0.4
192	Elm	1	.....	2.2	10.1	3.2	72.7	1.6	0.6	8.9	.....
193	Linden	1	.....	16.1	5.7	8.0	60.8	4.0	0.8	2 3	1.2
194	Red pine	1	2.81	5.3	4.2	4.7	62.4	2.6	1.0	15.7	0.2
195	White pine	1	3.30	8.0	3.2	3.0	69.8	2.5	1.6	8.4	1.0
196	Fir	3	2.01	8.0	1.0	1.4	43.7	8.3	0.8	31.1	0.1

TABLE II.

Composition of Fresh or Air-dry Agricultural Products, giving the average quantity of Water, Sulphur, Ash, and Ash-ingredients, in 1,000 parts of substance, by Prof. Wolff.

Substance.	Water.	Ash.	Potash.	Soda.	Magnesia.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Silica.	Chlorine.	Sulphur.
I.—HAY.											
Meadow hay	144	66.6	17.1	4.7	3.3	7.7	4.1	3.4	19.7	5.3	1.7
Dead ripe hay	144	66.2	5.0	1.9	2.3	8.5	2.9	0.5	41.8	3.8	2.7
Red clover	160	56.5	19.5	0.9	6.9	19.2	5.6	1.7	1.5	2.1	2.1
White clover	160	60.3	10.6	4.7	6.0	19.4	8.5	5.3	2.7	1.9	2.7
Swedish clover	160	46.5	15.7	0.7	7.1	14.8	4.7	1.9	0.6	1.3	....
Lucern	160	60.0	15.2	0.7	3.5	28.8	5.1	3.7	1.2	1.1	2.6
Esparsette	160	45.8	17.9	0.8	2.6	14.6	4.7	1.5	1.8	1.4	....
Green vetches	160	73.4	30.9	2.1	5.0	19.3	9.4	2.7	1.3	2.3	1.5
Green oats	145	61.8	24.1	2.0	2.0	4.1	5.1	1.7	20.5	2.5	1.5
II.—GREEN FODDER.											
Meadow grass, in blossom	700	23.3	6.0	1.6	1.1	2.7	1.5	1.2	6.9	1.9	0.6
Young grass	800	20.7	11.6	0.4	0.6	2.2	2.2	0.8	2.1	0.4	0.4
Rye grass	700	21.8	5.8	0.9	0.5	1.6	1.7	0.8	8.4	1.1	0.7
Timothy	700	21.0	6.1	0.6	0.8	2.0	2.3	0.8	7.5	1.1	0.8
Other grasses	700	21.3	7.2	0.4	0.6	1.2	1.7	1.0	8.2	0.9	0.7
Oats, beginning to head	820	17.0	7.1	0.8	0.6	1.2	1.4	0.6	4.7	0.8	0.3
" in blossom	770	16.6	6.5	0.6	0.5	1.1	1.4	0.5	5.5	0.7	0.4
Barley, beginning to head	750	22.8	8.6	0.4	0.7	1.6	2.8	0.7	7.0	1.2	0.5
" in blossom	680	22.5	5.9	0.1	0.7	1.4	2.2	0.7	10.8	0.8	0.7
Wheat, beginning to head	770	22.4	7.8	0.4	0.3	1.1	1.7	0.4	9.4	1.2	0.3
" in blossom	690	21.7	5.6	0.1	0.5	0.7	1.6	0.4	12.8	0.6	0.5
Rye fodder	700	16.3	6.8	0.1	0.5	1.2	2.4	0.2	5.2	....	....
Hungarian millet	680	23.1	8.6	....	1.9	2.5	1.8	0.8	6.7	1.5	....
Red clover	800	13.4	4.6	0.2	1.6	4.6	1.3	0.4	0.4	0.5	0.5
White clover	810	13.6	2.4	1.1	1.4	4.4	2.0	1.2	0.6	0.4	0.6
Swedish clover	815	10.2	3.5	0.2	1.6	3.2	1.0	0.4	0.1	0.3	....
Lucern	758	17.6	4.5	0.2	1.0	8.5	1.5	1.1	0.4	0.3	0.3
Esparsette	785	11.6	4.6	0.2	0.7	3.7	1.2	0.4	0.5	0.3	....
Anthyllis vulneraria	780	12.8	1.8	0.5	0.6	6.5	0.9	0.2	0.4	....	....
Green vetches	820	15.7	6.6	0.5	1.1	4.1	2.0	0.6	0.3	0.5	0.3
" peas	815	13.7	5.6	....	1.1	3.9	1.8	0.5	0.4	0.2	....
" rape	850	13.5	4.4	0.5	0.6	3.1	1.2	2.2	0.4	1.0	0.6
III.—ROOT CROPS.											
Potato	750	9.4	5.6	0.1	0.4	0.2	1.8	0.6	0.2	0.3	0.2
Artichoke	800	10.3	6.7	....	0.3	0.4	1.6	0.8	.....	0.2	....
Beet	838	8.0	4.3	1.2	0.4	0.4	0.8	0.3	0.2	0.5	0.1
Sugar-beet	816	8.0	4.0	0.8	0.7	0.5	1.1	0.4	0.3	0.2	....
Turnip	909	7.5	3.0	0.8	0.3	0.8	1.0	1.1	0.2	0.3	0.4
White turnip*	915	6.1	3.1	0.2	0.1	0.8	1.1	0.4	0.1	0.4	....
Kohl-rabi	877	9.5	4.9	0.6	0.2	0.9	1.4	0.8	0.1	0.5	....
Carrot	860	8.8	3.2	1.9	0.5	0.9	1.1	0.6	0.2	0.3	0.1
Sugar-beet heads†	840	6.5	1.9	1.6	0.7	0.6	0.8	0.5	0.1	0.1	....
Chiccory	800	10.4	4.2	0.8	0.7	0.9	1.5	1.0	0.6	0.4	....

* No special variety?

† Crowns of sugar-beet roots.

COMPOSITION OF FRESH OR AIR-DRY AGRICULTURAL PRODUCTS.

SUBSTANCE.	WATER.	ASH.	POTASH.	SODA.	MAGNESIA.	LIME.	PHOSPHORIC ACID.	SULPHURIC ACID.	SILICA.	CHLORINE.	SULPHUR.
IV.—LEAVES AND STEMS OF ROOT CROPS.											
Potato tops, end of August	825	15.6	2.3	0.4	2.6	5.1	1.0	0.9	1.2	0.7	0.6
" " first of October	770	11.8	0.7	0.1	2.7	5.5	0.6	0.6	0.5	0.4	0.5
Beet tops	907	14.8	4.3	3.1	1.4	1.7	0.8	1.1	0.7	1.7	0.5
Sugar-beet tops	897	18.0	4.0	3.0	3.3	3.6	1.3	1.4	0.6	1.0	....
Turnip tops	898	14.0	3.2	1.1	0.6	4.5	1.3	1.4	0.5	1.2	0.5
Kohl rabi tops	850	25.3	3.6	1.0	1.0	8.4	2.6	3.0	2.6	1.0	....
Carrot tops	808	26.1	3.7	6.0	1.2	8.6	1.2	2.1	1.5	1.9	1.4
Chiccory tops	850	18.7	11.3	0.1	0.6	2.7	1.7	1.7	0.2	0.8	....
Cabbage heads	885	12.4	6.0	0.5	0.4	1.9	2.0	1.1	0.1	0.3	0.5
" stems	820	11.6	5.1	0.6	0.5	1.3	2.4	0.9	0.2	0.1	....
V.—MANUFACTURED PRODUCTS AND REFUSE.											
Sugar-beet cake	692	9.7	3.6	0.8	0.5	2.5	1.0	0.4	0.6	0.5	....
a. Common cake	692	9.3	2.3	1.2	....	2.5	1.2	0.5	.....	1.2	....
b. Residue from centrif. machine	820	5.6	2.6	0.5	....	1.4	0.7	0.4	.....	....	.. ..
c. Residue of maceration	835	4.1	1.5	0.4	0.5	1.1	0.3	0.1	.....	0.1	...
Beet molasses	175	93.1	66.2	9.8	0.4	5.6	0.6	2.0	0.6	9.4	....
Molasses slump*	907	17.7	15.9		0.2		....	0.3	.....	0.3	....
Raw-beet sugar	43	13.7	4.6	3.3	....	1.2	....	3.1	0.1	0.3	....
Potato slump*	947	5.9	2.7	0.4	0.5	0.4	1.2	0.4	0.2	0.1	....
Potato fibre†	806	1.9	0.3	....	0.1	0.9	0.5	....	0.1	...	....
Potato skins‡	800	67.1	48.3	0.5	4.5	6.4	2.3	0.8	1.8	1.4	....
Fine wheat flour	136	4.1	1.5	0.1	0.3	0.1	2.1	....	.....	....	....
Rye flour	142	16.9	6.5	0.3	1.4	0.2	8.5	....	.....	....	....
Barley flour	140	20.0	5.8	0.5	2.7	0.6	9.5	0.6	.....	....	....
Barley dust §	118	49.8	9.4	0.7	3.8	1.2	14.4	....	9.9	....	....
Maize meal	140	9.5	2.7	0.3	1.4	0.6	4.3	....	.....	....	....
Millet meal	140	11.6	2.3	0.3	3.0	...	5.5	0.3	.....	....	...
Buckwheat grits	140	6.2	1.6	0.4	0.8	0.1	3.0	0.1	.....	0.1	....
Wheat bran	135	55.6	13.3	0.3	9.4	2.6	28.3	....	0.6	....	....
Rye bran	131	71.4	19.3	0.9	11.3	2.5	34.2	....	.....	....	....
Brewer's grains	768	12.0	0.5	0.1	1.2	1.4	4.6	0.1	3.9	....	....
Malt	475	14.6	2.5	....	1.2	0.5	5.3	....	4.8	....	....
Dried malt	42	26.6	4.6	...	2.2	1.0	0.7	...	8.8	....	....
Malt sprouts	92	59.6	20.8	....	0.8	0.9	12.5	3.8	17.7	....	....
Wine-grounds	650	16.1	8.6	0.1	0.5	2.5	2.5	1.2	.....	0.1	....
Grape skins	600	16.2	8.0	0.4	1.0	2.1	3.4	0.7	0.6	0.1	....
Beer	900	3.9	1.5	0.3	0.2	0.1	1.3	0.1	0.4	0.1	....
Wine	866	2.8	1.8	....	0.2	0.2	0.5	0.1	0.1	....	...
Rape cake	150	56.0	13.6	0.1	6.4	6.1	20.7	1.9	4.9	0.1	....
Linseed cake	115	55.2	12.9	0.8	8.8	4.7	19.4	1.9	3.6	0.8	....
Poppy cake	100	95.4	19.8	4.8	4.1	26.8	36.1	1.9	4.6	....	....
Walnut cake	136	46.4	15.4	....	5.7	3.1	20.3	0.5	0.7	0.1	....
Cotton-seed cake	115	61.5	21.8	....	2.6	2.8	29.5	0.7	2.5	....	....
VI.—STRAW.											
Winter wheat	141	42.6	4.9	1.2	1.1	2.6	2.3	1.2	28.2	....	1.6
Winter rye	154	40.7	7.6	1.3	1.3	3.1	1.9	0.8	23.7	....	0.9
Winter spelt	143	47.7	5.3	0.2	0.4	2.8	3.0	0.9	34.1	....	....
Summer rye	143	47.6	11.1	....	1.3	4.4	3.1	1.2	26.6	....	...
Barley	140	43.9	9.3	2.0	1.1	3.3	1.9	1.6	23.6	....	1.3
Oats	141	44.0	9.7	2.3	1.8	3.6	1.8	1.5	21.2	....	1.7
Maize	140	47.2	16.6	0.5	2.6	5.0	3.8	2.5	17.9	....	3.9
Peas	143	49.2	10.7	2.6	3.8	18.6	3.8	2.8	2.8	3.0	0.7
Field bean	180	58.4	25.9	2.2	4.6	13.5	4.1	0.1	3.1	3.1	2.2
Garden bean	150	51.5	19.1	3.1	2.7	14.1	4.1	1.8	2.4	2.7	2.1

---

* Residue from spirit manufacture.

† Refuse of starch manufacture.

‡ From boiled potatoes.

§ Refuse from making barley grits.

COMPOSITION OF FRESH OR AIR-DRY AGRICULTURAL PRODUCTS.

SUBSTANCE.	WATER.	ASH.	POTASH.	SODA.	MAGNESIA.	LIME.	PHOSPHORIC ACID.	SULPHURIC ACID.	SILICA.	CHLORINE.	SULPHUR.
VI.—STRAW.											
Buckwheat	160	51.7	24.1	1.1	1.9	9.5	6.1	2.7	2.8	4.0	....
Rape	170	38.0	9.7	3.9	2.1	10.1	2.7	2.7	2.6	4.7	1.4
Poppy	160	66.0	25.1	0.9	4.3	19.9	2.8	3.4	7.5	1.7	....
VII.—CHAFF.											
Wheat	138	92.5	8.4	1.7	1.2	1.9	4.0	....	75.1	....	0.8
Spelt	130	88.7	7.9	0.2	2.1	2.0	6.0	1.9	61.4	....	....
Barley	140	122.4	9.4	1.1	1.6	12.7	2.4	3.7	86.7	....	....
Oats	143	79.0	10.4	3.8	2.1	7.0	0.2	2.0	47.3	....	....
Maize cobs	115	5.0	2.4	0.1	0.2	0.2	0.2	0.1	1.3	0.2	1.3
Flax-seed hulls	120	58.3	18.1	2.5	1.6	17.2	1.6	2.8	10.0	3.6	1.8
VIII.—TEXTILE PLANTS, ETC.											
Flax straw	140	31.9	11.8	1.6	2.3	8.3	4.3	2.0	2.2	1.5	1.4
Rotted flax stems	100	21.6	1.9	1.0	1.2	11.1	1.3	0.7	3.0	....	0.2
Flax fiber	100	6.0	0.2	0.2	0.3	3.8	0.7	0.2	0.3	....	....
Entire flax plant	250	32.3	11.8	1.5	2.9	5.0	7.4	1.6	0.8	1.9	....
Entire hemp plant	300	28.2	5.2	0.9	2.7	12.2	3.3	0.8	2.1	0.7	....
Entire hop plant	250	74.0	19.4	2.8	4.3	11.8	9.0	3.8	15.9	3.4	2.0
Hops	120	59.8	22.3	1.3	2.1	10.1	9.0	1.6	9.2	0.2	4.2
Tobacco	180	197.5	54.1	7.3	20.7	73.1	7.1	7.7	19.0	8.8	....
IX.—LITTER.											
Heath	200	36.1	4.8	1.9	3.0	6.8	1.8	1.6	12.7	0.8	....
Broom (*Spartium*)	160	18.9	6.9	0.5	2.8	3.2	1.6	0.7	1.9	0.5	....
Fern (*Aspidium*)	160	58.9	25.2	2.7	4.5	8.3	5.7	3.0	3.6	6.0	....
Scouring rush (*Equisetum*)	140	204.4	27.0	1.0	4.7	25.6	4.1	12.9	110.0	11.7	....
Sea-weed (*Fucus*)	180	118.0	17.1	28.8	11.2	16.4	3.7	28.3	2.0	11.9	....
Beech leaves	150	57.4	3.0	0.3	3.4	25.8	2.4	2.1	19.5	0.2	....
Oak leaves	150	41.7	1.5	0.2	1.7	20.2	3.4	1.8	12.9	....	....
Fir leaves (*Pinus sylvestris*)	160	11.8	1.2	....	1.1	4.9	1.9	0.5	1.5	0.5	...
Red pine leaves (*Pinus picea*)	160	48.9	0.7	....	1.1	7.4	4.0	1.4	34.3	....	....
Reed (*Arundo phrag.*)	180	38.5	3.3	0.1	0.5	2.8	0.8	1.1	27.5	....	....
Sedge (*Carex*)	140	69.5	23.1	5.1	2.9	3.7	4.7	2.3	21.8	3.9	....
Rush (*Juncus*)	140	45.6	16.7	3.0	2.9	4.3	2.9	4.0	5.0	6.5	....
Bulrush (*Scirpus*)	140	74.4	7.2	7.7	2.2	5.4	4.8	4.2	32.2	3.9	....
X.—GRAINS AND SEEDS OF AGRICULTURAL PLANTS.											
Wheat	148	17.7	5.5	0.6	2.2	0.6	8.2	0.4	0.3	....	1.5
Rye	149	17.3	5.4	0.3	1.9	0.5	8.2	0.4	0.3	....	1.7
Barley	145	21.8	4.8	0.6	1.8	0.5	7.2	0.5	5.9	....	1.4
Oats	140	26.4	4.2	1.0	1.8	1.0	5.5	0.4	12.3	...	1.7
Spelt, with husk	148	35.8	6.2	0.6	2.1	0.9	7.2	0.6	15.8	....	...
Maize	136	12.3	3.3	0.2	1.8	0.3	5.5	0.1	0.3	....	1.2
Rice, with husk	120	69.0	12.7	3.1	5.9	3.5	32.6	0.4	0.4	....	....
" husked	130	3.4	0.8	0.2	0.5	0.1	1.7	....	0.1	....	....
Millet, with husk	130	39.1	4.7	0.4	3.3	0.4	9.1	0.1	20.5	....	1.8
" husked	181	12.3	2.8	0.7	2.3	....	6.6	0.2	....	....	...
Sorghum	140	16.0	4.2	0.5	2.4	0.2	8.1	....	1.2	....	...
Buckwheat	141	9.2	2.1	0.6	1.2	0.3	4.4	0.2	.....	0.2	....
Rape seed	120	37.3	8.8	0.4	4.6	5.2	16.4	1.3	0.4	0.1	3.2
Flax seed	118	32.2	10.4	0.6	4.2	2.7	13.0	0.4	0.4	....	1.7
Hemp seed	122	48.1	9.7	0.4	2.7	11.3	17.5	0.1	5.7	0.1	....
Poppy seed	147	52.2	7.1	0.5	5.0	18.5	16.4	1.0	1.7	2.3	....

COMPOSITION OF FRESH OR AIR-DRY AGRICULTURAL PRODUCTS.

X.—GRAINS AND SEEDS OF AGRICULTURAL PLANTS.

SUBSTANCE.	WATER.	ASH.	POTASH.	SODA.	MAGNESIA.	LIME.	PHOSPHORIC ACID.	SULPHURIC ACID.	SILICA.	CHLORINE.	SULPHUR.
Mustard seed	120	87.8	6.0	2.2	3.9	7.1	14.7	1.8	0.9	0.2	10.1
Beet seed	140	48.7	9.1	8.4	9.2	7.6	7.6	2.0	1.0	4.6	0.8
Turnip seed	120	35.0	7.7	0.8	3.0	6.1	14.1	2.5	0.2	....	7.8
Carrot seed	120	74.8	14.3	8.6	5.0	29.0	11.8	4.2	4.0	2.5	2.7
Peas	138	24.2	9.8	0.9	1.9	1.2	8.8	0.8	0.2	0.6	2.4
Vetches	136	20.7	6.8	2.2	1.8	0.6	7.9	0.9	0.4	0.2	....
Field beans	141	29.6	12.0	0.4	2.0	1.5	11.6	1.5	0.4	0.8	2.8
Garden beans	143	26.1	11.5	0.8	2.0	2.0	7.9	1.0	0.2	0.3	2.5
Lentils	134	17.8	7.7	1.8	0.4	0.9	5.2	....	0.2	0.6	....
Lupines	138	34.0	11.4	6.0	2.1	2.7	8.7	2.3	0.3	0.6	....
Clover seed	150	36.9	13.8	0.2	4.5	2.3	12.4	1.7	0.9	0.5	....
Esparsette seed	160	37.6	10.8	1.1	2.5	11.9	9.0	1.2	0.3	0.4	2.8

XI.—FRUITS AND SEEDS OF TREES, ETC.

SUBSTANCE.	WATER.	ASH.	POTASH.	SODA.	MAGNESIA.	LIME.	PHOSPHORIC ACID.	SULPHURIC ACID.	SILICA.	CHLORINE.	SULPHUR.
Grape seeds	120	24.7	7.1	....	2.1	8.4	5.9	0.6	0.3	0.1	....
Alder "	140	44.2	16.6	0.7	3.5	13.6	5.7	1.5	1.4	....	....
Beech nuts	180	27.1	6.2	2.7	3.1	6.7	5.6	0.6	0.5	0.1	....
Acorns, fresh	560	9.6	6.2	0.1	0.5	0.7	1.6	0.2	0.2	0.1	....
" dried	158	18.3	11.8	0.1	1.0	1.3	3.8	0.5	0.4	0.3	...
Horse-chestnuts, fresh	492	12.0	7.1	....	0.1	1.4	2.7	0.2	.....	0.8	...
" green husk	818	8.0	6.1	....	0.1	0.8	0.5	0.1	0.1	0.4	....
Apple, entire fruit	840	2.7	1.0	0.7	0.2	0.1	0.4	0.2	0.1	...	....
Pear, " "	800	4.1	2.2	0.4	0.2	0.3	0.6	0.2	0.1	....	....
Cherry, " "	780	4.3	2.2	0.1	0.2	0.3	0.7	0.2	0.4	0.1	....
Plum, " "	820	4.0	2.4	....	0.2	0.4	0.6	0.2	0.1	....	....

XII.—LEAVES OF TREES.

SUBSTANCE.	WATER.	ASH.	POTASH.	SODA.	MAGNESIA.	LIME.	PHOSPHORIC ACID.	SULPHURIC ACID.	SILICA.	CHLORINE.	SULPHUR.
Mulberry	670	11.7	2.3	....	0.6	3.0	1.2	0.1	4.1	....	....
Horse-chestnut, spring	700	21.5	8.3	....	0.8	4.6	5.0	1.3	0.6	0.8	....
" autumn	600	30.1	5.9	...	2.4	12.2	2.5	0.5	4.2	1.2	....
Walnut, spring	700	22.2	9.9	....	1.1	6.2	4.9	0.6	0.3	0.1	....
" autumn	600	23.4	7.6	....	2.8	15.3	1.1	0.8	0.6	0.2	....
Beech, summer	750	12.1	2.2	0.2	1.1	4.4	0.9	0.4	1.8	0.1	....
" autumn	550	30.5	1.6	0.2	1.8	18.7	1.3	1.1	10.3	0.1	....
Oak, summer	700	13.8	4.6	....	1.9	3.6	1.7	0.4	0.6	....	....
" autumn	600	19.6	0.7	0.1	0.8	9.5	1.6	0.9	6.1	....	....
Fir, autumn	550	6.3	0.6	....	0.6	2.6	1.3	0.3	0.8	0.3	....
Red pine, autumn	550	26.2	0.4	....	0.6	4.0	2.1	0.7	18.4	....	....

XIII.—WOOD. (AIR-DRY.)

SUBSTANCE.	WATER.	ASH.	POTASH.	SODA.	MAGNESIA.	LIME.	PHOSPHORIC ACID.	SULPHURIC ACID.	SILICA.	CHLORINE.	SULPHUR.
Grape	150	23.4	7.0	1.6	1.6	8.7	3.0	0.6	0.2	0.2	...
Mulberry	150	18.7	0.9	2.0	0.8	7.8	0.3	1.4	0.5	0.6	....
Birch	150	2.6	0.3	0.2	0.2	1.5	0.2	....	0.1	....	....
Beech, body-wood	150	5.5	0.9	0.2	0.6	3.1	0.3	0.1	0.3	....	....
" small wood	150	8.9	1.4	0.2	1.5	4.1	1.0	0.1	0.6	....	....
" brush	150	12.3	1.7	0.3	1.3	5.9	1.5	0.1	1.2	....	....
Oak, body-wood	150	5.1	0.5	0.2	0.2	3.7	0.3	0.1	0.1	....	....
" small branches with bark	150	10.2	2.0	...	0.8	5.5	0.9	0.2	0.3	....	....
Horse-chestnut, young wood in autumn	150	28.1	5.5	....	1.5	14.3	5.9	....	0.2	0.4	
Walnut	150	25.5	3.9	....	2.0	14.2	3.1	0.8	0.7	0.1	....
Apple tree	150	11.0	1.3	0.2	0.6	7.8	0.5	0.3	0.2	....	....
Red pine	150	2.1	0.1	0.6	0.1	1.0	0.1	0.1	0.1	....	....
White pine	150	2.4	0.4	0.2	0.1	1.2	0.1	0.1	0.2	....	....
Fir	150	2.6	0.3	0.1	0.2	1.3	0.2	0.1	0.4	....	...
Larch	150	2.7	0.4	0.2	0.7	0.7	0.1	0.1	0.1	...	...

COMPOSITION OF FRESH OR AIR-DRY AGRICULTURAL PRODUCTS.

XIV.—BARK.

SUBSTANCE.	WATER.	ASH.	POTASH.	SODA.	MAGNESIA.	LIME.	PHOSPHORIC ACID.	SULPHURIC ACID.	SILICA.	CHLORINE.	SULPHUR.
Birch	150	11·3	0·4	0·6	0·9	5·2	0·8	0·2	2·3	0·2	....
Horse-chestnut, young in autumn	150	55·9	13·5	....	2·2	34·3	3·9	0·6	0·6	0·7	....
Walnut, young in autumn	150	54·4	6·3	....	5·8	38·1	3·2	0·1	0·4	0·2	...
Red pine	150	23·9	1·3	1·0	1·1	14·9	0·6	0·2	3·8	0·1	....
White pine	150	28·1	2·3	0·9	0·8	19·6	0·7	0·5	2·3	0·8	..
Fir	150	17·1	0·5	0·2	0·2	7·5	1·4	0·1	5·3	....	....

TABLE III.

PROXIMATE COMPOSITION OF AGRICULTURAL PLANTS AND PRODUCTS, giving the average quantities of Water, Organic Matter, Ash, Albuminoids, Carbohydrates, etc., Crude Fiber, Fat, etc., by Professors WOLFF and KNOP.*

HAY.

SUBSTANCE.	WATER.	ORGANIC MATTER.†	ASH.	ALBUMINOIDS.	CARBOHYDRATES, ETC.‡	CRUDE FIBRE.§	FAT, ETC.‖
Meadow hay, medium quality	14.3	79.5	6.2	8.2	41.3	30.0	2.0
Aftermath	14.3	79.2	6.5	9.5	45.7	24.0	2.4
Red clover, full blossom	16.7	77.1	6.2	13.4	29.9	33.8	3.2
" " ripe	16.7	77.7	5.6	9.4	20.3	48.0	2.0
White clover, full blossom	16.7	74.8	8.5	14.9	34.3	25.6	3.5
Swedish or Alsike clover (*Trifolium hybridum*)	16.7	75.0	8.3	15.3	29.2	30.5	3.3
" clover, ripe	16.7	78.3	5.0	10.2	23.1	45.0	2.2
Lucern, young	16.7	74.6	8.7	19.7	32.9	22.0	3.3

---

* *Landwirthschaftlicher Kalender*, 1867, through Knop's *Agricultur-Chemie*, 1868, pp. 715–720. This Table is, as regards water and ash, a repetition of Table II. but includes the newer analyses of 1865–7. Therefore the averages of water and ash do not in all cases agree with those of the former Tables. It gives, besides, the proportions of nitrogenous and non-nitrogenous compounds, *i. e.*, albuminoids and carbohydrates, etc. It also states the averages of crude fibre and of fat, etc. The discussion of the data of this Table belongs to the subjects of food and cattle-feeding. They are, however, inserted here, as it is believed they are not to be found elsewhere in the English language.

† *Organic matter* here signifies the combustible part of the plant.

‡ *Carbohydrates, etc.*, include fat, starch, sugar, pectin, etc., all in fact of *organic matter*, except albuminoids and crude fibre.

§ *Crude fibre* is impure cellulose.

‖ *Fat, etc.*, is the ether extract, and contains, besides fat, wax, chlorophyll, and in some cases resins.

PROXIMATE COMPOSITION OF AGRICULTURAL PLANTS AND PRODUCTS.

SUBSTANCE.		WATER.	ORGANIC MATTER.	ASH.	ALBUMINOIDS.	CARBOHYDRATES, ETC.	CRUDE FIBRE.	FAT, ETC.
HAY.								
Lucern, in blossom		16.7	76.9	6.4	14.4	22.5	40.0	2.5
Sand lucern, early blossom (*Medicago intermedia*)		16.7	77.2	6.1	15.2	23.9	35.1	3.0
Esparsette, in blossom		16.7	77.1	6.2	18.3	36.7	27.1	2.5
Incarnate clover, in blossom (*Trifolium incarnatum*)		16.7	76.1	7.2	12.2	30.1	33.8	3.0
Yellow " " " (*Medicago lupulina*)		16.7	77.3	6.0	14.6	36.5	26.2	3.3
Vetches, in blossom		16.7	75.0	8.3	14.2	35.3	25.5	2.5
Peas, " "		16.7	76.3	7.0	14.3	36.3	25.2	2.6
Field spurry, in blossom (*Spergula arvensis*)		16.7	73.8	9.5	12.0	39.8	22.0	3.2
" " after blossom		16.7	75.5	7.8	7.8	41.7	26.0	2.5
Serradella, " " (*Ornithopus sativus*)		16.7	77.7	5.6	14.6	20.2	33.9	1.5
" before "		16.7	75.8	7.5	15.3	37.2	26.1	1.9
Italian rye grass (*Lolium italicum*)	Cut in blossom.	14.3	77.9	7.8	8.7	51.4	16.9	2.8
Timothy (*Phleum pratense*)		14.3	81.2	4.5	9.7	48.8	22.7	3.0
Early meadow grass (*Poa annua*)		14.3	83.3	2.4	10.1	47.2	25.9	2.9
Crested dog's-tail (*Cynosurus cristatus*)		14.3	80.2	5.5	9.5	48.0	22.6	2.8
Soft brome grass (*Bromus mollis*)		14.3	80.7	5.0	14.3	35.0	31.0	1.8
Orchard grass (*Dactylis glomerata*)		14.3	81.1	4.6	11.6	40.7	28.9	2.7
Barley grass (*Hordeum pratense*)		14.3	80.4	5.3	9.6	42.0	27.2	2.0
Meadow foxtail (*Alopecurus pratensis*)		14.3	79.0	6.7	10.6	39.5	29.0	2.5
Oat grass, French rye grass (*Arrhenatherum avenaceum*)		14.3	75.8	9.9	11.1	35.3	29.4	2.7
English rye grass (*Lolium perenne*)		14.3	79.2	6.5	10.2	38.9	30.2	2.7
Harter Schwingel (*Festuca ?*)		14.3	81.0	4.7	10.4	37.5	33.2	2.9
Sweet-scented vernal grass (*Anthoxanthum odoratum*)		14.3	80.3	5.4	8.9	40.3	31.2	2.9
Velvet grass (*Holcus lanatus*)		14.3	80.2	5.5	9.9	36.7	33.6	3.1
Spear grass, Kentucky Blue grass (*Poa pratensis*)		14.3	80.6	5.1	8.9	39.1	32.6	2.3
Rough meadow grass (*Poa trivialis*)		14.3	78.6	7.1	8.4	37.6	32.6	3.2
Yellow oat grass (*Avena flavescens*)		14.3	79.8	5.9	6.4	42.6	30.8	2.2
Quaking grass (*Briza media*)		14.3	78.3	7.4	5.2	42.8	30.3	2.6
Average of all the grasses		14.3	79.9	5.8	9.5	41.7	28.7	2.6
STRAW								
Winter wheat		14.3	80.2	5.5	2.0	30.2	48.0	1.5
" rye		14.3	82.5	3.2	1.5	27.0	54.0	1.3
" spelt		14.3	79.7	6.0	2.0	27.7	50.5	1.4
" barley		14.3	80.2	5.5	2.0	29.3	48.4	1.4
Summer barley		14.3	78.7	7.0	3.0	33.7	43.0	1.4
" " with clover		14.3	77.7	8.0	6.0	34.7	37.5	1.7
Oat		14.3	80.7	5.0	2.5	38.2	40.0	2.0
Vetch fodder		14.3	79.7	6.0	7.5	28.2	44.0	2.0
Pea		14.3	81.7	4.0	6.5	35.2	40.0	2.0
Bean		17.3	77.7	5.0	10.2	33.5	34.0	1.0
Lentil		14.3	79.2	6.5	14.0	27.2	36.6	2.0
Lupine		14.2	81.4	4.4	4.9	34.7	41.8	1.5
Maize		14.0	82.0	4.0	3.0	39.0	40.0	1.1
CHAFF AND HULLS.								
Wheat		14.3	73.7	12.0	4.5	33.2	36.0	1.4
Spelt		14.3	77.2	8.5	2.9	32.8	41.5	1.3
Rye		14.3	78.2	7.5	3.5	28.2	46.5	1.2
Barley		14.3	72.7	13.0	3.0	38.7	30.0	1.5
Oat		14.3	67.7	18.0	4.0	29.7	34.0	1.5
Vetch		15.0	77.0	8.0	8.5	32.5	36.0	2.0
Pea		14.3	79.7	6.0	8.1	36.6	35.0	2.0
Bean		15.0	77.0	8.0	10.5	29.5	37.0	2.0
Lupine		14.3	82.9	2.8	2.5	47.2	33.0	2.5
Rape		10.3	77.5	8.5	3.5	40.0	34.0	1.6
Maize cobs		10.8	83.2	2.8	1.4	44.0	37.8	1.4

PROXIMATE COMPOSITION OF AGRICULTURAL PLANTS AND PRODUCTS

GREEN FODDER.

SUBSTANCE.	WATER.	ORGANIC MATTER.	ASH.	ALBUMINOIDS.	CARBOHYDRATES, ETC.	CRUDE FIBRE.	FAT, ETC.
Grass, before blossom	75.0	22.9	2.1	3.0	12.9	7.0	0.8
" after "	69.0	29.0	2.0	2.5	15.0	11.5	0.7
Red clover, before blossom	83.0	15.5	1.5	3.3	7.7	4.5	0.7
" full "	78.0	20.3	1.7	3.7	8.6	8.0	0.8
White clover, full "	80.5	17.5	2.0	3.5	8.0	6.0	0.8
Swedish clover, early blossom	85.0	13.5	1.5	3.3	5.7	4.5	0.6
" " full "	82.0	16.2	1.8	3.3	6.3	6.6	0.6
Lucern, very young	81.0	17.3	1.7	4.5	7.8	5.0	0.6
" in blossom	74.0	24.0	2.0	4.5	7.0	12.5	0.7
Sand lucern, early blossom	78.0	20.1	1.9	4.0	6.6	9.5	0.8
Esparsette, in "	80.9	18.5	1.5	3.2	8.8	6.5	0.6
Incarnate clover, in " (*Trifolium incarnatum*)	81.5	16.9	1.6	2.7	6.7	7.5	0.6
Yellow clover, in " (*Medicago lupulina*)	80.0	18.5	1.5	3.5	9.0	6.0	0.8
Serradella, " " (*Ornithopus sativus*)	80.0	18.7	1.3	3.6	7.0	8.1	0.4
Vetches, " "	82.0	16.2	1.8	3.1	7.6	5.5	0.6
Peas, " "	81.5	17.0	1.5	3.2	8.2	5.6	0.6
Oats, early blossom	81.0	17.6	1.4	2.3	8.8	6.5	0.5
Rye	72.9	25.5	1.6	3.3	14.9	7.3	0.9
Maize, late end August	84.3	14.6	1.1	0.9	8.7	5.0	0.5
" early " "	82.2	16.7	1.1	1.1	10.9	4.7	0.5
Hungarian millet, in blossom (*Panicum germanicum*)	65.6	32.0	2.4	5.9	15.0	11.5	1.5
Sorghum saccharatum	74.0	25.1	0.9	2.5	15.3	7.3	1.4
Sorghum vulgare	77.3	21.6	1.1	2.9	11.9	6.7	?
Field spurry, in blossom	80.0	18.0	2.0	2.3	10.4	5.3	0.7
Cabbage	89.0	9.8	1.2	1.5	6.3	2.0	0.4
" stumps	82.0	16.1	1.9	1.1	12.2	2.8	0.8
Field-beet leaves	90.5	6.7	1.8	1.9	4.6	1.3	0.5
Carrot leaves	82.2	14.2	3.6	3.2	8.0	3.0	1.0
Poplar and elm leaves	70.0	28.0	2.0	6.0	15.5	6.5	1.5
Artichoke stem	80.0	17.3	2.7	3.3	10.6	3.4	0.8
Rape leaves	dry	75.5	24.5	20.0	47.5	8.0	2.0

ROOTS AND TUBERS.

SUBSTANCE.	WATER.	ORGANIC MATTER.	ASH.	ALBUMINOIDS.	CARBOHYDRATES, ETC.	CRUDE FIBRE.	FAT, ETC.
Potato	95.0	24.1	0.9	2.0	21.0	1.1	0.3
Jerusalem artichoke	80.0	18.9	1.1	2.0	15.6	1.3	0.5
Turnip chervil? (Koerbelrübe)	76.0	23.1	0.9	3.2	17.0	1.0	0.6
Kohl-rabi	88.0	10.8	1.2	2.3	7.3	1.2	0.2
Field beets (about 3 lbs. weight)	88.0	11.1	0.9	1.1	9.1	0.9	0.1
Sugar beets (1–2 lbs.)	81.5	17.7	0.8	1.0	15.4	1.3	0.1
Ruta-bagas (about 3 lbs.)	87.0	12.0	1.0	1.6	9.3	1.1	0.1
Carrot (about ⅓ lb.)	85.0	14.0	1.0	1.5	10.8	1.7	0.2
Giant carrot (1–2 lbs.)	87.0	12.2	0.8	1.2	9.8	1.2	0.2
Turnips (Stoppelrübe)	91.5	7.7	0.8	0.8	5.9	1.0	0.1
Turnips (Turnipsrübe)	92.0	7.2	0.8	1.1	5.1	1.0	0.1
Parsnip	88.3	11.0	0.7	1.6	8.4	1.0	0.2
Pumpkin	94.5	4.5	1.0	1.3	2.2	1.0	0.1

GRAINS AND SEEDS.

SUBSTANCE.	WATER.	ORGANIC MATTER.	ASH.	ALBUMINOIDS.	CARBOHYDRATES, ETC.	CRUDE FIBRE.	FAT, ETC.
Rice	14.6	84.9	0.5	7.5	76.5	0.9	0.5
Winter wheat	14.4	83.6	2.0	13.0	67.6	3.0	1.5
Wheat flour	12.6	86.7	0.7	11.8	74.1	0.7	1.2
Spelt	14.8	81.3	3.9	10.0	54.8	16.5	1.5
Winter rye	14.3	83.7	2.0	11.0	69.2	3.5	2.0
Rye flour	14.0	84.4	1.6	10.5	72.5	1.5	1.6
Winter barley	14.3	83.4	2.3	9.0	65.9	8.5	2.5
Summer barley	14.3	83.1	2.6	9.5	66.6	7.0	2.5
Oats	14.3	82.7	3.0	12.0	60.9	10.3	6.0
Maize	14.4	83.5	2.1	10.0	68.0	5.5	7.0

Proximate Composition of Agricultural Plants and Products.

Substance.	Water.	Organic Matter.	Ash.	Albuminoids.	Carbohydrates, etc.	Crude fibre.	Fat, etc.
GRAINS AND SEEDS.							
Millet	14.0	83.0	3.0	14.5	62.1	6.4	3.0
Buckwheat	14.0	83.6	2.4	9.0	59.6	15.0	2.5
Vetches	14.3	83.4	2.3	27.5	49.2	6.7	2.7
Peas	14.3	83.2	2.5	22.4	52.3	9.2	2.5
Beans (field)	14.5	82.0	3.5	25.5	45.5	11.5	2.0
Lentils	14.5	82.5	3.0	23.8	52.0	6.9	2.6
Lupines	14.5	82.0	3.5	34.5	33.0	14.5	6.0
Acorns without shell, dry	20.0	78.4	1.6	5.0	68.8	4.6	4.3
" with " fresh	56.0	43.0	1.0	2.0	36.5	4.5	2.3
Chestnuts without shell, fresh	49.2	49.0	1.8	3.0	45.2	0.8	2.5
Madia seed	8.4	86.9	4.7	22.9	46.0	18.0	41.0
Flax seed	12.3	82.7	5.0	20.5	55.0	7.2	37.0
Rape seed	11.0	85.1	3.9	19.4	55.4	10.8	40.0
Hemp seed	12.2	83.6	4.2	16.3	55.2	12.1	33.6
Poppy seed	14.7	78.3	7.0	17.5	54.7	6.1	41.0
Horse chestnut	30.0	68.8	1.2	10.5	58.3	4.0	2.30
REFUSE.							
Sugar-beet cake	70.0	26.6	3.4	1.8	18.5	6.8	0.2
" " " residue from centrifugal machine	82.0	16.8	1.2	1.0	12.2	3.6	0.1
" " " " " maceration	92.6	6.6	0.8	0.8	4.4	1.4	0.1
Potato slump	94.8	4.6	0.6	1.0	3.0	0.6	0.1
Rye slump	89.0	10.5	0.5	2.1	6.8	1.6	0.4
Maize slump	89.0	10.5	0.5	2.0	7.2	1.3	1.2
Molasses slump	92.0	6.3	1.7	1.2	5.1	....	....
Brewer's grains	76.6	22.2	1.2	4.9	11.1	6.2	1.6
Malt sprouts	8.0	85.2	6.8	23.0	44.7	17.5	2.5
Fresh malt with sprouts	47.5	50.8	1.7	6.5	39.5	4.3	1.5
Dry malt without sprouts	4.2	93 1	2.7	8.8	76.3	8.0	2.5
Wheat bran	13.1	81.8	5.1	14.0	50.0	17.8	3.8
Rye bran	12.5	83 0	4.5	14.5	58.5	15.0	3.5
Rape cake	15.0	77.6	7.4	28.3	33.5	15.8	9.0
Linseed cake	11.5	80.6	7.9	28.3	41.3	11.0	10.0
Gold of pleasure cake	15.0	78.1	6.9	28.5	37.1	12.5	8.5
Poppy cake	10.0	81.6	8.4	32.5	37.7	11.4	8.1
Hemp cake	10.5	85.5	4.0	27.0	36.5	22.0	6.2
Beechnut cake	10.0	84.8	5.2	24.0	31.8	20.5	7.5
" " without shells	12.5	79.8	7.7	37.3	36.9	5.5	7.5
Beet molasses	16.7	72.5	10.8	8.0	64.5	....	....
Potato fibre	82.6	17.1	0.3	0.8	15.0	1.3	0.1
COFFEE, TEA.							
Coffee bean	12.0	93.0	7.0	10.0	49.0	34.0	12.6
Chocolate bean	11.0	85.0	4.0	20.0	52.0	18.0	44.0
Black China tea	15.0	79.0	6.0	5.0	32.0	40.0	2.0
Green " "	15.0	79.0	6.0	5.0	27.0	45.0	2.0

TABLE IV.

DETAILED ANALYSES OF BREAD GRAINS.

	Albuminoids.	Starch.	Gum and Sugar.	Fat.	Bran and Crude Fibre.	Ash.	Water.	Analyst.
WHEAT.								
From Elsass	14.6	59.7	7.2	1.2	1.7	1.6	14.0	Boussingault.
“ Saxony	11.8	64.4	1.4	2.6	2.5	1.6	15.6	Wunder.
“ America	10.9	68.4	3.3	1.2	3.3	1.6	10.8	Polson.
“ Flanders	10.7	61.0	9.2	1.0	1.8	1.7	14.6	Peligot.
“ Odessa	14.3	59.6	6.3	1.5	1.7	1.4	15.2	“
“ Tanganrock	13.6	57.9	7.9	1.9	2.3	1.6	14.8	“
“ Poland	21.5	53.4	6.8	1.5	1.7	1.9	12.2	“
“ Hungary	13.4	62.2	5.4	1.1	1.7	1.7	14.5	“
“ Egypt	20.6	55.4	6.0	1.1	1.8	1.6	14.8	“
RYE.								
From Hessia	13.6	50.5	8.9	0.9	10.1	1.8	15.0	Fresenius.
“ France	11.6	56.5	10.2	1.9	3.5	2.2	14.1	Payen.
“ Saxony	9.1	64.9	0.4	2.3	3.5	1.4	18.3	A. Müller.
“ “	9.6	56.7	6.4	2.1	3.5	3.3	16.5	Wolff.
BARLEY.								
	10.5	50.3	5.5	2.0	13.6	3.3	15.7	Wolff.
	13.2	53.7	4.2	2.6	11.5	2.8	12.0	Polson.
From Salzmunde, Prussia	9.3	60.4	1.2	2.0	9.7	2.4	15.0	Grouven.
OATS.								
	8.8	55.4	2.5	6.4	9.6	2.7	14.6	A. Müller.
	15.7	32.2	.....	....	......	4.1	12.9	Krocker.
	10.2	....	.....	6.1	10.0	2.7	12.6	Anderson.
BUCKWHEAT.								
Husked, from Vienna	2.6	78.9	3.8	0.9	1.0	....	12.7	Bibra.
“ “ “	3.6	76.7	4.3	1.3	1.3	....	13.7	“
“	13.1	.....	.....	3.9	3.5	2.5	13.0	Boussingault.
Unhusked	8.5	37.8	.....	....	......	2.0	14.2	Horsford & Krocker.
“	9.1	45.0	7.1	0.4	22.0	2.4	14.0	Zenneck.
MAIZE.								
From Saxony	8.8	58.0	5.3	9.2	4.9	3.2	10.5	Hellriegel.
“ America	8.8	54.4	2.7	4.6	15.8	1.7	12.0	Polson.
“ Galacz	9.1	49.5	2.9	4.5	20.4	1.8	11.8	“
“ Switzerland	.....	51.2	6.7	8.8	12.5	...	10.6	Bibra.
RICE.								
From Piemont	7.5	.....	.....	0.5	0.9	0.5	14.6	Boussingault.
“ Patna	7.2	79.9	1.6	0.1	0.5	0.9	9.8	Polson.
“ Piemont	7.8	.....	.....	0.2	3.4	0.3	13.7	Peligot.
“ East Indies	5.9	73.9	2.3	0.9	2.0	...	14.0	Bibra.
MILLET.								
Husked, Hagenau	20.6	.....	.....	8.0	2.4	2.2	14.0	Boussingault.
“ Nuremberg	10.3	57.0	11.0	8.0	2.0	....	12.2	Bibra.

TABLE V.

DETAILED ANALYSES OF POTATOES, by GROUVEN.

(*Agricultur-Chemie, 2te Auf.*, p.p. 495 *and* 355.)

	White Potatoes, newly dug.				Various Sorts. Average of 19 Analyses.
	Unmanured.		Manured.		
Water	74.95		78.01		76.00
Albumen	0.47	= 3.11	0.89	= 3.19	2.30
Casein	0.04		0.03		
Gliadin and Mucidin (?)	0.29		0.25		
Vegetable Fibrin	1.31		2.02		
Gum and pectin	0.76		1.56		1.81
Organic acids	2.00		1.50		
Fat	0.07		0.05		0.30
Starch	17.33		13.40		15.24
Cellulose	1.90		1.24		1.01
Ash	0.88		1.05		0.95
	100.		100.		

TABLE VI.—COMPOSITION OF FRUITS, according to FRESENIUS. (*Ann. Ch. u. Ph.*, 101, p. 219.)

FRUITS.		SOLUBLE MATTERS.						SEEDS, SKINS, AND INSOL. MATTERS.					WATER.	
		SUGAR.*	FREE ACID.†	ALBUMINOIDS.	PECTIN-BODIES, GUM, ORGANIC ACIDS IN COMBINATION.	SOLUBLE ASH-INGREDIENTS.	TOTAL SOLUBLE MATTERS.	SEEDS.	SKINS AND CELLULOSE.	PECTOSE.	INSOLUBLE ASH-INGREDIENTS.‡	TOTAL INSOLUBLE MATTERS.		
GOOSEBERRIES.														
1. Large, red, prickly	1854	3.063	1.358	0.441	0.969	0.317	11.148	2.481	0.512	0.294	(0.146)	3.287	85.565	100.000
2. Small, red, prickly	1854	6.030	1.573	0.445	0.513	0.452	9.013	2.442		0.515	(0.069)	2.957	88.030	100.000
3. " " "	1855	8.239	1.589	0.358	0.522	0.504	11.212	2.529		1.428	(0.247)	3.957	84.831	100.000
4. Medium yellow, nearly smooth	1854	6.383	1.078	0.578	2.112	0.200	10.351	3.380	0.442	0.308	(0.100)	4.130	85.519	100.000
5. " " " "	1855	7.507	1.334	0.369	2.113	0.277	11.600	2.081		0.955	(0.170)	3.036	85.364	100.000
6. Large, red, smooth	1855	6.483	1.664	0.306	0.843	0.553	9.849	2.808		0.390	(0.183)	3.198	86.953	100.000
CURRANTS.														
7. Red, medium, ripe	1854	4.78	2.31	0.45	0.28	0.54	8.36	4.45	0.66	0.69	(0.11)	5.80	85.84	100.00
8. " " "	1855	6.44	1.84	0.49	0.19	0.57	9.53	4.48		0.72	(0.23)	5.20	85.27	100.00
9. Very large cherry currants	1855	5.647	1.695	0.356	0.007	0.620	8.35	3.940		2.380	(0.185)	6.320	85.355	100.000
10. White	1854	6.61	2.26	0.77	0.18	0.54	10.36	4.94		0.53	(0.12)	5.47	84.17	100.00
11. "	1855	7.692	2.258	0.300		0.560	10.810	4.144		0.24		4.384	84.806	100.000
12. "	1856	7.12	2.53	0.68	0.19	0.70	11.22	4.85		0.51	(0.14)	5.36	83.42	100.00
STRAWBERRIES.														
13. Wild	1854	3.247	1.650	0.619	0.145	0.737	6.398	6.032		0.299	(0.315)	6.331	87.271	100.000
14. "	1855	4.550	1.332	0.567	0.049	0.603	7.101	5.580		0.300	(0.345)	5.880	87.019	100.000
15. Ananas	1855	7.575	1.333	0.359	0.119	0.280	9.666	1.960		0.900	(0.154)	2.860	87.474	100.000
RASPBERRIES.														
16. Red, wild	1854	3.597	1.980	0.546	1.107	0.270	7.500	8.460		0.180	(0.134)	8.640	83.860	100.000
17. Red, garden	1855	4.708	1.356	0.544	1.746	0.481	8.835	4.106		0.502	(0.296)	4.608	86.557	100.000
18. White, garden	1855	3.703	1.115	0.665	1.397	0.380	7.260	4.520		0.040	(0.061)	4.560	88.180	100.000

* Saccharose and Fructose.

† Expressed as hydrated malic acid.

‡ Already included in Seeds, Skins, etc.

COMPOSITION OF FRUITS, according to FRESENIUS. (*Ann. Ch. u. Ph.*, 101, p. 219.)

FRUITS.	SOLUBLE MATTERS.						SEEDS, SKINS, AND INSOL. MATTERS.					WATER.	
	SUGAR.*	FREE ACID.†	ALBUMINOIDS.	PECTIN-BODIES, GUM, ORGANIC ACIDS IN COMBINATION.	SOLUBLE ASH-INGREDIENTS.	TOTAL SOLUBLE MATTERS.	SEEDS.	SKINS AND CELLULOSE.	PECTOSE.	INSOLUBLE ASH-INGREDIENTS.‡	TOTAL INSOLUBLE MATTERS.		
19. BLACKBERRIES.	4.444	1.188	0.510	1.444	0.414	8.000	5.210		0.384	(0.074)	5.594	86.406	100.000
20. WHORTLEBERRIES.	5.780	1.341	0.794	0.555	0.858	9.328	12.864		0.256	(0.550)	13.120	77.552	100.000
21. MULBERRIES. Black.	9.192	1.860	0.394	2.061	0.566	14.043	0.905		0.345	(0.069)	1.250	84.707	100.000
GRAPES.													
22. Austrian white........................ 1854	13.780	1.020	0.832	0.498	0.360	16.490	2.592		0.941	(0.117)	3.533	79.977	100.000
23. Kleinberger........................ 1855	10.590	0.820	0.662	0.220	0.377	13.629	1.770		0.750	(0.077)	2.520	84.870	100.000
24. Riessling, Oppenheim 1855	13.52	0.71	4.07			18.30	....	....	....	....	5.66	76.04	100.00
25. " " 1855	15.14	0.50	3.46			19.10	....	....	....	....	6.52	74.38	100.00
26. " Johannisberg.................. 1850	19.24	0.66	2.95			22.93	....	....	....	....	.....	....	.....
27. Assmanshauser, red...................... 1856	17.28	0.75	....			.....	....	....	....	....	.....	...	......
CHERRIES.													
28. Sweet, pale-red 1854	13.110	0.851	0.908	2.286	0.600	17.250	5.480	0.450	1.450	(0.090)	7.380	75.370	100.000
29. Sweet, white... 1855	8.568	0.961	3.529		0.885	13.435	3.244	0.464	0.401	(0.070)	4.109	82.456	100.000
30. Sweet, black....... 1855	10.700	0.560	1.010	0.670	0.600	13.540	5.730	0.366	0.664	(0.078)	6.760	79.700	100.000
31. Sour.... 1855	8.772	1.277	0.825	1.831	0.565	13.270	5.182	0.808	0.246	(0.067)	6.236	80.494	100.00
PLUMS.													
32. Green Gage, common, yellow, *Mirabelle*. 1854	3.584	0.582	0.197	5.772	0.570	10.725	5.780	0.179	1.080	(0.082)	7.039	82.236	100.000
33. do. med. size, yellowish green, *Reineclaude* '54	2.960	0.960	0.477	10.475	0.318	15.190	3.250	0.680	0.010	(0.069)	3.940	80.841	100.000
34. do. large, green, very sweet and juicy " 1855	3.405	0.870	0.401	11.074	0.398	16.148	2.852	1.035	0.245	(0.087)	4.132	79.720	100.000
35. Blue, medium size, tart.... 1854	1.996	1.270	0.475	2.313	0.496	6.550	4.190	0.509		(0.041)	4.699	88.751	100.000
36. Black, fair flavor... 1855	2.252	1.331	0.426	5.851	0.553	10.413	3.829	1.020		(0.063)	4.849	85.238	100.000
PRUNES.													
37. Common, moderately sweet, wt. 16 grms..'55	5.793	0.952	0.785	3.646	0.734	11.910	3.540	1.990	0.630	(0.094)	6.160	81.930	100.000
38. Large Italian, very sweet, weight 19 grms. '55	6.730	0.841	0.832	4.105	0.590	13.098	3.124	0.972	1.534	(0.066)	5.630	81.272	100.000

* Saccharose and Fructose.

† Expressed as hydrated malic acid.

‡ Already included in Seeds, Skins, etc.

COMPOSITION OF FRUITS, according to FRESENIUS. (*Ann. Ch. u. Ph.*, 101, p. 219.)

Fruits.	Soluble Matters.						Seeds, Skins, and Insol. Matters.					Water.	
	Sugar.*	Free Acid.†	Albuminoids.	Pectin-bodies, Gum, Organic Acids in Combination.	Soluble Ash-ingredients.	Total Soluble Matters.	Seeds.	Skins and Cellulose.	Pectose.	Insoluble Ash-ingredients.‡	Total Insoluble Matters.		
Apricots.													
39. Handsome, rather large, weight 47 grms. 1854	1.140	0.898	0.832	5.929	0.820	9.619	4.300	0.967	0.148	(0.071)	5.415	84.966	100.000
40. Very delicate, large, weight 60 grams ... 1854	1.531	0.766	0.389	9.288	0.754	12.728	3.216	0.944	1.002	(0.104)	5.266	82.011	100.000
Peaches.													
41. Large Holland 1855	1.580	0.612	0.463	6.318	0.428	9.890	4.689	0.991		(0.042)	5.680	84.990	100.000
42. " " 1855	1.565	0.784	11.058		0.918	14.270	6.764	2.420		(0.168)	9.184	76.546	100.000
Apples.													
43. Large, English Reinette................ 1853	9.25	0.53	1.80			11.58	....	...	....	......	2.39	86.03	100.00
44. " " " 1854	5.96	0.39	0.52	7.61	0.22	14.70	0.07	1.71	1.49	(0.06)	3.27	82.03	100.00
45. " " " 1855	6.83	0.85	0.45	6.47	0.36	14.96	1.95		1.05	(0.08)	3.00	82.04	100.00
46. White table apple.... 1854	7.53	1.04	0.22	2.72	0.44	12.00	0.38	1.42	1.16	(0.08)	2.96	85.04	100.00
47. Borsdorfer 1853	7.61	0.61	6.85			15 07	....	....	....	......	2.44	82.49	100.00
48. White, *Matapfel*.................... 1853	8.98	1.01	3.85			13.84	....	....	....	......	4.58	82.18	100.00
49. English Winter Goldpearmain 1853	10.36	0.48	5.11			15.95	....	....	....	......	2.18	81.87	100.00
Pears.													
50. Sweet, red pear 1854	7.000	0.074	0.260	3.281	0.285	10.900	0.390	3.420	1.340	(0.050)	5.150	83.950	100.000
51. " " " 1855	7.940	trace.	0.237	4.409	0.284	12.870	3.518		0.605	(0.049)	4.123	83.007	100.000

* Saccharose and Fructose. † Expressed as hydrated malic acid. ‡ Already included in Seeds, Skins, etc.

TABLE VII.

FRUITS ARRANGED IN THE ORDER OF THEIR CONTENT OF SUGAR (Average).—(FRESENIUS.)

	PER CENT.
Peaches	1.6
Apricots	1.8
Plums	2.1
Reineclaudes	3.1
Mirabelles	3.6
Raspberries	4.0
Blackberries	4.4
Strawberries	5.7
Whortleberries	5.8
Currants	6.1
Prunes	6.3
Gooseberries	7.2
Red pears	7.5
Apples	8.4
Sour cherries	8.8
Mulberries	9.2
Sweet cherries	10.8
Grapes	14.9

TABLE VIII.

FRUITS ARRANGED IN THE ORDER OF THEIR CONTENT OF FREE ACID EXPRESSED AS HYDRATE OF MALIC ACID (Average).—(FRESENIUS.)

	PER CENT.
Red pears	0.1
Mirabelles	0.6
Sweet cherries	0.6
Peaches	0.7
Grapes	0.7
Apples	0.8
Prunes	0.9
Reineclaudes	0.9
Apricots	1.1
Blackberries	1.2
Sour cherries	1.3
Plums	1.3
Whortleberries	1.3
Strawberries	1.3
Gooseberries	1.5
Raspberries	1.5
Mulberries	1.9
Currants	2.0

TABLE IX.

FRUITS ARRANGED ACCORDING TO THE PROPORTIONS BETWEEN ACID, SUGAR, PECTIN AND GUM, ETC. (Averages).—(FRESENIUS.)

FRUITS.	ACID.	SUGAR.	PECTIN, GUM, ETC.
Plums	1	1.6	3.1
Apricots	1	1.7	6.4
Peaches	1	2.3	11.9
Raspberries	1	2.7	1.0
Currants	1	3.0	0.1
Reineclaudes	1	3.4	11.8
Blackberries	1	3.7	1.2
Whortleberries	1	4.3	0.4
Strawberries	1	4.4	0.1
Gooseberries	1	4.9	0.8
Mulberries	1	4.9	1.1
Mirabelles	1	6.2	9.9
Sour cherries	1	6.9	1.4
Prunes	1	7.0	4.4
Apples	1	11.2	5.6
Sweet cherries	1	17.3	2.8
Grapes	1	20.2	2.0
Red pears	1	94.6	44.4

TABLE X.

FRUITS ARRANGED ACCORDING TO THE PROPORTIONS BETWEEN WATER, SOLUBLE MATTERS, AND INSOLUBLE MATTERS (Averages).—(FRESENIUS.)

FRUITS.	WATER.	SOLUBLE MATTERS.	INSOLUBLE MATTERS.
Raspberries	100	9.1	6.9
Blackberries	100	9.3	6.5
Strawberries	100	9.4	5.2
Plums	100	9.7	0.9
Currants	100	11.0	6.6
Whortleberries	100	12.1	16.9
Gooseberries	100	12.2	3.6
Mirabelles	100	13.0	1.5
Apricots	100	13.3	2.1
Red pears	100	14.3	5.5
Peaches	100	14.6	2.1
Prunes	100	15.3	3.2
Sour cherries	100	16.5	1.8
Mulberries	100	16.6	1.5
Apples	100	16.9	3.6
Reineclaudes	100	18.5	1.2
Cherries	100	18.6	1.5
Grapes	100	22.3	5.8

TABLE XI.

PROPORTION OF OIL IN VARIOUS AIR-DRY SEEDS.

(According to BERJOT.)

(KNOP'S *Agricultur-Chemie*, p. 725.)

(The air dry seeds contain 10–12 per cent. of hygroscopic water.)

Colza, common	40–45
" *Schirmraps*	44
" red India	40
" white	40
Flax	34
Poppy	40–50
Sesame	53
Mustard, white	30
" black	29
Hemp	28
Peanut	38
Gold of Pleasure	35
Watermelon	36
Charlock	15–42
Orange	40
Colocynth	16
Cherry	42
Almond	40
Potato	16
Buckthorn	16
Currant	26
Beechnut	24

TABLE XII.

ARTIFICIAL FRUIT ESSENCES.

The following table shows the number of parts of each ingredient to be added to 100 parts of alcohol (all chemically pure).

(DINGLER'S *Polytechnic Journal.*)

SUBSTANCE.		PEACH.	APRICOT.	PLUM.	CHERRY.	BLACK CHERRY.	LEMON.	PEAR.	ORANGE.	APPLE.	GRAPE.	GOOSEBERRY.	RASPBERRY.	STRAWBERRY.	MELON.	PINEAPPLE.
Glycerine		5	4	8	8	....	5	10	10	4	10	...	4	2	8	3
Chloroform		...	1	...	...	...	1	....	2	1	2	...	...	...	...	1
Nitric ether		...	...	...	...	....	1	...	....	1	....	...	1	1	..	...
Aldehyde		2	...	5	...	....	2	....	2	2	2	1	1	...	2	1
Acetate of ethyl		5	....	5	5	10	10	5	5	1	....	5	5	5	....	..
Formiate of ethyl		5	...	1	...	...	....	....	1	....	2	...	1	1	1	. .
Butyrate of ethyl		5	10	2	...	...	....	....	1	....	....	...	1	5	4	5
Valerianate of ethel		5	5	...	...	...	....	....	....	....	....	...	.	...	5	...
Benzoate of ethel		...	....	...	5	5	....	....	1	...	....	1	1	...	....	...
Œnanthylate of ethel		5	1	4	1	2	....	....	....	...	10	1	1	...	....	...
Sebacic acid		1	....	...	...	..	...	....	....	....	....	...	1	...	10	...
Salicylate of methyl		2	2	...	..	...	...	....	1	....	1	...	1	1	....	...
Acetate of amyl		...	....	..	...	....	....	10	10	....	....	...	1	8	....	...
Butyrate of amyl		...	1	...	...	...	....	..	....	....	....	...	1	2	....	10
Valerianate of amyl		...	....	...	...	....	10	....	....	10	....	...	...	...	....	...
Essence of orange		...	...	...	...	....	....	....	10	.. .	....	...	..	...	....	...
Alcoholic solutions saturated in the cold of	Tartaric acid	...	...	...	...	....	10	....	1	....	5	5	5	...	....	...
	Oxalic acid	...	1	...	...	1	....	....	....	1	....	...	..	...	....	...
	Succinic acid	...	....	...	...	....	1	....	....	....	8	1	1	...	....	...
	Benzoic acid	...	....	...	1	2	....	....	....	. .	....	1	...	...	...	..

GLYCERINE AS A SOLVENT.

Klever has estimated the solubilities of a number of substances in glycerine. The following are his results.

At the ordinary temperature, 100 parts of glycerine dissolve:

98	parts of	Sodic carbonate.	16	parts of	Ferrous lactate.
60	"	Sodic borate.	15	"	Oxalic acid.
50	"	Potassic arseniate.	10	"	Cupric acetate.
50	"	Sodic arseniate.	10	"	Benzoic acid.
50	"	Zincic chloride.	10	"	Boracic acid.
50	"	Tannin.	10	"	Baric chloride.
50	"	Urea.	8	"	Sodic dicarbonate.
40	"	Alum.	8	"	Ferrous tartrate.
40	"	Potassic iodide.	7.5	"	Mercuric chloride.
40	"	Zincic iodide.	6.7	"	Cinchoninic sulphate.
35	"	Zincic sulphate.	5.5	"	Tartar emetic.
33	"	Potassic cyanide.	5	"	Calcic polysulphuret.
30	"	Cupric sulphate.	4	"	Strychnic nitrate.
27	"	Mercuric cyanide.	3.5	"	Potassic chlorate.
25	"	Potassic bromide.	3	"	Atropin.
25	"	Ferrous sulphate.	2.25	"	Brucin.
22.5	"	Strychnic sulphate.	1.90	"	Iodine.
20	"	Morphinic acetate.	1	"	Veratrin.
20	"	Plumbic acetate.	0.50	"	Cinchonin.
20	"	Arsenious acid.	0.50	"	Quinin.
20	"	Arsenic acid.	0.45	"	Morphin.
20	"	Ammonic carbonate.	0.25	"	Quininic tannate.
20	"	Sodic chlorate.	0.25	"	Strychnin.
20	"	Hydroammonic chlorate.	0.20	"	Phosphorus.
20	"	Hydromorphinic chlorate.	0.10	"	Sulphur.

FORMULÆ

OF FREQUENTLY OCCURRING SUBSTANCES.

Acrolein	C_3H_4O.
Alcohol	C_2H_6O (Ethylic).
Alizarin	$C_{10}H_6O_3,2H_2O$ (Strecker).
Aniline	C_6H_5,H_2N.
Antichlor	$Na_2S_2O_3$ (Hyposulphite).
Anthracene or paranapthalin	$C_{14}H_{10}$ (Anderson).
Argols	$KHC_4H_4O_6$ (Bitrartrate).

Asparagin	$C_4H_8N_2O_3,H_2O$.
Atropia	$C_{17}H_{23}NO_3$ (Planta).
Ball soda, 1st product in making	Na_2CO_3.
Barilla	Na_2CO_3 (crude).
Bleaching powder or Javelle water	$CaCl_3 + CaCl_2O_2$.
Benzol	C_6H_6.
Caffein or thein	$C_8H_{10}N_4O_2,H_2O$ (Strecker).
Calamine	$ZnCO_3$.
Calomel	$HgCl$.
Camphor	$C_{10}H_{16}O$.
Cellulin or cellulose	$C_{18}H_{30}O_{15}$.
Chalk	$CaCO_3$.
Chloral or trichoraldehyd	C_2Cl_3HO.
Chloraniline	$(C_6H_4Cl)H_2N$.
Chloroform	$CHCl_3$.
Cinchonia	$C_{20}H_{24}N_2O$.
Cinnabar	HgS.
Codeia	$C_{18}H_{21}NO_3$.
Copperas or green vitriol	$FeSO_4$.
Corrosive sublimate	$HgCl_2$.
Cream of tartar	$KHC_4H_4O_6$.
Creasote or kreasote	$C_{12}H_{16}O_2$?(Gorup-Besanez).
Dextrin	$C_6H_{10}O_5$.
Dextrose or grape sugar	$C_6H_{12}O_6,H_2O$.
Distearin	$\left\{\begin{matrix}(C_3H_5)^{III}\\(C_{18}H_{35}O)\\H\end{matrix}\right\}O_3$.
Elayl or olefiant gas	C_2H_4.
Epsom salts	$MgSO_4,7H_2O$.
Green vitriol	$FeSO_4$.
Fire damp or light carburetted hydrogen	CH_4.
Fruit sugar or lævulose	$C_6H_{12}O_6$.
Fusel oil or amylic alcohol	$C_5H_{12}O$.
Glycerin	$C_3H_8O_3$.
Glauber salts	$Na_2SO_4,10H_2O$.

Grape sugar dextrose	$C_6H_{12}O_6,H_2O$.
Gun-cotton or pyroxylin	$C_{18}H_{21},9NO_2,O_{15}$ (Hadow).
Hæmatein	$C_{16}H_{12}O_6$.
Javelle water, or bleaching powder	$CaCl_2 + CaCl_2O_2$.
Kreasote	$C_{12}H_{16}O_2$? (Gorup-Besanez).
Lactose, or sugar of milk	$C_{12}H_{24}O_{12}$.
Lævulose, or fruit-sugar	$C_6H_{12}O_6$.
Leucine	$C_6H_{13}NO_2$.
Malt sugar	$C_6H_{12}O_6$.
Marsh gas	CH_4.
Meerschaum	$2MgO,3SiO_2.4H_2O$.
Morphia	$C_{17}H_{19}NO_3$.
Naphthalin	$C_{10}H_8$.
Narcotin	$C_{22}H_{23}NO_7$.
Nitroglycerin	$C_3H_5(NO_2)_3O_3$.
Nitre	KNO_3.
Nux vomica, or strychnia	$C_{21}H_{22}N_2O_2$.
Olefiant gas	C_2H_4.
Palmatin	$C_{51}H_{98}O_6$ (Berthelot).
Paraffin	$x(CH_2)$.
Pearlash (crude potassic carbonate)	K_2CO_3.
Prussian blue	$Fe_7Cy_{18},18H_2O = Fe_4Fcy_3,18H_2O$.
" " (basic)	$Fe_7Cy_{18},Fe_2O_3,xH_2O = Fe_4Fcy_3,Fe_2O_3,xH_2O$.
Turnbull's blue, or ferrous ferricyanide	$Fe_5Cy_{12},xH_2O = Fe_3Fdcy_2,xH_2O$.
Williamson's blue, or ferro-potassic ferricyanide	$Fe_2KCy_6,xH_2O = FeK,Fdcy,xH_2O$.
Purple of cassius	$Sn^{II}Au_2Sn_2O_6 4H_2O$. (Figuier.)
Pyroxylin, or gun-cotton	$C_{18}H_{21},9NO_2,O_{15}$ (Hadow).
Quick-lime	CaO.
Quinia	$C_{20}H_{24}N_2O_2,3H_2O$.
Rochelle salts	$KNaC_4H_4O_6,4H_2O$.

Rosaniline	$C_{20}H_{19}N_3,H_2O$.
Salalembroth	$6H_4NCl,HgCl_2.H_2O$.
Salammoniac	H_4NCl.
Salenixum, or bisulphate of potash	$KHSO_4$.
Salgem, or rock salt	$NaCl$.
Salprunella, or fused nitre	KNO_3.
Salt cake	Na_2SO_4.
Salt of sorrel	$H_2C_2O_4,2H_2O$.
Saltpetre	KNO_3.
Scheele's green	$CuHAsO_3$.
Schweinfurt green	$3CuAsO_4,Cu2C_2H_3O_2$.
Spelter, or zinc	Zn.
Soapstone, or French chalk	$MgO,SiO_2.2MgO,3SiO_2$.
Steatite, or soapstone	$MgO,SiO_2.2MgO,3SiO_2$.
Stearin	$C_{57}H_{110}O_6$ (Berthelot).
Strychnia	$C_{21}H_{22}N_2O_2$.
Sucrose, or cane-sugar	$C_{12}H_{22}O_{11}$.
Tartar emetic	$2[C_4H_4K(SbO)O_6].H_2O$.
Toluol	C_7H_8.
Triolein	$C_{57}H_{104}O_6$.
Tripalmatin	$C_{51}H_{98}O_6$.
Tristearin	$C_{57}H_{110}O_6$.
Zylol	C_8H_{10}.

FORMULÆ
OF THE FREQUENTLY OCCURRING ACIDS.

Acid Acetic	$HC_2H_3O_2$.
" Acrylic	$HC_3H_3O_2$.
" Antimonic	H_5SbO_5.
" Antimonous	$HSbO_2$.
" Apocrenic	$H_2C_{24}H_{12}O_{13}$? (Mulder).
" Arsenic	H_3AsO_4.
" Arsenous	H_3AsO_3.
" Aspartic	$HC_4H_6NO_4$.
" Basic (stearic)	$HC_{18}H_{35}O_2$.

Acid	Benzoic	$HC_7H_5O_2$.
"	Bismuthic	$HBiO_3$.
"	Boric	H_3BO_3.
"	Bromic	$HBrO_3$.
"	Butic	$C_{20}H_{40}O_2$ (Heintz).
"	Butyric	$HC_4H_7O_2$.
"	Camphoric	$H_2C_{10}H_{14}O_4$.
"	Capric (rutic)	$HC_{10}H_{19}O_2$.
"	Caproic	$HC_6H_{11}O_2$.
"	Caprylic	$HC_8H_{15}O_2$.
"	Carbolic (phenic)	HC_6H_5O.
"	Carbazotic (picric-trinitrophenic)	$HC_6H_2(NO_2)_3O$.
"	Carbonic	H_2CO_3.
"	Carminic	$C_{14}H_{14}O_8$.
"	Citric	$H_3C_6H_5O_7,H_2O$ (Liebig).
"	Chloric	$ClO_2(OH)$.
"	Chlorous	$ClO(OH)$.
"	Chromic	H_2CrO_4.
"	Diphosphoric	$H_4P_2O_7$.
"	Gallic	$H_3C_7H_3O_5,H_2O$.
"	Glycolic	$HC_2H_3O_3$.
"	Hippuric	$HC_9H_8NO_3$.
"	Hydrobromic	HBr.
"	Hydrochloric	HCl.
"	Hydrocobalticyanic	H_3CoCy_6
"	Hydroferricyanic	H_3FeCy_6.
"	Hydroferrocyanic	H_4FeCy_6.
"	Hydrofluoric	HF.
"	Hydriodic	HI.
"	Hydrosulphocyanic	$HCyS$.
"	Hydrosulphuric	H_2S.
"	Hypobromous	$HBrO$.
"	Hypochlorous	$Cl(OH)$.
"	Hypoiodous	HIO.
"	Hyposulphurous	H_2SO_2.

Acid Iodic	HIO_3.
“ Kresylic	HC_7H_7O.
“ Lactic	$HC_3H_5O_3$.
“ Malic	$H_2C_4H_4O_5$.
“ Meta-gallic	$C_6H_4O_2$.
“ Meta-phosphoric	HPO_3.
“ Meta-stannic	H_2SnO_3.
“ Meta-silicic	H_2SiO_3.
“ Meta-tartaric	$H_2C_4H_4O_6$.
“ Myristic	$HC_{14}H_{27}O_2$.
“ Nitric	HNO_3.
“ Nitrous	HNO_2.
“ Oleic	$HC_{18}H_{33}O_2$.
“ Palmitic	$HC_{16}H_{31}O_2$.
“ Pentathionic	$H_2S_5O_6$,
“ Perchloric	$ClO_3(OH)$.
“ Perchromic	$H_2Cr_2O_8$.
“ Periodic	HIO_4.
“ Permanganic	$H_2Mn_2O_8$.
“ Phenic (carbolic)	HC_6H_5O.
“ Phosphoric	H_3PO_4.
“ Picric (carbazotic)	$H,C_6H_2(NO_2)_3O$.
“ Pyrocitric	$H_2C_5H_4O_4$.
“ Pyrogallic	$C_6H_6O_3$.
“ Pyroligneous	$HC_2H_3O_2$.
“ Pyrotartaric	$H_2C_4H_4O_6,H_2O$.
“ Racemic	$H_2C_4H_4O_6,H_2O$.
“ Saccharic	$H_2C_6H_8O_8$.
“ Silicic (ortho)	H_4SiO_4.
“ Stannic (ortho)	H_4SnO_4.
“ Stearic	$HC_{18}H_{35}O_2$.
“ Succinic	$H_2C_4H_4O_4$.
“ Sulphantimonic	H_3SbS_4.
“ Sulphocarbonic	H_2CS_3.
“ Sulphosulphuric	$H_2S_2O_3$.
“ Sulphuric	H_2SO_4.

Acid Sulphurous	H_2SO_3, 14 aq.
" Tetrathionic	$H_2S_4O_6$.
" Trithionic	$H_2S_3O_6$.
" Tannic	$C_{27}H_{22}O_{17}$ (Strecker).
" Tartaric	$H_2C_4H_4O_6$.
" Uric or lithic	$H_2C_5H_2N_4O_3$.
" Valeric or valerianic	$HC_5H_9O_2$.

ARTIFICIAL FORMATION OF ORGANIC BODIES.

1828. Urea. (Wöhler.)
1831. Formic acid. (Pelouze.)
1846. Marsh gas. (Melsens.)
1847. Acetic acid. (Dumas, Malaguti, and Le Blanc.)
1857. Cinnamic acid. (Bertagnini.)
1857. " " (Harnitz Harnitzky.)
1858. Formic acid, ethylene, marsh gas, and acetylene. (Berthelot.)
1858. Acetic and propionic acids. (Wanklyn.)
1859. Glycols. (Wurtz.)
1860. Malic and tartaric acid. (Kekulé, Perkin and Duppa.)
1861. Gallic acid. (Lauteman.)
1861. Sugar and formic acid. (Boutherow.)
1861. Formic acid. (Kolbe.)
1862. Alcohol. (Wurtz.)
1862. Amylene. (Wurtz.)
1862. Amine from lower cyanides. (Mendius.)
1863. Lactic acid. (Wislecenius.)
1863. Diatomic acids. (Lippeman.)
1863. Leucic " (Frankland.)
1863. Malonic " (Kolbe and Muhler.)
1863. Carballylic " (Maxwell Simpson.)
1863. Isomer of Rutylic alcohol. (Boutherow.)
1864. Secondary butylic alcohol. (Lieben.)
1864 and 1865. Fatty and aromatic series of acids. (H. Hainitzky.)

1864 and 1865. Toluene and Xylene. (Fittig and Tollens.)
1865. Aceconitic acid. (Bæyer.)
1865. Butyric and Caproic acid. (Frankland.)
1865. Isomer of tartaric acid. (Schögen.)
1866. Toluic acid. (Kékulé.)
1867. Oxalic and malonic acids. (Berthelot.)
1868. Neurine. (Wurtz.)
1869. Picolin. (Schiff.)
1870. Oil of Rue. (Gorup-Besanez.)
1870. Alizarine. (Graebe, Linderman, etc.)

ALCOHOLS.

MONATOMIC ALCOHOLS.

First series, $C_{2n}H_{2n+2}+2O_2$ (*fatty group*).

Methylic alcohol, or wood spirit, hydrate of methyl (Taylor, 1812; Dumas and Peligot, 1835)	$C_2H_4O_2$
Vinous alcohol, or ordinary alcohol, hydrate of ethyl	$C_4H_6O_2$
Propylic alcohol, or hydrate of trityle (Chancel, 1852)	$C_6H_8O_2$
Butylic alcohol, or hydrate of tetryle (Wurtz, 1852)	$C_8H_{10}O_2$
Amylic alcohol, or hydrate of pentyle (Scheele, 1785; Cahours and Balard, 1830)	$C_{10}H_{12}O_2$
Caproic alcohol, or hydrate of hexyle (Faget, 1852)	$C_{12}H_{14}O_2$
Œnanthylic alcohol, or hydrate of heptyle (Faget, 1862)	$C_{14}H_{16}O_2$
Caprylic alcohol, or hydrate of octyle (Bouis, 1851)	$C_{16}H_{18}O_2$
Rutic or capric alcohol, or hydrate of decyle	$C_{20}H_{22}O_2$
Cetylic alcohol, or hydrate of cetyl (Chevreul, 1823; Dumas and Peligot, 1836)	$C_{32}H_{34}O_2$
Cerotic alcohol, or ceric, or hydrate of ceryle (Brodie, 1848)	$C_{54}H_{56}O_2$
Melissic, or myricic alcohol, or hydrate of myricile (Brodie, 1848)	$C_{60}H_{62}O_2$

Second series, $C_{2n}H_{2n}O_2$.

Acetylenic, or vinylic alcohol (Berthelot, 1860)	$C_4H_4O_2$
Allylic alcohol, or hydrate of allyle (Cahours and Hoffmann, 1856)	$C_6H_6O_2$
Menthic alcohol	$C_{20}H_{20}O_2$

Third series, $C_{2n}H_{2n-2}O_2$.

Campholic alcohol, or Borneo camphor (Pelouze, 1840)	$C_{20}H_{18}O_2$

Fourth series, $C_{2n}H_{2n-6}O_2$ (*aromatic series*).

Benzyl alcohol, or hydrate of benzyl (Cannizaro, 1853)	$C_{14}H_8O_2$
Toluic, or tollylic alcohol (Cannizaro, 1853)	$C_{16}H_{10}O_2$
Cumylic alcohol, or hydrate of cumyl (Kraut, 1854)	$C_{20}H_{14}O_2$
Syroceric alcohol, or hydrate of syroceryle (Warren de la Rue, Muller, 1859)	$C_{36}H_{30}O_2$

Fifth series, $C_{2n}H_{2n-8}O_2$.

Cinnamic alcohol, or styrone, hydrate of cinnamyle (Simon, 1839)	$C_{18}H_{10}O_2$
Cholesteric alcohol, or cholchesterine (Conradi, 1775)	$C_{32}H_{24}O_2$

DIATOMIC ALCOHOLS, OR GLYCOLS.

Ethylic glycol, or hydrate of the oxide of ethylene (Wurtz, 1856)	$C_4H_6O_4$
Propylic glycol, or hydrate of the oxide of propylene (Wurtz, 1856)	$C_6H_8O_4$
Butyl glycol, or hydrate of the oxide of butylene (Wurtz, 1856)	$C_8H_{10}O_4$
Amyl glycol, or hydrate of the oxide of amylene (Wurtz, 1856)	$C_{10}H_{12}O_4$
Hexylglycol, or hydrate of oxide of hexylene (Wurtz, 1854)	$C_{12}H_{14}O_4$
Capryl glycol, or hydrate of the oxide of octylene (De Clermont, 1865)	$C_{16}H_{18}O_4$
Saligenine (Piria, 1845)	$C_{14}H_8O_4$
Anise alcohol (Cannizaro and Bertagnini)	$C_{16}H_{10}O_4$

TRIATOMIC ALCOHOLS.

Glycerin (Scheele, 1779; Berthelot, 1860)	$C_6H_8O_6$
Amylglycerin (Bauer, 1863)	$C_{10}H_{10}O_6$

TETRATOMIC ALCOHOLS.

Propylphycite (Carius, 1866)	$C_6H_8O_8$
Erythrite (De Luynes, 1862)	$C_8H_{10}O_8$

HEXATOMIC ALCOHOLS.

Mannite (Proust, 1806)	$C_{12}H_{14}O_{12}$
Glucose (Lowitz, 1790; Proust, 1802)	$C_{12}H_{12}O_{12}$
Inosite (Scheerer, 1850)	$C_{12}H_{12}O_{12}$
Pinite (Berthelot, 1853)	$C_{12}H_{14}O_{12}$
Quercite (Braconnot, 1849)	$C_{12}H_{14}O_{12}$

ALLOYS AND COMPOSITIONS.

(By Haswell.)

Substance.	Copper.	Zinc.	Tin.	Nickel.	Lead.	Antimony.	Bismuth.	Silver.	Cobalt of Iron.	Iron.	Arsenic.
Argentan	55	24	—	21	—	—	—	—	—	—	—
Argentiferous	50	2.5	2.5	40	2.5	—	—	—	—	2.5	—
Babbitt's metal	3.7	—	89	—	—	7.3	—	—	—	—	—
Brass, common	84.3	5.2	10.5	—	—	—	—	—	—	—	—
“ “	75	25	—	—	—	—	—	—	—	—	—
“ “ hard	79.3	6.4	14.3	—	—	—	—	—	—	—	—
“ mathematical instruments	92.2	—	7.8	—	—	—	—	—	—	—	—
“ pinchbeck	80	20	—	—	—	—	—	—	—	—	—
“ red tombac	88.8	11.2	—	—	—	—	—	—	—	—	—
“ rolled	74.3	22.3	3.4	—	—	—	—	—	—	—	—
“ tutenag	50	31	—	19	—	—	—	—	—	—	—
“ very tenacious	88.9	2.8	8.3	—	—	—	—	—	—	—	—
“ wheels, valves	90	—	10	—	—	—	—	—	—	—	—
“ white	10	80	10	—	—	—	—	—	—	—	—
“ wire	67	33	—	—	—	—	—	—	—	—	—
“ yellow, fine	66	34	—	—	—	—	—	—	—	—	—
Britannia metal	—	—	25	—	—	25	—	—	—	—	—
“ “ when fused, add	—	—	—	—	—	25	25	—	—	—	—
Bronze, red	87	13	—	—	—	—	—	—	—	—	—
“ red	86	11.1	2.9	—	—	—	—	—	—	—	—
“ yellow	67.2	31.2	1.6	—	—	—	—	—	—	—	—
“ cymbals	80	—	20	—	—	—	—	—	—	—	—
“ gun metal, large	90	—	10	—	—	—	—	—	—	—	—
“ “ small	93	—	7	—	—	—	—	—	—	—	—
“ medals	93	—	7	—	—	—	—	—	—	—	—
“ statuary	91.4	5.5	1.4	—	1.7	—	—	—	—	—	—
Chinese silver	65.1	19 8	—	13	—	—	—	2.48	12	—	—
Chinese white copper	40 4	25.4	2.6	31.6	—	—	—	—	—	—	—
Church bells	80	5.6	10.1	—	4.3	—	—	—	—	—	—
“ “	69	—	31	—	—	—	—	—	—	—	—
Clock bells	72	—	26.5	—	—	—	—	—	—	1.5	—
Clocks, musical bells	87.5	—	12.5	—	—	—	—	—	—	—	—
German silver	33.3	33.4	—	33.3	—	—	—	—	—	—	—
“ “	40.4	25.4	—	31.6	—	—	—	—	—	2.6	—
“ “ fine	49.5	24	—	24	—	—	—	—	—	2.5	—
Gongs	81.6	—	18.4	—	—	—	—	—	—	—	—
House bells	77	—	23	—	—	—	—	—	—	—	—
Lathe bushes	80	—	20	—	—	—	—	—	—	—	—
Machinery bearings	87 5	—	12.5	—	—	—	—	—	—	—	—
“ “ hard	77.4	7	15.6	—	—	—	—	—	—	—	—
Metal that expands in cooling	—	—	—	—	75	16.7	8.3	—	—	—	—
Muntz metal	60	40	—	—	—	—	—	—	—	—	—
Pewter, best	—	—	86	—	—	14	—	—	—	—	—
“	—	—	80	—	20	—	—	—	—	—	—
Printing characters	—	—	—	—	80	20	—	—	—	—	—
Sheathing metal	56	45	—	—	—	—	—	—	—	—	—
Speculum “	66	—	22	—	—	—	—	—	—	—	12
“ “	50	21	29	—	—	—	—	—	—	—	—
Telescopic mirrors	66.6	—	33.4	—	—	—	—	—	—	—	—
Temper	33.4	—	66.6	—	—	—	—	—	—	—	—
Type and stereotype plates	—	—	—	—	69	15.5	15.5	—	—	—	—
White metal	7.4	7.4	28.4	—	—	56.8	—	—	—	—	—
“ “ hard	69.8	25.8	4.4	—	—	—	—	—	—	—	—
Oreide	73	12.8	Magnesia .... 4.4 Cream of tartar 6.5 Sal-ammoniac 2.5 Quicklime ... 1.8 } fluxes.								

ALLOYS FOR SOLDERS.

		Melts—F.
Newton's fusible	$\mathrm{8Bi+5Pb+8Sn}$	212°.
Rose's "	$\mathrm{2Bi+1Pb+1Sn}$	201°.
A more "	$\mathrm{5Bi+3Pb+2Sn}$	199°.
Still more "	$\mathrm{12Sn+25Pb+50Bi+13Cd}$	155°.
For tin solder, coarse	$\mathrm{1Sn+8Pb}$	500°.
" " ordinary	$\mathrm{2Sn+1Pb}$	360°.
For brass, soft spelter	$\mathrm{1Cu+1Zn}$	550°.
Hard, for iron	$\mathrm{2Cu+1Zn}$	700°.
For steel	$\mathrm{19Sn+3Cu+1Zn}$	—
For fine brass work	$\mathrm{1Sn+8Cu+8Zn}$.	
Pewter soft solder	$\mathrm{1Bi+1Pb+2Sn}$.	
Gold solder	$\mathrm{24Au+2Sn+1Cu}$.	
Silver solder, hard	$\mathrm{4Sn+1Cu}$.	
" " soft	$\mathrm{2Sn}$+1 brass (wire).	
For lead	$\mathrm{16Sn+33Pb}$.	

FLUXES FOR SOLDERING OR WELDING.

Iron	Borax.
Tinned iron	Resin.
Copper and brass	Sal-ammoniac.
Zinc	Chloride of zinc.
Lead	Tallow or resin.
Lead and tin pipes	Resin and sweet oil.

AMALGAMS.

GOLD.—One weight of mercury amalgamates with two weights of gold.

SILVER.—10 silver to 19 mercury.
7 " " 20 "

TIN.—1 tin to 3 mercury, for looking-glasses.
1 tin, 1 lead, 2 bismuth, 10 mercury, for glass-globes.
1 tin, 1 zinc, 3 mercury, for rubbers in electric machines.

TABLE.

(BY H. SPRENGEL, PH.D.)

Showing the total amount of oxygen, and the oxygen available for combustion, in a few oxygen compounds.

NAME.	FORMULA.	TOTAL O IN 100.	AVAILABLE O IN 100.
Peroxide of hydrogen	H_2O_2	94.1	47.0
Water	H_2O	88.8	—
Nitric acid	HNO_3	76.2	63.5
Nitric anhydride	N_2O_5	74.0	74.0
Carbonic acid	CO_2	72.7	—
Peroxide of lithium?	Li_2O_2	71.1	35.5
Oxalic acid	$H_2C_2O_4$	71.1	—
Nitric peroxide	NO_2	69.5	69.5
Tetranitromethane	$C(NO_2)_4$	65.3	65.3
Sulphuric acid	H_2SO_4	65.3	?
Perchloric acid	$HClO_4$	63.6	55.7
Trinitroglycerin	$C_3H_5(NO_2)_3O_3$	63.4	42.3 ?
Nitrate of ammonia	NH_4NO_3	60.0	50.0 ?
Gun-cotton	$C_6H_7(NO_2)_3O_5$	59.3	32.3 ?
Nitrate of sodium	$NaNO_3$	56.4	47.0
Trinitroacetonitril	$C_2(NO_2)_3N$	54.5	54.5
Peroxide of acetyl	$C_4H_6O_4$	54.2	13.5 ?
Acetic acid	$C_2H_4O_2$	53.3	?
Glycerin	$C_3H_8O_3$	52.2	?
Silica	SiO_2	51.9	—
Nitrate of urea	H_4N_2CO,HNO_3	51.4	32.5
Cellulose	$C_6H_{10}O_5$	49.4	?
Picric acid	$C_6H_3(NO_2)_3O$	48.9	41.9
Nitrate of potassium	$KaNO_3$	47.5	39.6
Chlorate of potassium	$KaClO_3$	39.2	39.2
Cyanic acid	$CNHO$	37.2	?
Cyanuric acid	$C_3N_3H_3O_3$		
Cyamelide	$C_nN_nH_nO_n$		
Fulminuric acid	$C_3H_3N_3O_3$		
Peroxide of manganese	MnO_2	36.7	18.3
Nitrate of diazobenzine	$C_6H_4N_2,HNO_3$	28.7	23.9
Nitrobenzine	$C_6H_5(NO_2)$	26.2	26.2
Iodic acid	I_2O_5	23.9	23.9
Phenol	C_6H_6O	17.1	?
Fulminating mercury	$C_2Hg(NO_2)N$	11.2	11.2
Charcoal	$C_mH_nO_p$	10.0	?

THE OLD NAMES FOR A FEW SALTS.

Salt (ammoniacal, fixed). Calcic chloride.
" (ammoniacal, secret) of Glauber. Ammonic sulphate.
" (arsenical, neutral) of Macquer. Potassic hydric arsenate.
" (bitter cathartic). Magnesium sulphate.
" (common). Sodic chloride.
" (digestive) of Sylvius. Potassic acetate.
" (epsom). Magnesic sulphate.
" (febrifuge) of Sylvius. Potassic chloride.
" (fusible). Ammonic phosphate.
" (fusible) of Urine. Ammonio-sodic phosphate.
" (green). In the mines of Wieliczka the workmen give this name to the upper stratum of native salt, which is rendered impure by a mixture of clay.
" (marine). Sodic chloride.
" (marine, argillaceous). Aluminic chloride.
" (microcosmic). Ammonio-sodic phosphate.
" (nitrous ammonical). Ammonic nitrate.
" of Amber. Succinic acid.
" of Benzoin. Benzoic acid.
" of Canal. Magnesic sulphate.
" of Colcothar. Ferrous sulphate.
" of Egra. Magnesic sulphate.
" of Lemons (essential). Potassic hydric oxalate.
" of Saturn. Plumbic acetate.
" of Sedlitz. Magnesic sulphate.
" of Seignette. Potassio-sodic tartrate.
" of Soda. Sodic carbonate.
" of Sorrel. Potassic hydric oxalate.
" of Tartar. Potassic carbonate.
" of Vitriol. Purified zinc sulphate.
" of Wisdom. Ammonio-mercuric chloride.
" (perlate). Disodic orthophosphate.
" (polychrest) of Glaser. Potassic sulphate.
" (sedative). Boracic acid.
" (spirit of). Hydrochloric acid was formerly called by this name, which it still retains in commerce.
" (sulphureous) of Stahl. Potassic sulphite.
" (wonderful). Sodic sulphate.
" (wonderful, perlate). Disodic orthophosphate.

TABLE

SHOWING THE INDEX OF REFRACTION OF A FEW SUBSTANCES.

(FOWNES.)

SUBSTANCE.	INDEX OF REFRACTION.
Tabasheer*	1.10
Ice	1.30
Water	1.34
Fluor-spar	1.40
Plate glass	1.50
Rock crystal	1.60
Chrysolite	1.69
Carbon disulphide	1.70
Garnet	1.80
Glass (with much plumbic oxide)	1.90
Phosphorus	2.20
Diamond	2.50
Plumbic chromate	3.00
Cinnabar	3.20

ELECTRICITY.

(NYSTROM.)

ELECTRO-CHEMICAL ORDER OF SIMPLE SUBSTANCES.

ELECTRO-POSITIVE.

Potassium.
Sodium.
Lithium.
Barium.
Strontium.
Calcium.
Magnesium.
Aluminium.
Uranium.
Manganese.
Zinc.
Iron.
Nickel.
Cobalt.
Cadmium.
Lead.
Tin.
Bismuth.
Copper.
Silver.
Mercury.
Palladium.
Platinum.
Gold.
Hydrogen.
Silicon.
Titanium.
Tellurium.
Antimony.
Carbon.
Boron.
Tungsten.
Molybdenum.
Vanadium.
Chromium.
Arsenicum.
Phosphorus.
Iodine.
Bromine.
Chlorine.
Fluorine.
Nitrogen.
Selenium.
Sulphur.
Oxygen.
ELECTRO-NEGATIVE.

ORDER OF COMPOUNDS.

ELECTRO-POSITIVE.

Fur.
Smooth glass.
Woolen cloth.
Feathers.
Wood.
Paper.
Silk.
Lac.
Rough glass.
Sulphur.
Cotton.
ELECTRO-NEGATIVE.

In chemical formulas the electro-positive substance is placed first, and the negative last. *Oxygen*, being the substance most electro-negative, combines with the most electro-positive substance in the couple, and the force liberated by the oxidation, or that which kept the oxidated substance solid, forms the electricity. No electricity can be formed without the consumption of some force or substance.

The substances are arranged in their order of positive and negative electricity. The substance is positive to either one below it, and negative to any one above. The exciting fluid to be diluted sulphuric acid. Other fluids cause some difference in the order, depending upon the different chemical affinity between the fluid and the substances in the galvanic couple.

---

* A silicious deposit in the joints of the bamboo.

ORDER OF CONDUCTING POWER FOR ELECTRICITY.

Metals, best conductors.
Well-burnt charcoal.
Plumbago.
Concentrated acids.
Powdered charcoal.
Diluted acids.
Saline solutions.
Metallic ores.
Animal fluids.
Sea water.
Spring water.
Rain water.
Ice above 18° Fahr.
Snow.
Living vegetables.
Living animals.
Steam.
Salts soluble in water.
Rarefied air.
Vapor of alcohol.
Moist earth and stones.
Powdered glass.
Flower of sulphur.
Dry metallic oxides.
Oils, the heaviest the best.
Ashes.
Transparent crystals.
Ice below 18° Fahr.
Phosphorus.
Lime.
Dry chalk.
Caoutchouc.
Camphor.
Silicious stones.
Dry marble.
Porcelain.
Baked wood.
Dry gases and air.
Leather.
Parchment.
Dry paper.
Feathers.
Hair.
Wool.
Dyed silk.
Bleached silk.
Raw silk.
Diamond.
Mica.
All vitrifications.
Glass.
Jet.
Wax.
Sulphur.
Resins.
Amber.
Shellac.
Gutta-percha, *the worst conductor of all.*

Velocity of electricity through the best conductors is equal to that of light through planetary space—about 200,000 miles per second. When the conductor is insulated with a solid non-conducting substance, like gutta-percha, and immersed in water as a submarine cable, the velocity may be reduced to only 20,000 miles per second, or less.

The substances are set up in their order of conducting power for electricity. The conducting power of substances for heat appears to be in the same proportion as that for electricity. The poor conductors for electricity are called *insulators*, and employed between good conductors to stop the flow or passage of the electric fluid.

POISONS AND THEIR ANTIDOTES.*

As poisoning may and does often occur from accident or design, it is well for every person to make himself familiar, if not with the proper antidote (for every poison has its antidote), with some necessary preliminary treatment before the doctor arrives. Much suffering and even death may then, in the majority of cases, be prevented.

"When known that poison has been taken into the stomach, the first thing is to evacuate it by means of the stomach-pump or an emetic, unless vomiting takes place spontaneously.

"As an emetic, ground *mustard* mixed in warm water is always safe. Take one tablespoonful to one pint of warm water. Give the patient one-half in the first instance, and the remainder in fifteen minutes, if vomiting has not commenced. In the interval drink copious draughts of warm water. Irritate the throat with a feather or finger, to induce vomiting.

---

* The following table has been carefully compiled from Wood's Lexicon, Cutter's Anatomy, and Jahr's (Hull) Symptoms.

After vomiting has begun give mucilaginous drinks, such as flax-seed tea, gum-arabic water, or slippery elm.

"If the patient is drowsy, give a strong infusion of cold coffee, keep him walking, slap smartly on the back; use electricity; it may be well to dash cold water on the head, to keep the patient awake.

"After the poison is evacuated from the stomach to sustain vital action, give warm water and wine or brandy. If the limbs are cold, apply warmth and friction.

"In all cases of poisoning, call immediately a physician, as the after treatment is of great importance."

POISON.	ANTIDOTE AND REMEDIES. (*Large doses.*)	ANTIDOTE. (*Homœopathically—small doses.*)
ACID ACETIC.	Chalk, whiting, magnesia, soap or oil. Alkaline bicarbonates, milk, white of egg, or almost any demulcent.	China, nux vomica, coffea, arsenicum, belladona.
ACID HYDROCYANIC, or PRUSSIC ACID; BITTER ALMONDS (oil of); LAUREL WATER.	Drink at once one teaspoonful of ammonic hydrate (spirits of hartshorn) in one pint of water. Inhale odor of ammonia. Chlorine, either in vapor, or taken internally. Cold infusions, artificial respiration, stimulating injections. Sulphate of iron.	Same.
ACID HYDROCHLORIC, MURIATIC, or MARINE ACID.	Neutralize the acid by chalk or calcined magnesia, or a dilute solution of an alkaline carbonate, milk, white of egg, strong soapsuds and lime. Large draughts of tepid water or mucilage should follow the antidote.	Large doses: magnesia calcinata, sapo, medicus. Of small doses: bryonia (?), camphor.
ACID SULPHURIC or OIL OF VITRIOL.	Same as hydrochloric acid—muriatic acid.	Pulsatilla.
ACID OXALIC.	Powdered chalk; magnesia, or its carbonate, suspended in water or milk. An emetic, if free vomiting is not induced by the above means.	Same.

Poisons and their Antidotes—(*Continued*).

Poison.	Antidote and Remedies. (*Large doses.*)	Antidote. (*Homœopathically—small doses.*)
Acid Phosphoric.	Magnesia, emetics, and emollient drinks.	Camphor and coffea.
Acid Nitric or Aquafortis.	Same as hydrochloric acid.	Calcarea carbonate. Camphor. Conium maculatum. Hepar-sulphuris-calcareum. Mercurius. Petroleum. Phosphorus. Phosphorus acid. Sulphur.
Alcohol.	The stomach-pump. Cold affusions. Ammonic hydrate (spirits of hartshorn).	Same.
Chloroform and Ether.	Cold affusions on the head and neck, ammonia to the nostrils, artificial respiration, electricity, opening the trachea.	Same.
Ammonic Hydrate (Ammonia, or Spirits of Hartshorn), Potash or Soda.	Weak acids, as vinegar and water, followed by acidulated demulcent drinks. Lemon juice, olive oil in large quantities, large draughts of cream or milk. Use no emetic. In poisoning by the vapor of ammonia, the inhalation of the vapor of acetic acid or of dilute hydrochloric acid.	Same.
Iodine and Iodide of Potassium (Potassic Iodide).	Take a mustard emetic. Drink a mixture of starch, gruel, or arrowroot beat in water.	Same.
Mad Dog Bite, or Hydrophobia.	Cauterization of the wound with argentic nitrate (nitrate of silver, lunar caustic). The following is said to be successful: Slice or bruise the green or dry root of *elecampane*, put into a pint of fresh milk, and boil down to half a pint, strain when cold; drink, fasting, at least six hours afterward. The next morning, fasting, repeat	Same.

POISONS AND THEIR ANTIDOTES—(*Continued*).

POISON.	ANTIDOTE AND REMEDIES. (*Large doses.*)	ANTIDOTE. (*Homœopathically—small doses.*)
HYDROPHOBIA. (*Continued.*)	the dose, using two ounces of the root. Repeat this the third morning, and it will be sufficient. According to Dr. Grzyvala, of England, and Prof. Guber, of Paris, *xanthium spinosum* possesses antirabic properties. Of the dried leaves, powdered, the dose for an adult is nine grains, thrice daily. For children under that age, half that dose. Sure cure for hydrophobia, both in man and animals. "Cases treated with the actual cautery and the daily use of *genista tinctoria*, died with hydrophobia, when with the above plant (*xanthium spinosum*), similar cases were all mastered." (British Med. Jour.)	
TOADSTOOLS (non-edible mushrooms).	Prof. Maurice Schiff, of Florence, has demonstrated that the *non-edible* mushrooms contain a common poison, *muscarin*, and that its effects are counteracted by atropin or dantrin.	Same.
ARSENIC; COBALT (fly powder); KING'S YELLOW; RATSBANE; SCHEELE'S GREEN.	An emetic, stomach-pump, zincic sulphate, cupric sulphate; or mustard may be used as an emetic, or salt and water; or vomiting may be produced by tickling the throat with a feather. The vomiting should be assisted by demulcent drinks. After free vomiting, give large quantities of calcined magnesia. The antidote for arsenic is hydrated sesquioxide of iron, freshly precipitated. If the poison has passed into the bowels, castor-oil.	Camphor, china, chin-sulph., ferrum, hep. *iod.*, *ipec.*, *nux. v.*, samb., *tabac*, verat.
ANTIMONY (Wine of); TARTAR EMETIC.	Vomiting should be produced by tepid water; any astringent infusion, such as tea, oak, bark, tannin (ground nutgall); afterward opiates (paregoric), warm bath, and mustard poultices.	Hepar-sulphuris-calcareum. Mercurius. Pulsatilla (?).
BARYTA SALTS.	Stomach-pump or emetics; magnesic sulphate or soda.	Same.

POISONS AND THEIR ANTIDOTES—(*Continued*).

POISON.	ANTIDOTE AND REMEDIES. (*Large doses.*)	ANTIDOTE. (*Homœopathically—small doses.*)
COPPER; VERDIGRIS; BLUE VITRIOL.	Demulcent fluids to induce vomiting, stomach-pump, albumen in large excess, milk, cooking soda, iron filings, manna, preparations of sulphur.	Belladona, calcarea carb., china, coc. dulc. (?), hep. sulph., ipec., mer. corr.. nux v., rhus, sulphur.
IRON.	Sodic carbonate; mucilaginous drinks.	Arnica, arsenicum, belladona, china, hep. s., ipec., merc., puls., verat.
LEAD; ACETATE OF LEAD (Sugar of Lead); WHITE LEAD; LITHARGE.	Emetic—mustard. Follow with zincic sulphate (Epsom or Glauber salts). Antidote is weak sulphuric acid. Take large draughts of milk containing white of eggs.	Alum, acid. sulph. in the shape of a lemonade, belladona, hyos., merc., nux v., op., plat., pulsatilla, sabad., sec. c., stram., strychnine.
IODINE.	Starch or wheat flour beat in water, taken in large quantities. Take a mustard emetic; tepid baths.	(Mercurius, arsenicum), antimony, camphor, arsenicum, china, chin-sulph., coffea, hep. s., op., etc.
MERCURY; CORROSIVE SUBLIMATE (bug poison); WHITE PRECIPITATE; RED PRECIPITATE (Vermilion).	Beat the *whites of six eggs* (albumen) in one quart of cold water; give a cupful every two minutes. Induce vomiting. A substitute for eggs is *soap-suds* slightly thickened with wheat flour. The white of one egg neutralizes four grains of the poison. Emetics should not be given.	Acid. nitric., acid. phos., am. c., arn., ars., asaf., acer., aurum m., bell., camphor, carb. v., china, con., cupr., dulc., elec., ferr. iod., opium, phosphorus, staph., sulphate of zinc, etc.; white of an egg.
NITRATE OF POTASH (Saltpetre); NITRATE OF SODA (Chili Saltpetre).	Take at once a *mustard* emetic; drink copious draughts of warm water; followed with oil or cream.	Same.
PEARL-ASH LEY (f'm wood ashes); SALTS OF TARTAR.	Drink freely of *vinegar* and water; followed with a mucilage, as flaxseed tea.	Same.

Poisons and their Antidotes—(*Continued*).

Poison.	Antidote and Remedies. (*Large doses.*)	Antidote. (*Homœopathically—small doses.*
Phosphorus Matches; Rat Exterminator.	Give two tablespoonfuls of calcined *magnesia;* followed by mucilaginous drinks.	Camphor, nux v., coffea, vinum.
Carbonic Acid Gas (charcoal fumes); Chlorine Gas; Nitrous Oxide Gas; or Ordinary Gas; Burning Fluid.	Fresh air and artificial respiration; may inhale ammonia, ether, or the vapor of warm water.	Same.
Aconite or Aconitin (Monkshood).	Thorough evacuation of the stomach, either by an emetic (mustard) or the stomach-pump; ammonia and brandy, and the use of stimulating injections; free use of finely-powdered animal charcoal; vegetable infusion containing tartaric acid. Tincture of nux vomica. Iodine and potassic iodide. Keep patient active. Emetics—mustard, zincic sulphate, or ipecac. Wine, vegetable acids (vinegar acid fruits).	Camphor, nux v., par. (?), guacco (?)
Atropin; Belladonna (Deadly Nightshade).	An emetic and use of stomach-pump, as with aconite. Morphine administered by the mouth or subcutaneous injection. Drink black coffee.	Black coffee, camphor, hepar sulph., opium, puls., vinum, zinc.
Daturin.	Same as above.	Same.
Hellebore; Helleb. Niger.	Emesis and subsequent stimulation. Opium has been used.	Camphor, china.
Nicotin.	Same as above.	Same.
Opium.	Any portion of the unabsorbed poison should be removed quickly from the stomach. Use the stomach-pump, or an emetic of gr. xx or gr. xxx zincic sulphate, or about gr. x cupric sulphate. Or powdered mustard or salt. Keep patient in	Large doses of black coffee, also by injection; camphor, ether, am. c., natr., ipec., asaf. Of small doses: bell., camph., coff.,

POISONS AND THEIR ANTIDOTES—(*Continued*).

POISON.	ANTIDOTE AND REMEDIES. (*Large doses.*)	ANTIDOTE. (*Homœopathically—small doses.*)
OPIUM (*Continued*).	motion. Apply cold water to head and chest. Belladonna is recommended as an antidote.	hyos., ipec., merc., strychnine, nux. v., plumb., stram., vinum.
STRYCHNINE, or NUX VOMICA.	An emetic, or use of the stomach-pump; internal use of chloroform by inhalation; tannic acid, 25 parts of tannin to one of strychnine; solution of potassic iodide, iodine, chlorine, camphor, animal charcoal, lard or fat, nicotin.	Of large doses: wine, coffee, camph., opium. Of small doses: alcohol, bel., camph., cham., cocc., coff., op., puls., stram.

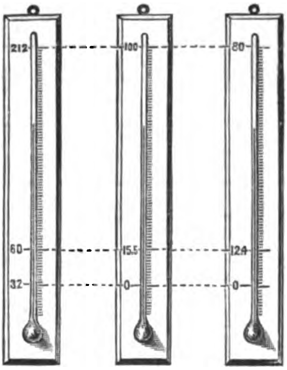
As a rule, "for *vegetable* poisons give an emetic of *mustard;* drink freely of warm water; irritate the throat with a feather to induce vomiting. Keep the patient awake until a physician arrives."

STING OF INSECTS.—*Ammonia;* or cooking soda, moistened with water, applied in the form of a paste. The wound may be sucked, followed by application of water. Pennyroyal. Ledum palustri.

FOR BURNS.—Apply immediately hot alcohol or turpentine; never cold water. May be bathed afterwards with a mixture of lime-water and sweet oil.

THERMOMETERS.

There are three differently graduated thermometers in use, namely, *Fahrenheit*, *Centigrade*, and *Reaumur*.



No. 1 = Fahrenheit.
No. 2 = Centigrade.
No. 3 = Reaumur.

To convert the scale of one thermometer into either of the others:

n° C. = $\frac{4}{5}$ n° R. = $\frac{9}{5}$ n° + 32° F.
n° R. = $\frac{5}{4}$ n° C. = $\frac{9}{4}$ n° + 32° F.
n° F. = $\frac{5}{9}$ (n° − 32°) C. = $\frac{4}{9}$ (n° − 32°) R.

COMPARISON OF FAHRENHEIT AND CENTIGRADE THERMOMETERS.

Fahr.	*Cent.*	*Fahr.*	*Cent.*	*Fahr.*	*Cent.*	*Fahr.*	*Cent.*	*Fahr.*	*Cent.*
—15	—26.11	49	9.44	113	45.00	177	80.55	241	116.11
—14	—25.55	50	10.00	114	45.55	178	81.11	242	116.66
13	—25.00	51	10.55	115	46.11	179	81.66	243	117.22
12	24.44	52	11.11	116	46.66	180	82.22	244	117.77
11	23.89	53	11.66	117	47.22	181	82.77	245	118.33
10	23.33	54	12.22	118	47.77	182	83.33	246	118.88
9	22.78	55	12.77	119	48.33	183	83.88	247	119.44
8	22.22	56	13.33	120	48.88	184	84.44	248	120.00
7	21.67	57	13.88	121	49.44	185	85.00	249	120.55
6	21.11	58	14.44	122	50.00	186	85.55	250	121.11
5	20.55	59	15.00	123	50.55	187	86.11	251	121.66
4	20.00	60	15.55	124	51.11	188	86.66	252	122.22
3	19.44	61	16.11	125	51.66	189	87.22	253	122.77
2	18.89	62	16.66	126	52.22	190	87.77	254	123.33
1	18.33	63	17.22	127	52.77	191	88.33	255	123.88
0	17.78	64	17.77	128	53.33	192	88.88	256	124.44
+1	—17.22	65	18.33	129	53.88	193	89.44	257	125.00
+2	—16.66	66	18.88	130	54.44	194	90.00	258	125.55
3	—16.11	67	19.44	131	55.00	195	90.55	259	126.11
4	15.55	68	20.00	132	55.55	196	91.11	260	126.66
5	15.00	69	20.55	133	56.11	197	91.66	261	127.22
6	14.44	70	21.11	134	56.66	198	92.22	262	127.77
7	13.88	71	21.66	135	57.22	199	92.77	263	128.33
8	13.33	72	22.22	136	57.77	200	93.33	264	128.88
9	12.77	73	22.77	137	58.33	201	93.88	265	129.44
10	12.22	74	23.33	138	58.88	202	94.44	266	130.00
11	11.66	75	23.88	139	59.44	203	95.00	267	130.55
12	11.11	76	24.44	140	60.00	204	95.55	268	131.11
13	10.55	77	25.00	141	60.55	205	96.11	269	131.66
14	10.00	78	25.55	142	61.11	206	96.66	270	132.22
15	9.44	79	26.11	143	61.66	207	97.22	271	132.77
16	8.88	80	26.66	144	62.22	208	97.77	272	133.33
17	8.33	81	27.22	145	62.77	209	98.33	273	133.88
18	—7.77	82	27.77	146	63.33	210	98.88	274	134.44
19	—7.22	83	28.33	147	63.88	211	99.44	275	135.00
20	—6.66	84	28.88	148	64.44	212	100 00	276	135.55
21	6.11	85	29.44	149	65.00	213	100.55	277	136.11
22	5.55	86	30.00	150	65.55	214	101.11	278	136.66
23	5.00	87	30.55	151	66.11	215	101.66	279	137.22
24	4.44	88	31.11	152	66.66	216	102.22	280	137.77
25	3.88	89	31.66	153	67.22	217	102.77	281	138.33
26	3.33	90	32.22	154	67.77	218	103.33	282	138.88
27	2.77	91	32.77	155	68.33	219	103.88	283	139.44
28	2.22	92	33.33	156	68.88	220	104.44	284	140.00
29	1.66	93	33.88	157	69.44	221	105.00	285	140.55
30	1.11	94	34.44	158	70.00	222	105 55	286	141.11
31	.55	95	35.00	159	70.55	223	106.11	287	141.66
32	.0	96	35.55	160	71.11	224	106.66	288	142.22
33	+0.55	97	36.11	161	71.66	225	107.22	289	142.77
+34	+1.11	98	36.66	162	72.22	226	107.77	290	143.33
35	1.66	99	37.22	163	72.77	227	108.33	291	143.88
36	2.22	100	37.77	164	73.33	228	108.88	292	144.44
37	2.77	101	38.33	165	73.88	229	109.44	293	145.00
38	3.33	102	38.88	166	74.44	230	110.00	294	145.55
39	3.88	103	39.44	167	75.00	231	110.55	295	146.11
40	4.44	104	40.00	168	75.55	232	111.11	296	146.66
41	5.00	105	40.55	169	76.11	233	111.66	297	147.22
42	5.55	106	41.11	170	76.66	234	112.22	298	147.77
43	6.11	107	41.66	171	77.22	235	112 77	299	148.33
44	6.66	108	42.22	172	77.77	236	113.33	300	148.88
45	7.22	109	42.77	173	78.33	237	113.88	400	204.44
46	7.77	110	43.33	174	78.88	238	114.44	600	315.55
47	8.33	111	43.88	175	79.44	239	115.00	800	423.33
48	8.88	112	44.44	176	80.00	240	115.55	1000	537.77

COMPARISON OF CENTIGRADE AND FAHRENHEIT THERMOMETERS.

Cent.	*Fahr.*	*Cent.*	*Fahr.*	*Cent.*	*Fahr.*	*Cent.*	*Fahr.*	*Cent.*	*Fahr.*
276	461	—49	—56 2	19	66.2	420	788	1100	2012
—260	—436	—48	—54.4	20	68.0	430	806	1110	2030
—250	—418	—47	—52.6	21	69.8	440	824	1120	2048
—240	—400	—46	—50.8	22	71.6	450	842	1130	2066
—230	—382	—45	—49.0	23	73.4	460	860	1140	2084
—220	—364	—44	—47.2	24	75.2	470	878	1150	2102
—210	—346	—43	—45.4	25	77.0	480	896	1160	2120
—200	—328	—42	—43.6	26	78.8	490	914	1170	2138
—190	—310	—41	—41.8	27	80.6	500	932	1180	2156
—180	—292	—40	—40.0	28	82.4	510	950	1190	2174
—170	—274	—39	—38.2	29	84.2	520	968	1200	2192
—160	—256	—38	—36.4	30	86.0	530	986	1210	2210
—150	—238	—37	—34.6	31	87.8	540	1004	1220	2228
—140	—220	—36	—32.8	32	89.6	550	1022	1230	2246
—130	—202	—35	—31.0	33	91.4	560	1040	1240	2264
—120	—184	—34	—29.2	34	93.2	570	1058	1250	2282
—110	—166	—33	—27.4	35	95.0	580	1076	1260	2300
—100	—148.0	—32	—25.6	36	96.8	590	1094	1270	2318
— 99	—146.2	—31	—23.8	37	98.6	600	1112	1280	2336
— 98	--144.4	—30	—22.0	38	100.4	610	1130	1290	2354
— 97	—142.6	—29	—20.2	39	102.2	620	1148	1300	2372
— 96	—140.8	—28	—18.4	40	104.0	630	1166	1310	2390
— 95	—139.0	—27	—16.6	41	105.8	640	1184	1320	2408
— 94	—137.2	—26	- 14.8	42	107.6	650	1202	1330	2426
— 93	—135.4	—25	—13.0	43	109.4	660	1220	1340	2444
— 92	—133.6	—24	—11.2	44	111.2	670	1238	1350	2462
— 91	—131.8	—23	— 9.4	45	113.0	680	1256	1360	2480
— 90	—130.0	—22	— 7.6	46	114.8	690	1274	1370	2498
— 89	—128.2	—21	— 5.8	47	116 6	700	1292	1380	2516
— 88	—126.4	—20	— 4.0	48	118.4	710	1310	1390	2534
— 87	—124.6	—19	— 2.2	49	120.2	720	1328	1400	2552
— 86	—122.8	—18	— 0.4	50	122.0	730	1346	1410	2570
— 85	—121.0	—17	+ 1.4	60	140	740	1364	1420	2588
— 84	—119.2	—16	3.2	70	158	750	1382	1430	2606
— 83	—117.4	—15	5.0	80	176	760	1400	1440	2624
— 82	—115.6	—14	6 8	90	194	770	1418	1450	2642
— 81	—113.8	—13	8.6	100	212	780	1436	1460	2660
— 80	—112.0	—12	10.4	110	230	790	1454	1470	2678
— 79	—110.2	—11	12.2	120	248	800	1472	1480	2696
— 78	—108.4	—10	14.0	130	266	810	1490	1490	2714
— 77	—106.6	— 9	15.8	140	284	820	1508	1500	2732
— 76	—104.8	— 8	17.6	150	302	830	1526	1510	2750
— 75	—103.0	— 7	19.4	160	320	840	1544	1520	2768
— 74	—101.2	— 6	21.2	170	338	850	1562	1530	2786
— 73	— 99.4	— 5	23.0	180	356	860	1580	1540	2804
— 72	— 97.6	— 4	24.8	190	374	870	1698	1550	2822
— 71	— 95.8	— 3	26.6	200	392	880	1616	1560	2840
— 70	— 94.0	— 2	28.4	210	410	890	1634	1570	2858
— 69	— 92.2	— 1	30.2	220	428	900	1652	1580	2876
— 68	— 90.4	Zero.	+32.	230	446	910	1670	1590	2894
— 67	— 88.6	+1	+33.8	240	464	920	1688	1600	2912
— 66	— 86.8	2	35.6	250	482	930	1706	1610	2930
— 65	— 85.0	3	37.4	260	500	940	1724	1620	2948
— 64	— 83 2	4	39.2	270	518	950	1742	1630	2966
— 63	— 81.4	5	41.0	280	536	960	1760	1640	2984
— 62	— 79.6	6	42.8	290	554	970	1778	1650	3002
— 61	— 77.8	7	44.6	300	572	980	1796	1660	3020
— 60	— 76.0	8	46.4	310	590	990	1814	1670	3038
— 59	— 74.2	9	48.2	320	608	1000	1832	1680	3056
— 58	— 72.4	10	50.0	330	626	1010	1850	1690	3074
— 57	— 70.6	11	51.8	340	644	1020	1868	1700	3092
— 56	— 68.8	12	53.6	350	662	1030	1886	1710	3110
— 55	— 67.0	13	55.5	360	680	1040	1904	1720	3128
— 54	— 65.2	14	57.2	370	698	1050	1922	1730	3146
— 53	— 63.4	15	59.0	380	716	1060	1940	1740	3164
— 52	— 61.6	16	60.8	390	734	1070	1958	1750	3182
— 51	— 59.8	17	62.6	400	752	1080	1976	1760	3200
— 50	— 58.0	18	64.4	410	770	1090	1994	1770	3218

Cent.	*Fahr.*	*Cent.*	*Fahr.*	*Cent.*	*Fahr.*	*Cent.*	*Fahr.*	*Cent.*	*Fahr.*
1780	3236	1870	3398	1950	3542	2030	3686	2110	3830
1790	3254	1880	3416	1960	3560	2040	3704	2120	3848
1800	3272	1890	3434	1970	3578	2050	3722	2130	4166
1810	3290	1900	3452	1980	3596	2060	3740	2140	4184
1820	3308	1910	3470	1990	3614	2070	3758	2150	4162
1830	3326	1920	3488	2000	3632	2080	3776	2160	4180
1840	3344	1930	3506	2010	3650	2090	3794	2180	4216
1850	3362	1940	3524	2020	3668	2100	3812	2200	4252
1860	3380								

NUMBER OF DEGREES CENTIGRADE = NUMBER OF DEGREES FAHRENHEIT.

Degrees Centigrade.	Tenths of a Degree—Centigrade Scale.									
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	Fahr.	*Fahr.*	*Fahr.*	*Fahr.*	*Fahr.*	*Fahr.*	*Fahr.*	*Fahr.*	*Fahr.*	*Fahr.*
0	0.00	0.18	0.36	0.54	0.72	0.90	1.08	1.26	1.44	1.62
1	1.80	1.98	2.16	2.34	2.55	2.70	2.88	3.06	3.24	3.42
2	3.60	3.78	3.96	4.14	4.32	4.50	4.68	4.86	5.04	5.22
3	5.40	5.58	5.76	5.94	6.12	6.30	6.48	6.66	6.84	7.02
4	7.20	7.38	7.56	7.74	7.92	8.10	8 28	8.46	8.64	8.82
5	9.00	9.18	9 36	9.54	9.72	9.90	10.08	10.26	10.44	10.62
6	10.80	10.98	11.16	11.34	11.52	11.70	11.88	12.06	12.24	12.42
7	12.60	12.78	12.96	13.14	13.32	13.50	13.68	13.86	14.04	14.22
8	14.40	14.58	14.76	14.94	15.12	15.30	15.48	15.66	15.84	16.02
9	16.20	16.38	16.56	16.74	16.92	17.10	17.28	17.46	17.64	17.82

NUMBER OF DEGREES FAHRENHEIT = NUMBER OF DEGREES CENTIGRADE.

Degrees Fahrenheit.	Tenths of a Degree—Fahrenheit Scale.									
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	Cent.	*Cent.*	*Cent.*	*Cent.*	*Cent.*	*Cent.*	*Cent.*	*Cent.*	*Cent.*	*Cent.*
0	0.00	0.06	0.11	0.17	0.22	0.28	0.33	0.39	0.44	0.50
1	0.56	0.61	0.67	0.72	0.78	0.83	0.89	0.94	1.00	1.06
2	1.11	1.17	1.22	1.28	1.33	1.39	1.44	1.50	1.56	1.6
3	1.67	1.72	1.78	1.83	1.89	1.94	2.00	2.06	2.11	2.17
4	2.22	2.28	2.33	2.39	2.44	2.50	2.56	2.61	2.67	2.72
5	2.78	2.83	2.89	2.94	3.00	3.06	3.11	3.17	3.22	3.28
6	3.33	3.39	3.44	3.50	3.56	3.61	3.67	3.72	3.78	3.80
7	3.89	3.94	4.00	4.06	4.11	4.17	4.22	4.28	4.33	4.39
8	4.44	4.50	4.56	4.61	4.67	4.72	4.78	4.83	4.89	4.94
9	5.00	5.06	5.11	5.17	5.22	5.28	5.33	5.39	5.44	5.50

EXPANSION OR DILATATION OF SOLIDS.

(FARADAY.)

At 212°, the length of the bar at 32° = 1.

Bismuth	1.0013908	Platinum	1.0009542
Brass	1.0019062	Sandstone	1.001743
Cast-iron	1.0011112	Silver	1.00201
Cement	1.001435	Slate	1.0011436
Copper	1.001745	Steel	1.0011899
Fire-brick	1.0004928	Stock-brick	1.0005502
Glass	1.0008545	Tin	1.002
Gold	1.001495	Wrought-iron	1.0012575
Granite	1.0007894	Zinc	1.002942
Lead	1.0028426		

DIFFERENT REMARKABLE TEMPERATURES.

		CENTIGRADE.
GREATEST ARTIFICIAL COLD produced by a bath of carbon bisulphide and liquid nitrous acid		−140°
GREATEST COLD produced by ether and liquid carbonic anhydride		−110°
GREATEST NEUTRAL COLD recorded in arctic expeditions		−49°
Mercury freezes		−39°
Sodic phosphate	9 parts by weight	+10° to −29°
Acid nitric (dilute)	4 " " "	
Ammonic nitrate	5 parts by weight	+10° to −26°
Acid nitric (dilute)	4 " " "	
Sodic sulphate	6 " " "	
Sodic sulphate	3 parts by weight	+10° to −19°
Acid nitric (dilute)	2 " " "	
Pounded ice or snow	2 parts by weight	+10° to −18°
Sodic chloride	1 " " "	
Sodic sulphate	8 parts by weight	+10° to −17°
Acid hydrochloric	5 " " "	
Ammonic nitrate	1 part by weight	10° to −13°.33
Water	1 " " "	
Sodic phosphate	9 parts by weight	10° to −29°.44
Ammonic nitrate	6 " " "	
Acid nitric (dilute)	4 " " "	
Snow	2 parts by weight	−26°.11 to −55°.5
$CaCl_2$	3 " " "	
Snow	2 parts by weight	−55°.55 to −67°.77
Acid sulphuric	10 " " "	

		Centigrade.
Snow	3 parts by weight	0° to −46°.11
Potash fused	4 " " "	
Sodic sulphate	3 parts by weight	10° to −19°.44
Acid nitrous (dilute)	2 " " "	
Sodic phosphate	9 parts by weight	10° to −24°.44
Acid nitrous (dilute)	4 " " "	
Ammonia (liquid) freezes		−43°.33
Blood (human), heat of		36°.67
" " freezes		3°.89
Brandy freezes		−21°.67
Charcoal burns		433°.33
Ice melts		0°
Greatest density of water		+4°
Blood heat		36°.6
Water boils		100°.00
Mercury boils		350°.00
Red-heat (just visible—Daniel)		526°
Silver melts		1002°
Cast-iron melts		1530°
Highest heat of wind furnace		1804°
Point of absolute cold deprived of all heat		−275°
Lard melts		35°.00
Milk freezes		−1°.11
Nitrous oxide freezes		−101°.11
Nitric acid (Sp. Gr. 1.424) freezes		−42°.77
Sea-water freezes		2°.22
Snow and salt (equal parts)		17°.78
Sulphuric acid (Sp. Gr. 1.641) freezes		−42°.7
Acetous fermentation begins		25°.55
" " ends		31°.11
Vinous fermentation		15°.55 to 25°.00

TABLE OF BOILING POINTS OF SATURATED SOLUTIONS.

(Watt's Dict. Chem.—Legrand.)

Salt.	Weight of Salt dissolved in 100 parts of H_2O.	Boiling Point.
Potassic acetate	798.2	169° C.
Calcic nitrate	362.2	151°
Potassic carbonate	205.0	135°
Sodic acetate	209.0	124°.4
Sodic nitrate	224.8	121°

BOILING POINTS OF SATURATED SOLUTIONS—(*Continued.*)

SALT.	WEIGHT OF SALT DISSOLVED IN 100 PARTS OF H_2O.	BOILING POINT.
Potassic nitrate....................	335.1	115°.9
Ammonic chloride....................	88.9	114°.2
Potassic tartrate....................	296.2	114°.7
Potassic chlorate....................	61.5	104°.2
Sodic chloride....................	41.2	108°.4
Sodic phosphate (dried)....................	112.6	106°.6
Strontic chloride....................	117.5	117°.8
Sodic carbonate....................	48.5	104°.6
Baric chloride....................	60.1	104°.4

BOILING POINTS CORRESPONDING TO ALTITUDES OF THE BAROMETER.

BAROMETER.	BOILING POINT.	BAROMETER.	BOILING POINT.	BAROMETER.	BOILING POINT.
15 inches.	81.66° C.	21 inches.	90.22° C.	27.02 in.	97.05° C.
16.06	83 33	22.04	91.50	28.00	98.05
17	84.77	23.02	92.66	29.03	99.05
18	86.22	24.03	93.83	30	100.00
19	87.61	25.03	94.94	31.01	100.94
20	88.94	26.01	95.99		

TABLE OF THE CORRESPONDING HEIGHTS OF THE BAROMETER IN MILLIMETRES AND ENGLISH INCHES.

(FROM MILLER'S ORGANIC CHEMISTRY.)

MILLIMETRES.		ENGLISH INCHES.	MILLIMETRES.		ENGLISH INCHES.	MILLIMETRES.		ENGLISH INCHES.
720	=	28.347	739	=	29.095	758	=	29.843
721	=	28.386	740	=	29.134	759	=	29.882
722	=	28.425	741	=	29.174	760	=	29.922
723	=	28.465	742	=	29.213	761	=	29.961
724	=	28.504	743	=	29.252	762	=	30.000
725	=	28.543	744	=	29.292	763	=	30.039
726	=	28.583	745	=	29.331	764	=	30.079
727	=	28.622	746	=	29.370	765	=	30.118
728	=	28.662	747	=	29.410	766	=	30.158
729	=	28.701	748	=	29.449	767	=	30.197
730	=	28.740	749	=	29.488	768	=	30.236
731	=	28.780	750	=	29.528	769	=	30.276
732	=	28,819	751	=	29.567	770	=	30.315
733	=	28.858	752	=	29.606	771	=	30.355
734	=	28.898	753	=	29.645	772	=	30.394
735	=	28.937	754	=	29.685	773	=	30.433
736	=	28.976	755	=	29.724	774	=	30.473
737	=	29.016	756	=	29.764	775	=	30.512
738	=	29.055	757	=	29.803			

WEIGHTS AND MEASURES.

FRENCH MEASURES OF LENGTH.

(*According to United States Standard.*)

NAMES.	METRES.	U. S. IN.	U. S. FT.	U. S. YDS.	U. S. MI.
Millimetre*..	$\frac{1}{1000}$ metres.	.039368	.003281	—	—
Centimetre†..	$\frac{1}{100}$ "	.393685	.032807	—	—
Decimetre....	$\frac{1}{10}$ "	3.93685	.328071	.109357	—
Metre‡.......	1 "	39.3685	3.28071	1.09357	—
Decametre...	10 "	393.685	32.8071	10.9357	—
Hectometre..	100 "	Road measure	328.071	109.357	.0621347
Kilometre....	1000 "		3280.71	1093.57	.6213466
Myriametre..	10,000 "		32807.1	10935.7	6.213466

MEASURE OF LENGTH.

MILES.	FURLONGS.	CHAINS.	RODS.	YARDS.	FEET.	INCHES.
1	8	80	320	1760	5280	63360
0.125	1	10	40	220	660	7920
0.0125	0.1	1	4	22	66	792
0.003125	0.025	0.25	1	5.5	16.5	198
0.00056818	0.0045454	0.045454	0.181818	1	3	36
0.00018939	0.00151515	0.01515151	0.0606060	0.33333	1	12
0.000015783	0.000126262	0.001262626	0.00505050	0.0277777	0.083333	1§

* Nearly the $\frac{1}{25}$ part of an inch. † Full $\frac{3}{8}$ inch.

‡ Very nearly 3 ft. 3$\frac{3}{8}$ in., which is too long by only one part in 6062.

The *metre*, at the time its length was fixed by the French government, was supposed to be a ten-millionth part of a quadrant of a meridian circle of the earth passing through Dunkirk and Barcelona.

Subsequent more extended geodetic measurements have shown that it differs from this by about $\frac{1}{4000}$ of its length. A platinum rod is therefore used as the standard, which measures at 32° (Fahr.)—0° (C.) 39.3085 U. S. inches = one metre.

1 inch....................................	2.54	centimetres.
1 foot	0.3048	metres.
1 yard....................................	0.9144	"
1 rod......................................	5.0297	"
1 furlong.................................	201.1643	"
1 mile.....................................	1609.3149	"

§ The *Standard Measure of Length* in the United States is a brass rod = 1 yard at the temperature of 32° Fah. The length of a pendulum vibrating seconds *in vacuo* at Philadelphia is 1.08614 yards, at + 32° Fahrenheit.

The inch is sometimes divided into 3 *barleycorns*, or 12 *lines*.

1 point = $\frac{1}{72}$ inch.
6 points = 1 line = $\frac{1}{12}$ inch.
12 lines = 1 inch.

FRENCH SQUARE MEASURE.

(*According to U. S. Standard.*)

Names.	U. S. Sq. In.	U. S. Sq. Feet.	U. S. Sq. Yds.	U. S. Acres.
Sq. Millimetre..........	.001549	.00001076	.0000012	—
Sq. Centimetre.........	.154988	.00107631	.0001196	—
Sq. Decimetre..........	10.4988	.10763058	.0119589	—
Sq. Metre, or Centiare.	1549.88	10.763058	1.195895	.000247
Sq. Decametre, or Are..	154988	1076.3058	119.5895	.024709
Decare (not used)......	—	10763.058	1195.895	.247086
Hectare..............	—	107630.58	11958.95	2.47086
	Sq. Miles.			
Sq. Kilometre..........	.3860716	10763058	1195895	247.086
Sq. Myriametre.........	38.60716	—	—	24708.6

1 square inch	....	6.49	square centimetres.
1 " foot	....	0.0929	" metres.
1 " yard	....	0.8360	" "
1 " rod	....	25.292	" "
1 " rood	....	10.1168	ares.
1 " acre	....	40.4671	"
1 " mile	....	258.9894	hectares.

MEASURE OF SURFACE.

Sq. Miles.	Acres.	Sq. Chains.	Sq. Rods.	Sq. Yards.	Sq. Ft.	Sq. In.
1	640	6400	102400	3097600	27878400	4014489600
0.001562	1	10	100	4840	43560	696960
0.0001562	0.1	1	16	484	4356	69696
0.000009764	0.00625	0.0625	1	30.25	272.25	39204
0.000000323	0.0002066	0.002066	0.0330	1	9	1296
0.0000000358	0.000002296	0.00002296	0.00367	0.1111111	1	144
0.00000000025	0.000000143	0.00000143	0.00002552	0.0007716	0.006944	1

MEASURES OF CAPACITY.

(*According to U. S. Standard.*)

NAME.	LITRES.	CUBIC MEASURE.	DRY MEASURE.	LIQUID MEASURE.	CUBIC INCHES.
Millilitre, or Cubic Centimetre......	$\frac{1}{1000}$	1 cu. cent.	.001816 dry pint.	.0084525 gill.	.0610165
Centilitre..........	$\frac{1}{100}$	10 " "	.01816 " "	.084525 "	.610165
Decilitre...........	$\frac{1}{10}$	100 " "	.1816 " "	.8425 " =.21131 pt.	6.10165
Litre..............	1	1000 " "	.1135 pk. = .908 dry qt. =1.816 dry pt.	1.05656 qt. =2.1131 pt.	61.0165
Decalitre, or Centistere............	10	10 " dec.	.283742 bu. =1.135 pk. =9.08 dry qt.	2.64141 U. S. liq. gallon.	610.165, or .353105 cu. ft.
					CUBIC FEET.
Hectolitre, or Decistere............	100	$\frac{1}{10}$ " met.	2.83742 bu.	26.4141 U. S. liq. gallon.	3.53105
Kilolitre, or Stere.	1000	1 " "	28.3742 "	264.141 U. S. liq. gallon.	35.3105, or 1.3078 cu. yd.
Myriolitre, or Decastere............	10000	10 " "	283.742 "	2641.41 U. S. liq. gallon.	353.105, or 13.078 cu. yd.

DRY MEASURE.*

1 pint...........................	0.55067 litres.
1 quart..........................	1.10135 "
1 peck...........................	8.8108 "
1 bushel*........................	35.2432 "

LIQUID MEASURE.†

1 minim..........................	0.0000616 litres.
1 fluid drachm...................	0.003697 "
1 fluid ounce....................	0.029578 "
1 pint...........................	0.47325 "
1 quart..........................	0.9465 "
1 gallon†........................	3.786 "
1 barrel.........................	129.249 "
1 hogshead.......................	258.498 "

---

* The basis of this measure is the old British Winchester struck bushel of 2150.42 cubic inches, or 77.627413 pounds Avoirdupois of pure water at its maximum density. Its dimensions by law are 18½ inches inner diameter, 19½ inches outer diameter, and 8 inches deep.

† The basis of this measure in the United States is the old British wine gallon of 231 cubic inches; or 8.33888 lbs. Avoirdupois of pure water, at its maximum density (39°.2 Fah., 4° C.), the barometer at 30 inches. A cylinder 7 inches in diameter and 6 inches high contains 230.904 cubic inches, or almost precisely a gallon.

UNITED STATES MEASURE OF LIQUIDS.

Gallon.	Quarts.	Pints.	Gills.	Cu. In.	Wt. in Lbs. Av.
1	4	8	32	231	8.33888
0.25	1	2	8	57.75	2.15019
0.125	0.5	1	4	28.875	1.04269
0.03125	0.125	0.25	1	7.2175	—
0.004329	0.017315	0.03463	0.13858	1	0.03609

CUBIC MEASURE IN CUBIC METRES.

1 cubic yard	.76450	cubic metres.
1 cubic foot	28.31486	" decimetres.
1 cubic inch	16.38591	" centimetres.

MEASURE OF CAPACITY.

Cu. Yd.	Barrels.	Bushels.	Cu. Ft.	Pecks.	Gallons.	Cu. In.
1	5.6103	25.2467	27	100.987	201.974	46656
0.1782	1	4.5	4.8125	18	36	8316
0.03961	0.2222	1	1.2438	4	8	2150.42
0.037037	0.2078	0.804	1	3.73809	7.47619	1728
0.009902	0.05555	0.25	0.26733	1	2	462
0.004951	0.02777	0.125	0.13369	0.5	1	231
0.00002143	0.0001202	0.000465	0.0005787	0.0021645	0.004329	1

To convert parts per 100,000 into grains per gallon, multiply by 0.7.
" " grains per gallon into parts per 100,000, divide by 0.7.
" " grams per litre into grains per gallon, multiply by 70.

BRITISH IMPERIAL MEASURE, BOTH LIQUID AND DRY.

(*Great Britain only.*)

The basis of this system is the imperial gallon of 277.274 cubic inches, or 10 pounds Avoirdupois of pure water at the temperature of 62° F., when the barometer is at 30 inches.

Measures.	Avoirdupois Pounds of Water.	Cubic Inches.	Cubic Feet.	Edge of a Cube of equal capacity Inches.
4 gills.............1 pint.	1.25	34.6592	....	3.2605
2 pints..........1 quart.	2.50	69.3185	....	4.1079
2 quarts.........1 pottle.	5.	138.637	....	5.1756
2 pottles........1 gallon.	10.	277.274	....	6.5208
2 gallons.........1 peck.	20 Dry measure.	554.548	....	8.2157
4 pecks.........1 bushel.	80	2218.192	1.2837	13.0417
4 bushels......1 coomb.	320	8872.768	5.1347	
2 coombs......1 quarter.	640	17745.536	10.2694	

To reduce imperial liquid measure to U. S. ones of the same name, multiply by 1.20032; or add one-fifth part. To reduce imperial measure to U. S. ones, multiply by 1.031515.

SURVEYOR'S MEASURE.

Inches.	Link.	Pole.	Chain.	Furlong.	Mile.
$7\frac{92}{100}$	1				
198	25	1			
792	100	4	1		
7920	1000	40	10	1	
63360	8000	320	80	8	1

GEOGRAPHICAL AND NAUTICAL MILES.

1 statute mile = 5280 ft. = 0.86875 nautical mile.
1 nautical mile = 6037.424 = 1.150 statute mile.

ROPES AND CABLES

1 cable length = 120 fathoms = 720 feet.
1 fathom = 6 feet.

SURVEYOR'S MEASURE.

Miles.	Acres.	Roods.	Sq. Chains.	Perches.	Sq. Links.
1	640	2560	6400.0	102.400	64.000.000
	1	4	10 0	160	100.000
		1	2.5	40	25.000
			1.0	16	10.000
				1	625

1 *square* mile = 6400 square chains = 640 acres.
1 *mile* = 8 fur. = 320 rods = 1760 yards = 5280 feet = 63.360 inches.
1 sq. acre = 160 sq. rods = 4840 sq. yards = 43560 sq. feet.

208.7103 feet square, or 69.5701 yards square, or 220 feet × 198 feet = 1 acre.

FRENCH MEASURE OF WEIGHTS.

NAME.	NO. OF GRAINS.	WT. OF WATER QUALITY AT MAX. DENSITY.	IN AVOIRDUPOIS WEIGHT.	
			Grains.	
Milligram	$\frac{1}{1000}$	1 cu. m.m	.01543316	
Centigram	$\frac{1}{100}$	10 cu. m.m.	.1543316	
Decigram	$\frac{1}{10}$	$\frac{1}{10}$ cu. centimetre.	1.543316	
				Ounces.
Gram	1	1 cu. centimetre.	15.43316	.0352758
			Pounds av.	
Decagram	10	10 cu. cent.	.02204737	.352758
Hectogram	100	1 decalitre	.2204737	3.52758
Kilogram	1000	1 litre	2.204737	35.2758
				Ton of 2240 lbs.
Myriogram	10000	10 litres	22.04737	.00984258
Quintal	100000	1 hectolitre	220.4737	.0984258
Tonneau; Millier or Tonne.	1000000	1 cubic metre	2204.737	.984258

The gram is the basis of French weights, and is the weight of a cubic centimetre of distilled water at its maximum density, at sea level, in latitude of Paris; barometer, 29.922 inches.

AVOIRDUPOIS.

1 dram	1.77168 grams.
1 ounce	28.34704 "
1 pound	453.55264 "
1 hundred weight (100 lbs.)	45355.264 "
1 ton (2000 lbs)	907.10528 kilograms.
1 ton (2240)	1015.9579 "

AVOIRDUPOIS.

TON.	CWT.	POUNDS.	OUNCES.	DRAMS.
1	20	2240	35840	573440
0.05	1	112	1792	28672
0.00044642	0.0089285	1	16	256
0.00002790	0.000558	0.0625	1	16
0.00000174	0.0000348	0.0016	0.0625	1

TROY WEIGHT.

1 grain*	0.064795 grams.
1 pennyweight	1.555098 "
1 ounce	31.10186 "
1 pound	373.2223 "

TROY.

POUNDS.	OUNCES.	PWT.	GRAINS.	POUND AVOIR.
1	12	240	5760	0.822861
0.083333	1	20	480	0.068571
0.004166	0.05000	1	24	0.0034285
0.0001736	0.00208333	0.0416666	1	0.00020571
1.215275	14.58333	219.6666	7000	1

1 Troy pound = .822857 Avoirdupois pound.
1 Avoirdupois pound = 1.215278 Troy "

1 lb. Av. = 7000 gr. Tr. = 1 lb. 2 oz. 11 pwt. 16 gr. Tr.
1 lb. Tr. or Ap. = 5760 " = 13 oz. $2\frac{114}{175}$ dr. Av.
1 oz. Tr. or Ap. = 480 " = 1 oz. $1\frac{97}{175}$ dr. Av.
1 oz. Av. = $437\frac{1}{2}$ " = 18 pwt. $5\frac{1}{2}$ gr. Tr.
1 dr. Ap. = 60 " = $2\frac{34}{175}$ dr. Av.
1 dr. Av. = $27\frac{11}{32}$ " = 1 pwt. $3\frac{11}{32}$ gr. Tr.
1 pwt. Tr. = 24 " = $\frac{768}{875}$ dr. Av.
1 sc. Ap. = 20 " = $\frac{128}{175}$ dr. Av.
1 gr. Tr. or Ap. = 1 " = $\frac{32}{875}$ dr. Av.

NOTE.—To change a quantity from one weight to its equivalent in another weight, *reduce the given quantity to Troy grains, and then find their value in denominations of the weight required.*

APOTHECARIES WEIGHT.

1 grain	0.064795 grams.
1 scruple	1.29591 "
1 dram	3.88773 "
1 ounce	31.10186 "
1 pound	373.2223 "

---

* Grain (Lat. *granum*, a seed), the smallest measure of weight in use; it is obtained from wheat; it is taken from the middle ear and well dried. 5760 grains equal 1 Troy pound, and 7000 grains equal 1 Avoirdupois pound.

EQUIVALENT OF METRIC MEASURES OF CAPACITY IN U. S. APOTHECARIES MEASURE.

Litres.	Gal.	Pint.	Fluid Ounce.	Fluid Dram.	Minims.
Hectolitre	26	3	5	5	20
Decalitre.	2	5	2	1	20
Litre	—	2	1	6	32
Decilitre	—	—	3	3	3
Centilitre	—	—	—	2	42

APOTHECARIES FLUID MEASURE.

Minims.	Drams.	Ounces.	Pints.	Gallons.
61240	1024	128	8	1
7680	128	16	1	
480	8	1		
60	1			

APOTHECARIES'.*

Pounds.	Ounces.	Drams.	Scruples.	Grains.
1	12	96	288	5760
0.08333	1	8	24	480
0.01041666	0.125	1	3	60
0.0034722	0.0416666	0.3333	1	20
0.00017361	0.020833	0.16666	0.05	1

DIAMOND WEIGHT.

Carat.†	Grain.	Parts.	Grains (Troy).
1.	4.	64	3.2
0.25	1.	16	0.8
0.015625	0.0625	1	0.05
0.3125	12.5	20	1.

---

* The pound, ounce, and grain are the same as in Troy weight.

† 1 carat in United States = 3.2 grs.; in London, 3.17 grs.; in Paris, 3.18 grs.

GOLD ASSAY WEIGHT.

POUND.	OUNCE.	CARAT.*	GRAIN.	QUARTER.†
1	12	288	1152	4608
	1	24	96	384
		1	4	16
			1	4

Perfectly pure gold is worth $20.67183 per ounce Troy; or $18.84151 Avoir.
" " silver " $ 1.36166 " " ; or $ 1.24110 "
Standard gold " $18.60465 " " ; or $16.95736 "
" silver " $ 1.22549 " " ; or $ 1.11698 "

In the United States the standard for coin is 9 parts by weight of gold or silver to 1 part of alloy.

Silver.

$15 = 1 lb. Troy; or $18.23 = 1 lb. Avoirdupois.
357.03 grains pure silver = $1; 23.22 grains pure gold = $1.

TABLE

SHOWING DIFFERENCE OF TIME AT 12 O'CLOCK (noon) AT NEW YORK.

(DICK'S ENCYCLOPÆDIA.)

NEW YORK	12.00 M.	BOSTON	12.12 P.M.
Buffalo	11.40 A.M.	Quebec	12.12 "
Cincinnati	11.18 "	Portland	12.15 "
CHICAGO	11.07 "	LONDON	4.55 "
ST. LOUIS	10.55 "	PARIS	5.05 "
SAN FRANCISCO	8.45 "	ROME	5.45 "
New Orleans	10.56 "	CONSTANTINOPLE	6.41 "
WASHINGTON	11.48 "	VIENNA	6.00 "
Charleston	11.36 "	ST. PETERSBURG	6.57 "
HAVANA	11.25 "	PEKIN (night)	12.40 A.M.

---

* The carat is an Abyssinian weight.

† The assay quarter-grain equals 1¼ grains Troy.

TABLE OF THE VALUE OF STANDARD COINS IN CIRCULATION IN U. S. MONEY.

JANUARY 1, 1875.

COUNTRY.	MONETARY UNIT.	STANDARD.	VALUE IN U. S. MONEY.	STANDARD COINS.
Argentine Republic	Peso fuerte	Gold	$1.00	None.
Austria	Florin	Silver	.45,8	Florin.
Belgium	Franc	Gold and silver	.19,3	5, 10, and 20 francs.
Bolivia	Dollar	Gold and silver	.96,5	Escudo, ½ bolivar, and bolivar.
Brazil	Milreis of 1000 reis	Gold	.54,5	None.
British Possessions in North America	Dollar	Gold	1.00	
Bogota	Peso	Gold	.91,2	
Central America	Dollar	Silver	.91,8	Dollar.
Chili	Peso	Gold	.91,2	Condor, doubloon, and escudo.
Cuba	Peso	Gold	.92,5	
Denmark	Crown	Gold	.26,8	10 and 20 crowns.
Ecuador	Dollar	Silver	.91,8	Dollar.
Egypt	Pound of 100 piasters	Gold	4.97,4	5, 10, 25, and 50 piasters.
France	Franc	Gold and silver	.19,3	5, 10, and 20 francs.
Great Britain	Pound sterling	Gold	4.86,6½	½ sovereign and sovereign.
Greece	Drachma	Gold and silver	.19,3	5, 10, 20, 50, and 100 drachmas.
German Empire	Mark	Gold	.23,8	5, 10, and 20 marks.
Hayti	Dollar	Silver	.95,2	
Japan	Yen	Gold	.99,7	1, 2, 5, 10, and 20 yen.
India	Rupee of 16 annas	Silver	.43,6	
Italy	Lira	Gold and silver	.19,3	5, 10, 20, 50, and 100 lire.
Liberia	Dollar	Gold	1.00	
Mexico	Dollar	Silver	.99,8	Peso or dollar, 5, 10, 25, and 50 centavo.
Netherlands	Florin	Silver	.38,5	½ florin, florin, and 2½ florins.
Norway	Crown	Gold	.26,8	10 and 20 crowns.
Paraguay	Peso	Gold	1.00	
Peru	Dollar	Silver	.91,8	
Porto Rico	Peso	Gold	.92,5	
Portugal	Milreis of 1000 reis	Gold	1.08,4	2, 5, and 10 milreis.
Russia	Rouble of 100 copecks	Silver	73,4	¼, ½, and 1 rouble.
Sandwich Islands	Dollar	Gold	1.00	
Spain	Peseta of 100 centimes	Gold and silver	.19,3	5, 10, 20, 50, and 100 pesetas.
Sweden	Crown	Gold	.26,8	10 and 20 crowns.
Switzerland	Franc	Gold and silver	.19,3	5, 10, and 20 francs.
Tripoli	Mahbub of 20 piasters	Silver	.82,9	
Tunis	Piaster of 16 caroubs	Silver	.11,8	
Turkey	Piaster	Gold	.04,3	25, 50, 100, 250, and 500 piasters.
United States of Colombia	Peso	Silver	.91,8	
Uruguay	Patacon	Gold	.94,9	

B. H. BRISTOW, *Secretary of the Treasury.*

INDEX.