Combining weights or relative magnitudes of Atoms.

Hydrogen	1	Chlorine	36
Carbon	6	Arsenic	38
Oxygen	8	Potassium	40
Boron	8	Tin	58
Silicium	8	Antimony	64
Aluminum	10	Copper	64
Magnesium	12	Barium	68
Nitrogen	14	Bismuth	72
Phosphorus	16	Lead	104
Sulphur	16	Silver	110
Calcium	20	Iodine	124
Sodium	24	Mercury	200
Iron	28		
Manganese	28		
Zinc	34		

Hr Garin Sct

See page 7.

TABLES

AND

DIAGRAMS

ILLUSTRATIVE OF

CHEMISTRY AND PHARMACY.

BY

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CONTENTS.

PREFACE.

The following Tables and Diagrams have for their object to illustrate that part of Chemistry which relates to the combinations of simple substances, and the various changes to which those combinations are liable. This is the most important department of the science. It has, by the discovery and extension of the atomic doctrine, attained to a high degree of precision, and seems destined to raise Chemistry, ere long, to the rank of an exact science.

Considering the importance of this subject, it has appeared to me, that the illustration of it, by means of diagrams and tabular views of a comprehensive kind, has not been carried to that extent which it might be with advantage. In the following pages I have endeavoured to supply this deficiency, partly by tables presenting the atomic constitution of compound substances, and partly by diagrams, which exhibit the reaction between the elements of those substances, leading to the formation of new products.

I have placed the diagrams first, as I wish to direct attention to them chiefly; and it is easy to refer to the subsequent tables, for the composition of any substance concerned in the reactions which they represent. The form of diagram, of which I make use, is one contrived some years ago by Dr D. Boswell Reid, and which seems to be admirably adapted for presenting, in a clear and precise manner, the nature and results of such reaction. Some of these diagrams have been already published: others I have used in the illustration of my Lectures; but the greater number have not appeared before in any shape. I have particularly indicated those which are intended to assist the explanation of pharmaceutic processes.

The Tables which follow are framed in accordance with the best authorities, and the most recent researches. They exhibit the "atomic weights" of elementary substances, and the composition and equivalents of compound substances, including most of the salts and the products of the organic kingdoms. There is also a table of the densities of gases and vapours, intended to illustrate the connection between the atomic weights and specific gravities of elastic fluids; and which is farther explained by a series of diagrams, exhibiting the composition of gaseous substances by volume. As the use of symbols is now very prevalent among chemists, I have, in the case of each compound, added the symbolic formula by which it is represented. The last of the tables are illustrative of Isomerism and Isomorphism, two subjects which are assuming a character of the highest importance in chemistry. Some remarks are offered in explanation of those doctrines, and of the changes in chemical theory they are likely to introduce.

DIAGRAMS ILLUSTRATING CHEMICAL REACTION.

In the form of diagram here employed, the *materials* between which the reaction takes place are stated on the left hand. These are shewn resolved into their elements; and by lines, parallel or inclined, those elements are traced to their new combinations, forming the *products* of the reaction, which are stated on the right. The attached numbers are the atomic weights of the substances engaged. Lines of three different kinds are employed to indicate the forms in which the product is obtained. Where the product of the reaction is obtained in the gaseous state, a line of points is used, ... ; where the product is liquid, an interrupted line, – – – – –, and a continuous line, ———, where the product is in the solid form.

I have stated, in each instance, what it is the object of the reaction to form, and have marked the pharmaceutic processes of the Edinburgh College, and some of those peculiar to the Pharmacopœias of London and Dublin.

The equivalent numbers exhibit the proportional quantities of materials that are necessary to decompose each other, and the amount of each product. But in Pharmacy, and in Practical Chemistry, quantities somewhat different are employed; the general rule being, to use an excess of the cheaper ingredient, as this ensures the complete decomposition of that which is more expensive. In our Pharmacopœia this principle is carried much too far; and Dr Barker even found, in remodelling the Dublin Pharmacopœia, that in many cases the proportions of materials which it was most economical to use were such as agreed with the atomic numbers.

Among the following cases of reaction may be remarked some of a singular kind, in which substances of a complicated constitution are resolved, by reaction between their elements, into substances altogether different. Thus, the salt named Nitrate of Ammonia is resolved by heat into water, and a gas named Nitrous Oxide; the animal principle Urea is converted by the action of water into carbonate of ammonia, oxalic acid is resolved into carbonic acid and carbonic oxide gases, sugar into carbonic acid gas and alcohol; and there are various other examples of this nature. To illustrate these, the form of diagram, here employed, is peculiarly fitted, as it enables us to demonstrate the correspondence of atomic weights, and to shew how, by a different arrangement of atoms, one compound is convertible into another. Cases of this kind are the more interesting, as they may be considered as so many proofs of the accuracy of the atomic doctrine.

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TABLES AND DIAGRAMS.

Analysis of Atmospheric Air by detonation with Hydrogen Gas.

Atmos. air, 5 volumes.	Nitrogen gas, 4 vols, or 4 atoms,	56	56 Nitrogen gas, 4 vols.
	Oxygen gas, 1 vol. or 2 atoms,	16	
Hydrogen gas, 2 volumes,		2	18 Water, 2 equiv.

Analysis of Atmospheric Air by mixture with Nitric Oxide Gas.

Atmos. air, 4 vols.	Nitrogen gas, 4 atoms,	56	56 Nitrogen gas, 4 vols.
	Oxygen gas, 2 atoms,	16	
Nitric oxide gas, 2 vols, or 1 equiv.		30	46 Nitrous acid vapour.

To obtain Oxygen Gas.

Materials.			*Products.*
44 Peroxide of manganese.	Oxygen, $\frac{1}{2}$ atom,	4	4 Oxygen gas.
	Deutox. mangan.	40	40 Deutoxide of mangan.

To obtain Oxygen Gas.

Materials.			*Products.*
44 Peroxide of mangan.	Oxygen,	8	8 Oxygen gas.
	Protox. mangan.	36	
40 Sulphuric acid,		40	76 Proto-sulph. of mangan.

To obtain Oxygen Gas in a very pure state.

Materials.				*Products.*
124 Chlorate of potash.	Chloric acid,	Oxygen, 5 atoms,	40	48 Oxygen gas, 6 atoms.
		Chlorine,	36	
	Potash,	Oxygen,	8	
		Potassium,	40	76 Chloride of potassium.

To obtain Hydrogen Gas.

Materials.			*Products.*
9 Water.	Hydrogen,	1	1 Hydrogen gas,
	Oxygen,	8	
34 Zinc,		34	
40 Sulphuric acid,		40	82 Sulphate of zinc.

To obtain Hydrogen Gas.

Materials.			*Products.*
9 Water.	Hydrogen,	1	1 Hydrogen gas.
	Oxygen,	8	
28 Iron.		28	
40 Sulphuric acid,		40	76 Proto-sulphate of iron.

To form Deutoxide of Hydrogen.

Materials.			*Products.*
9 Water.	Hydrogen,	1	17 Deutoxide of hydrogen.
	Oxygen,	8	
84 Peroxide of barium.	Oxygen,	8	
	Barytes,	76	
37 Muriatic acid,		37	113 Muriate of barytes.

To prepare Nitric Acid.

Pharmaceutic process.

Materials.			*Products.*
102 Nitrate of potash.	Nitric acid,	54	72 Liquid nitric acid.
	Potash,	48	
98 Liquid sulphuric acid, 2 equiv.	Water,	9	
	Water,	9	
	Sulphuric acid,	40	
	Sulphuric acid,	40	128 Bisulphate of potash.

To obtain Nitric Oxide Gas.

Materials.			*Products.*
108 Nitric acid, 2 equiv.	Nitrogen, 2 atoms,	28	60 Nitric oxide gas, 2 equiv.
	Oxygen, 4 atoms,	32	
	Oxygen, 6 atoms,	48	
162 Nitric acid, 3 equivalents,		162	
129 Copper, 3 atoms,		192	402 Nitrate of copper, 3 equiv.

Analysis of Nitric Oxide Gas.

30 Nitric oxide gas, 2 volumes.	Nitrogen,	14	14 Nitrogen gas.
	Oxygen, 2 atoms,	16	
2 Hydrogen gas, 2 volumes,		2	18 Water, 2 equiv.

To obtain Nitrous Oxide Gas.

Materials.				*Products.*
71 Nitrate of ammonia.	Ammonia.	Nitrogen,	14	44 Nitrous oxide gas, 2 equiv.
		Hydrogen, 3 at.	3	
	Nitric acid.	Nitrogen,	14	
		Oxygen, 2 atoms,	26	
		Oxygen, 3 atoms,	24	27 Water, 3 equiv.

Reaction which produces Sulphuric Acid.

Materials.			*Products.*
38 Hypo-nitrous acid.	Nitrogen,	14	30 Nitric oxide gas.
	Oxygen,	8	
	Oxygen,	8	
	Oxygen,	8	
32 Sulphurous acid,		32	
9 Water,		9	49 Liquid sulphuric acid.

Reaction which forms Hypo-sulphuric Acid.

Materials.			*Products.*
64 Sulphurous acid, 2 equiv.		64	108 Hypo-sulphate of manganese.
32 Sulphurous acid,		32	
44 Peroxide of manganese.	Oxygen,	8	
	Protox. mang.	36	
44 Peroxide of manganese.	Oxygen,	8	
	Protox. mang.	36	76 Sulphate of manganese.

To obtain Hypo-sulphuric Acid.

Materials.			*Products.*
108 Hypo-sulph. of manganese.	Hypo-sulph. A.	72	148 Hypo-sulp. of bar.
	Protox. mang.	36	36 Protox. mangan.
152 Barytes, 2 equiv.	Barytes,	76	
	Barytes,	76	
76 Sulphate of manganese.	Sulphuric acid,	40	116 Sulph. of barytes.
	Protox. mang.	36	36 Protox. manganese.

---

148 Hypo-sulphate of barytes.	Hypo-sulphuric acid,	72	72 Hypo-sulphuric acid.
	Barytes,	76	
40 Sulphuric aid,		40	116 Sulphate of barytes.

Reaction which forms Hypo-sulphurous Acid.

Materials.				*Products.*
32 Sulphurous acid.	Sulphur,	16	48 Hypo-sulphurous acid.	96 Hypo-sulphite of potash.
	Oxygen,	8		
	Oxygen,	8		
16 Sulphur,		16		
48 Potash,		48	48 Potash.	

To prepare Sulphuretted Hydrogen Gas.

Pharmaceutic Process.

Materials.			*Products.*
9 Water.	Hydrogen,	1	17 Sulphuretted hydrogen gas.
	Oxygen,	8	
44 Sulphuret of iron.	Sulphur,	16	
	Iron,	28	
40 Sulphuric acid,		40	76 Sulphate of iron.

To prepare Sulphuretted Hydrogen Gas.

Materials.			*Products.*
27 Water, 3 equiv.	Hydrogen, 3 at.	3	51 Sulphuretted hydrogen gas, 3 equiv.
	Oxygen, 3 at.	24	
176 Sulphuret of antimony, 2 equiv.	Sulphur, 3 at.	48	
	Antimony, 2 at.	128	
111 Muriatic acid, 3 equiv.		111	263 Muriate of antim. 2 equiv.

Combustion of Sulphuretted Hydrogen.

17 Sulphuretted hydrogen gas, 1 volume.	Sulphur,	16	32 Sulphurous acid gas.
	Hydrogen,	1	
24 Oxygen gas, $1\frac{1}{2}$ vols, or 3 atoms.	Oxygen, 2 at.	16	
	Oxygen,	8	9 Water.

Decomposition of Sulphuretted Hydrogen by Chlorine.

36 Chlorine,		36	37 Muriatic acid.
17 Sulphuretted hydrogen.	Hydrogen,	1	
	Sulphur,	16	16 Sulphur.

Reaction in preparing "Precipitated Sulphur."

Pharmaceutic Process.

Materials.			*Products.*
37 Muriatic acid,		37	65 Muriate of lime.
61 Hydro-bisulphuret of lime.	Lime,	28	
	Hydrogen,	1	17 Sulphuretted hydrogen gas.
	Sulphur,	16	
	Sulphur,	16	16 Sulphur.

To obtain Carbonic Oxide Gas.

Materials.				*Products.*
50 Carbonate of lime.	Carbonic acid.	Carbon,	6	14 Carbonic oxide gas.
		Oxygen,	8	
		Oxygen,	8	
	Lime,		28	28 Lime.
28 Iron,			28	36 Protoxide of iron.

To obtain Carbonic Oxide Gas.

Materials.				*Products.*
6 Carbon,			6	14 Carbonic oxide gas.
50 Carbonate of lime.	Carbonic acid.	Oxygen,	8	
		Oxygen,	8	14 Carbonic oxide gas.
		Carbon,	6	
	Lime,		28	28 Lime.

Reaction between Carbonic Oxide and Nitrous Oxide, occasioned by Electricity.

22 Nitrous oxide gas.	Nitrogen,	14	14 Nitrogen gas.
	Oxygen,	8	
14 Carbonic oxide gas.	Oxygen,	8	
	Carbon,	6	22 Carbonic acid gas.

To obtain Carbonic Acid.

Materials.			*Products.*
50 Carbonate of lime.	Carbonic acid,	22	22 Carbonic acid gas.
	Lime,	28	
40 Muriatic acid,		37	65 Muriate of lime.

To obtain Carbonic Acid.

Pharmaceutic Process.

Materials.			*Products.*
50 Carbonate of lime.	Carbonic acid,	22	22 Carbonic acid gas.
	Lime,	28	
40 Sulphuric acid,		40	68 Sulphate of lime.

Combustion of Bi-Hydruret of Carbon, (Fire Damp.)

8 Bi-hydruret of carbon.	Carbon,	6	22 Carbonic acid gas.
	Hydrogen, 2 atoms,	2	
32 Oxygen, 4 atoms.	Oxygen, 2 atoms,	16	
	Oxygen, 2 atoms,	16	18 Water, 2 equiv.

To obtain Olefiant Gas.

Materials.			*Products.*
23 Alcohol.	Carbon, 2 atoms,	12	14 Olefiant gas.
	Hydrogen, 2 atoms,	2	
	Hydrogen,	1	
	Oxygen,	8	
49 Liquid sulphuric acid,		49	58 Dilute sulph. acid.

Combustion of Olefiant Gas.

14 Olefiant gas, (1 volume.)	Carbon, 2 at.	12	44 Carbonic acid gas, 2 equiv.
	Hydrogen, 2 at.	2	
48 Oxygen, 6 at. (3 volumes.)	Oxygen, 4 at.	32	
	Oxygen, 2 at.	16	18 Water, 2 equiv.

Combustion of Super-Olefiant gas.

21 Super-olefiant gas, (1 volume.)	Carbon, 3 atoms,	18	66 Carbonic acid gas, 3 equiv.
	Hydrogen, 3 atoms,	3	
72 Oxygen, 9 at. ($4\frac{1}{2}$ volumes.)	Oxygen, 6 atoms,	48	
	Oxygen, 3 atoms,	24	27 Water, 3 equiv.

To obtain Phosphorous Acid.

Materials.			*Products.*
27 Water, 3 equiv.	Hydrogen, 3 at.	3	111 Muriatic acid, 3 equiv.
	Oxygen, 3 at.	24	
140 Chloride of phosph. 2 equiv.	Chlorine, 3 at.	108	
	Phosphorus, 2 at.	32	56 Phosph. acid, 2 equiv.

To obtain Boracic Acid.

Materials.			*Products.*
40 Sulphuric acid,		40	72 Sulphate of soda.
80 Bi-borate of soda.	Soda,	32	
	Boracic acid, 2 equiv.	48	48 Boracic acid, 2 eq.

To prepare Muriatic Acid Gas.

Materials.			*Products.*
60 Chloride of sodium.	Chlorine,	36	37 Muriatic acid gas.
	Sodium,	24	
9 Water.	Hydrogen,	1	
	Oxygen,	8	
40 Sulphuric acid,		40	72 Sulphate of soda.

To prepare Liquid Muriatic Acid.

Pharmaceutic Process. *Lond. Dub.*

Materials.			*Products.*
69 Muriate of soda.	Muriatic acid,	37	109 Liquid muriatic acid.
	Soda,	32	
112 Dilute sulphuric acid.	Water, 8 equiv.	72	
	Sulphuric acid,	40	72 Sulphate of soda.

Decomposition of Muriatic Acid Gas.

37 Muriatic acid gas, 2 volumes.	Chlorine,	36	36 Chlorine gas.
	Hydrogen,	1	
8 Oxygen gas, ½ volume,		8	9 Water.

To obtain Chlorine Gas.

Pharmaceutic Process. *Dub.*

Materials.			*Products.*
69 Muriate of soda.	Chlorine,	36	36 Chlorine gas.
	Hydrogen,	1	9 Water.
	Sodium,	24	
	Oxygen,	8	
44 Peroxide of manganese.	Oxygen,	8	
	Protox. mang.	36	
40 Sulphuric acid,		40	72 Sulphate of soda.
40 Sulphuric acid,		40	76 Sulphate of manganese.

To obtain Chlorine Gas.

Materials.			*Products.*
37 Muriatic acid.	Chlorine,	36	36 Chlorine gas.
	Hydrogen,	1	9 Water.
37 Muriatic acid,		37	
44 Peroxide of manganese.	Oxygen,	8	
	Protox. mang.	36	73 Muriate of manganese.

Reaction which produces Chloride of Nitrogen.

Materials.			*Products.*
17 Ammonia.	Nitrogen,	14	158 Chloride of nitrogen.
	Hydrogen, 3 at.	3	
252 Chlorine, 7 atoms.	Chlorine, 4 at.	144	
	Chlorine, 3 at.	108	111 Muriatic acid, 3 equiv.

Decomposition of Perchloride of Carbon.

3 Hydrogen, 3 atoms,		3	111 Muriatic acid gas, 3 equiv.
120 Perchloride of carbon.	Chlorine, 3 at.	108	
	Carbon, 2 at.	12	12 Carbon, 2 atoms.

Reaction in preparing Euchlorine Gas.

Materials.			*Products.*
76 Chloric acid.	Chlorine,	36	132 Protoxide of chlorine, 3 equiv.
	Oxygen, 3 atoms,	24	
	Oxygen, 2 atoms,	16	
74 Muriatic acid, 2 equiv.	Chlorine, 2 atoms,	72	
	Hydrogen, 2 atoms,	2	18 Water, 2 equiv.

To obtain Chloric Acid.

Materials.			*Products.*
152 Chlorate of barytes.	Chloric acid,	76 - - - - -	Chloric acid.
	Barytes,	76	
40 Sulphuric acid,		40	116 Sulphate of barytes.

Reaction which produces Peroxide of Chlorine and Perchloric Acid.

Materials.				*Products.*
248 Chlorate of potash, 2 equiv.	Chloric acid, 2 equiv.	Perox. chlorine, 2 eq.	136	136 Peroxide chlor. 3 equiv.
		Oxygen, 2 atoms,	16	
	Potash, 2 equiv.		96	140 Perchl. of potash.
124 Chlorate of potash,			124	
80 Sulphuric acid, 2 equiv.			80	176 Sulphate of potash, 3 eq.

Reaction which produces Nitro-muriatic Acid.

Materials.			*Products.*
37 Muriatic acid.	Chlorine,	36 - - - - -	36 Chlorine.
	Hydrogen,	1	9 Water.
54 Nitric acid.	Oxygen,	8	
	Nitrous acid,	46 - - - - -	46 Nitrous acid.

To prepare Iodine.

Pharmaceutic Process. *Dub.*

Materials.			*Products.*
125 Hydriodic acid.	Iodine,	124	124 Iod. vapours.
	Hydrogen,	1	9 Water.
48 Potash,		48	
44 Peroxide of manganese.	Oxygen,	8	
	Protox. mangan.	36	
40 Sulphuric acid,		40	88 Sulph. of pot.
40 Sulphuric acid,		40	76 Sulphate of manganese.

To prepare Iodine.

Materials.			*Products.*
125 Hydriodic acid.	Iodine,	124	124 Iodine.
	Hydrogen,	1	9 Water.
125 Hydriodic acid,		125	
44 Peroxide of manganese.	Oxygen,	8	
	Protox. mang.	36	161 Hydriodate of manganese.

To obtain Liquid Hydriodic Acid.

Materials.			*Products.*
9 Water,		9	134 Liquid hydriodic acid.
124 Iodine,		124	
17 Sulphuretted hydrogen.	Hydrogen,	1	
	Sulphur,	16	16 Sulphur.

Hydriodic Acid decomposed by Mercury.

Materials.			*Products.*
125 Hydriodic acid.	Hydrogen,	1	1 Hydrogen gas.
	Iodine,	124	
200 Mercury,		200	324 Iodide of mercury.

To obtain Bromine.

Materials.				*Products.*
101 Hydro-bro. of magnesia.	Hydro-bromic acid,	Bromine,	80	80 Bromine.
		Hydrogen,	1	
	Magnesia,		20	
36 Chlorine,			36	57 Muriate of magnesia.

To obtain Hydro-bromic Acid.

Materials.			*Products.*
80 Bromine,		80	81 Hydro-bromic acid gas.
125 Hydriodic acid.	Hydrogen,	1	
	Iodine,	124	124 Iodine.

Decomposition of Hydro-bromic Acid.

36 Chlorine gas,		36	37 Muriatic acid gas.
81 Hydro-bromic acid gas.	Hydrogen,	1	
	Bromine,	80	80 Bromine.

To obtain Fluoric Acid.

Materials.			*Products.*
38 Fluoride of calcium.	Fluorine,	18	19 Fluoric acid.
	Calcium,	20	
9 Water.	Hydrogen,	1	
	Oxygen,	8	
40 Sulphuric acid,		40	68 Sulphate of lime.

Reaction in the preparation of Bi-cyanide of Mercury.

Materials.			*Products.*
54 Prussic acid, 2 equiv.	Hydrogen, 2 atoms,	2	18 Water, 2 equiv.
	Cyanogen, 2 equiv.	52	
216 Peroxide of mercury.	Oxygen, 2 atoms,	16	
	Mercury,	200	252 Bi-cyanide of mercury.

Combustion of Cyanogen Gas.

26 Cyanogen gas, 1 volume.	Nitrogen,	14	14 Nitrogen gas.
	Carbon, 2 atoms,	12	
32 Oxygen gas, 2 volumes or 4 atoms,		32	44 Carbonic acid gas, 2 equiv.

To prepare Prussic Acid.

Pharmaceutic Process. *Dub.*

Materials.			*Products.*
74 Muriatic acid, 2 equiv.	Hydrogen, 2 atoms,	2	54 Prussic acid, 2 equiv.
	Chlorine, 2 atoms,	72	
252 Bi-cyanide of mercury.	Cyanogen, 2 equiv.	52	
	Mercury,	200	272 Bi-chloride of mercury.

To prepare Prussic Acid.

Materials.			*Products.*
34 Sulphuretted hydrogen, 2 equiv.	Hydrogen, 2 at.	2	54 Prussic acid, 2 equiv.
	Sulphur, 2 at.	32	
252 Bi-cyanide of mercury.	Cyanogen, 2 equiv.	52	
	Mercury,	200	232 Bi-sulphuret of mercury.

Decomposition of Prussic Acid.

27 Prussic acid.	Hydrogen,	1	1 Hydrogen gas.
	Cyanogen,	26	
40 Potassium,		40	66 Cyanide of potassium.

Combustion of Prussic Acid.

27 Prussic acid, (2 volumes.)	Cyanogen,	Nitrogen,	14	14 Nitrog. gas.
		Carbon, 2 at.	12	44 Carbonic acid gas, 2 eq.
	Hydrogen,		1	
40 Oxygen, 5 at. ($2\frac{1}{2}$ volumes.)	Oxygen, 4 atoms,		32	
	Oxygen,		8	9 Water.

Prussic Acid converted by Muriatic Acid into Formic Acid and Ammonia.

Materials.			*Products.*
27 Prussic acid.	Carbon, 2 atoms,	12	37 Formic acid.
	Hydrogen,	1	
	Nitrogen,	14	
27 Water, 3 equiv.	Oxygen, 3 atoms,	24	
	Hydrogen, 3 atoms,	3	
37 Muriatic acid,		37	54 Muriate of ammonia.

Conversion of Cyanic Acid into Bi-Carbonate of Ammonia.

Materials.				*Products.*
27 Water, 3 equiv.	Hydrogen, 3 atoms,	3	17	61 Bi-carbonate of ammonia.
	Oxygen, 3 atoms,	24		
34 Cyanic acid.	Nitrogen,	14		
	Carbon, 2 atoms,	12		
	Oxygen,	8	44	

To prepare Ammonia.

Pharmaceutic Process.

Materials.				*Products.*
54 Muriate of ammonia.	Ammonia,		17	17 Ammon.
	Muriatic acid,	Hydrogen,	1	9 Water.
		Chlorine,	36	
28 Lime.	Oxygen,		8	
	Calcium,		20	56 Chloride of calcium

Ammonia formed by the action of Nitric Acid on Tin.

Materials.			*Products.*
54 Nitric acid.	Nitrogen,	14	17 Ammonia.
	Oxygen, 5 atoms,	40	
27 Water, 3 equiv.	Hydrogen, 3 atoms,	3	
	Oxygen, 3 atoms,	24	
232 Tin, 4 atoms,		232	296 Peroxide of tin.

Combustion of Ammonia.

17 Ammonia, (2 volumes.)	Nitrogen,	14	14 Nitrogen gas.
	Hydrogen, 3 atoms,	3	
24 Oxygen gas, ($1\frac{1}{2}$ volumes,)	3 atoms,	24	27 Water, 3 equiv.

Ammonia decomposed by Chlorine.

17 Ammonia.	Nitrogen,	14	14 Nitrogen gas.
	Hydrogen, 3 atoms,	3	
51 Ammonia, 3 equiv.		51	
108 Chlorine, 3 atoms,		108	162 Muriate of ammonia, 3 equiv.

To prepare Carbonate of Ammonia.

Pharmaceutic Process.

Materials.				*Products.*
54 Muriate of ammonia.	Ammonia,		17	39 Carb. of am.
	Muriatic acid.	Hydrogen,	1	9 Water.
		Chlorine,	36	
50 Carbonate of lime.	Carbonic acid,		22	
	Lime.	Oxygen,	8	
		Calcium,	20	56 Chloride of calcium.

To prepare Acetate of Ammonia.

Pharmaceutic Process.

Materials.			*Products.*
39 Carbonate of ammonia.	Carbonic acid,	22	22 Carbonic acid gas.
	Ammonia,	17	
51 Acetic acid,		51	68 Acetate of ammonia.

To prepare Nitrate of Ammonia.

Materials.			*Products.*
39 Carbonate of ammonia.	Carbonic acid,	22	22 Carbonic acid gas.
	Ammonia,	17	
54 Nitric acid,		54	71 Nitrate of ammonia.

To obtain Potassium.

Materials.				*Products.*
6 Carbon,			6	14 Carbonic oxide gas.
70 Carbonate of potash.	Carbonic acid,		22	22 Carbonic acid gas.
	Potash.	Oxygen,	8	
		Potassium,	40	40 Potassium.

To prepare Potash.

Pharmaceutic Process.

Materials.			*Products.*
70 Carbonate of potash.	Potash,	48 - - - - -	48 Potash.
	Carbonic acid,	22	
28 Lime,		28	50 Carbonate of lime.

To prepare Sulphate of Potash.

Pharmaceutic Process.

Materials.			*Products.*
50 Carbonate of lime.	Carbonic acid,	22	22 Carbonic acid gas.
	Lime,	28	
128 Bi-sulphate of potash.	Potash,	48	
	Sulphuric acid,	40	68 Sulphate of lime.
	Sulphuric acid,	40	88 Sulphate of potash.

To prepare Sulphate of Potash.

Pharmaceutic Process. *Lond. Dub.*

Materials.			*Products.*
70 Carbonate of potash.	Carbonic acid,	22	22 Carbonic acid gas.
	Potash,	48	88 Sulphate of potash.
128 Bi-sulphate of potash.	Sulphuric acid,	40	
	Sulphuric acid,	40	
	Potash,	48	88 Sulphate of potash.

Decomposition of Sulphate of Potash by Charcoal.

Materials.			*Products.*
24 Carbon, 4 atoms,		24	56 Carbonic oxide gas, 4 equiv.
40 Sulphuric acid.	Sulphur,	16	
	Oxygen, 3 at.	24	
48 Potash.	Oxygen,	8	
	Potassium,	40	56 Sulphuret of potassium.

Decomposition of Sulphate of Potash by Hydrogen.

Materials.				*Products.*
4 Hydrogen, 4 atoms,			4	36 Water, 4 eq.
88 Sulphate of potash.	Sulphuric acid.	Oxygen, 3 at.	24	
		Sulphur,	16	
	Potash.	Oxygen,	8	
		Potassium,	40	56 Sulphuret of potassium.

Reaction between Sulphuret of Potassium and Water.

Materials.				*Products.*
9 Water.	Hydrogen,	1	17 Sulph. hyd.	65 Hydro-sulphuret of potash.
	Oxygen,	8		
56 Sulphuret of potassium.	Sulphur,	16		
	Potassium,	40	48 Potash.	

To prepare Chlorate of Potash.

Materials.			*Products.*
180 Chlorine, 5 atoms,		180	425 Muriate of potash, 5 eq.
45 Water, 5 equiv.	Hydrogen, 5 at.	5	
	Oxygen, 5 at.	40	
240 Potash, 5 equiv.		240	
36 Chlorine,		36	
48 Potash,		48	124 Chlorate of potash.

To prepare Hydriodate of Potash.

Pharmaceutic Process. *Dub.*

Materials.			*Products.*
70 Carbonate of potash.	Carbonic acid,	22	22 Carbonic acid gas.
	Potash,	48	173 Hydriodate of potash.
124 Iodine,		124	
17 Sulphuretted hydrogen.	Hydrogen,	1	
	Sulphur,	16	16 Sulphur.

To prepare Hydriodate of Potash.

Materials.				*Products.*
124 Iodine,		124	125	161 Hydriodate of iron.
9 Water.	Hydrogen,	1		
	Oxygen,	8		
28 Iron,		28	36	

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161 Hydriodate of iron.	Hydriodic acid,	125	173 Hydriodate of potash.
	Protox. iron,	36	
70 Carbonate of potash.	Potash,	48	
	Carbonic acid,	22	58 Carb. of iron.

Reaction between Iodide of Potassium and Water.

Materials.				*Products.*
164 Iodide of potassium.	Iodine,	124	125	173 Hydriodate of potash.
	Potassium,	40		
9 Water.	Hydrogen,	1		
	Oxygen,	8	48	

To prepare Iodate of Potash.

Materials.			*Products.*
620 Iodine, 5 atoms,		620	860 Hydriodate of potash, 5 eq.
45 Water, 5 equiv.	Hydrogen, 5 at.	5	
	Oxygen, 5 at.	40	
240 Potash,		240	
124 Iodine,		124	
48 Potash,		48	212 Iodate of potash.

Reaction between Bromide of Potassium and Water.

Materials.				*Products.*
120 Bromide of potassium.	Bromine,	80	81	129 Hydro-bromate of potash.
	Potassium,	40		
9 Water.	Hydrogen,	1		
	Oxygen,	8	48	

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81 Hydro-bromic acid.	Hydrogen,	1	9 Water.
	Bromine,	80	
48 Potash.	Oxygen,	8	
	Potassium,	40	120 Bromide of potassium.

Reaction between Ferro-cyanide of Potassium and Water.

Materials.				*Products.*
186 Ferro-cyanide of potassium.	Cyanogen, 3 eq.	78	108	204 Ferro-cyanate of potash.
	Iron,	28		
	Potassium, 2 at.	80		
18 Water, 2 equiv.	Hydrogen, 2 at.	2		
	Oxygen, 2 at.	16	96	

To prepare Acetate of Potash.

Pharmaceutic Process.

Materials.			*Products.*
70 Carbonate of potash.	Carbonic acid,	22	22 Carbonic acid gas.
	Potash,	48	
51 Acetic acid,		51	99 Acetate of potash.

To prepare Phosphate of Soda.

Pharmaceutic Process.

Materials.			*Products.*
128 Phosphate of lime, 2 equiv.	Phosphoric acid,	36	100 Bi-phosphate of lime.
	Lime,	28	
	Phosphoric acid,	36	
	Lime,	28	
40 Sulphuric acid,		40	68 Sulphate of lime.

54 Carbonate of soda.	Carbonic acid,	22	22 Carbonic acid gas.
	Soda,	32	68 Phosphate of soda.
100 Bi-phosphate of lime.	Phosphoric acid,	36	
	Phosphoric acid,	36	
	Lime,	28	64 Phosphate of lime.

Reaction between Chloride of Sodium and Water.

Materials.				*Products.*
60 Chloride of sodium.	Chlorine,	36	37	69 Muriate of soda.
	Sodium,	24		
9 Water.	Hydrogen,	1		
	Oxygen,	8	32	

69 Muriate of soda.	Muriatic acid.	Hydrogen,	1	9 Water.
		Chlorine,	36	
	Soda.	Oxygen,	8	
		Sodium,	24	60 Chlor. of sod.

To prepare Muriate of Barytes.

Pharmaceutic Process.

Materials.		*Products.*
98 Carbonate of barytes.	Carbonic acid, 22	22 Carbonic acid gas.
	Barytes, 76	
37 Muriatic acid,	37	113 Muriate of barytes.

To prepare Muriate of Barytes.

Pharmaceutic Process.

Materials.		*Products.*
24 Carbon, 4 atoms.	Carbon, 3 at. 18	42 Carb. oxide gas, 3 eq.
	Carbon, 6	14 Carbonic oxide gas.
40 Sulphuric acid.	Sulphur, 16	
	Oxygen, 3 at. 24	
76 Barytes.	Oxygen, 8	
	Barium, 68	84 Sulphuret of barium.

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9 Water.	Hydrogen, 1 . . . 17	93 Hydro-sulphuret of barytes.
	Oxygen, 8	
84 Sulphuret of barium.	Sulphur, 16	
	Barium, 68 . . . 76	

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93 Hydro-sulphuret of barytes.	Hydrogen, 1	17 Sulphuretted hydrogen gas.
	Sulphur, 16	
	Barytes, 76	
37 Muriatic acid,	37	113 Muriate of barytes.

To prepare Precipitated Carbonate of Lime.

Pharmaceutic Process.

Materials.		*Products.*
54 Carbonate of soda.	Soda, 32	69 Muriate of soda.
	Carbonic acid, 22	
65 Muriate of lime.	Muriatic acid, 37	
	Lime, 28	50 Carbonate of lime.

To prepare Precipitated Phosphate of Lime.

Pharmaceutic Process. *Dub.*

Materials.		*Products.*
17 Ammonia,	17	54 Muriate of ammonia.
37 Muriatic acid,	37	
64 Phosphate of lime,	64	64 Phosphate of lime.

Reaction between Chloride of Calcium and Water.

Materials.			*Products.*
37 Muriatic acid.	Hydrogen,	1	9 Water.
	Chlorine,	36	
28 Lime.	Oxygen,	8	
	Calcium,	20	56 Chloride of calcium.

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9 Water.	Hydrogen,	1	37 Muriatic acid.
	Oxygen,	8	
56 Chloride of calcium.	Chlorine,	36	
	Calcium,	20	28 Lime.

To obtain Chloride of Magnesium.

Materials.			*Products.*
20 Magnesia.	Oxygen,	8	8 Oxygen gas.
	Magnesium,	12	
36 Chlorine,		36	48 Chloride of magnesium.

To obtain Magnesium.

Materials.			*Products.*
48 Chloride of magnesium.	Magnesium,	12	12 Magnesium.
	Chlorine,	36	
40 Potassium,		40	76 Chloride of potassium.

To prepare Carbonate of Magnesia.

Pharmaceutic Process.

Materials.			*Products.*
70 Carbonate of potash.	Potash,	48	88 Sulphate of potash.
	Carbonic acid,	22	
60 Sulphate of magnesia.	Sulphuric acid,	40	
	Magnesia,	20	42 Carbonate of magnesia.

To obtain Chloride of Aluminum.

Materials.			*Products.*
6 Carbon,		6	14 Carbonic oxide.
18 Alumina.	Oxygen,	8	
	Aluminum,	10	
36 Chlorine,		36	46 Chloride of aluminum.

To obtain Aluminum.

Materials.			*Products.*
46 Chloride of aluminum.	Aluminum,	10	10 Aluminum.
	Chlorine,	36	
40 Potassium,		40	76 Chloride of potassium.

To obtain Silicium.

Materials.			*Products.*
26 Fluo-silicic acid.	Silicium,	8	8 Silicium.
	Fluorine ?	18	
40 Potassium,		40	58 Fluoride of potassium.

To prepare Nitrate of Silver.

Pharmaceutic Process.

Materials.			*Products.*
54 Nitric acid.	Nitrogen,	14	30 Nitric oxide gas.
	Oxygen, 2 at.	16	
	Oxygen, 3 at.	24	
162 Nitric acid, 3 equiv.		162	
330 Silver, 3 atoms,		330	516 Nitrate of silver, 3 equiv.

Nitrate of Silver used as a Test of Muriatic Acid.

172 Nitrate of silver.	Nitric acid,		54	86 Nitr. of soda.
	Ox. silver.	Oxygen,	8	9 Water.
		Silver,	110	
69 Muriate of soda.	Soda,		32	
	Mur. acid.	Hydrogen,	1	
		Chlorine,	36	146 Chloride of silver.

To obtain Mercury from the Ore.

Materials.			*Products.*
232 Cinnabar, or bisulphuret of mercury.	Mercury,	200	200 Mercury.
	Sulphur, 2 atoms,	32	
56 Lime, 2 equiv.		56	88 Sulphuret of lime, 2 eq.

To prepare Bi-persulphate of Mercury.

Pharmaceutic Process.

Materials.			*Products.*
40 Sulphuric acid.	Sulphurous acid,	32	32 Sulphurous acid gas.
	Oxygen,	8	
40 Sulphuric acid.	Sulphurous acid,	32	32 Sulphurous acid gas.
	Oxygen,	8	
40 Sulphuric acid,		40	
40 Sulphuric acid,		40	
200 Mercury,		200	296 Bi-persulphate of mercury.

To prepare "Yellow Subsulphate of Mercury."

Pharmaceutic Process.

Materials.			*Products.*
45 Water, 5 equivalents,		45	245 Liquid sulph. acid, 5 equiv.
1184 Bi-persulp. of mercury, 4 equivalents.	Sulph. acid, 5 equiv.	200	
	Sulph. acid, 3 equiv.	120	
	Perox. mer. 4 equiv.	864	984 Subsulph. of mercury.

To prepare Corrosive Sublimate.

Pharmaceutic Process.

Materials.			*Products.*
296 Bi-persulph. of mercury.	Mercury,	200	272 Bi-chloride of mercury.
	Oxygen,	8	
	Sulph. acid,	40	
	Oxygen,	8	
	Sulph. acid,	40	
120 Chloride of sodium, 2 equiv.	Chlorine,	36	
	Chlorine,	36	
	Sodium,	24	72 Sulphate of soda.
	Sodium,	24	72 Sulphate of soda.

Reaction between Corrosive Sublimate and Water.

Materials.				*Products.*
272 Bichloride of mercury.	Chlorine, 2 at.	72	74	290 Bi-permuriate of mercury.
	Mercury,	200		
18 Water, 2 equiv.	Hydrogen, 2 at.	2		
	Oxygen, 2 at.	16	216	

To prepare White Precipitate of Mercury.

Pharmaceutic Process. *Dub.*

Materials.			*Products.*
17 Ammonia,		17	54 Muriate of ammonia.
17 Ammonia,		17	
290 Bi-permuriate of mercury.	Muriatic acid,	37	
	Muriatic acid,	37	
	Perox. mercury,	216	270 Permuriate of ammonia and mercury.

To prepare Calomel by Sublimation.

Pharmaceutic Process. *Lond. Dub.*

Materials.			*Products.*
200 Mercury,		200	236 Calomel.
296 Bi-persulphate of mercury.	Mercury,	200	236 Calomel.
	Oxygen, 2 at.	16	
	Sulph. acid, 2 eq.	80	
120 Chloride of sodium, 2 equiv.	Chlorine,	36	
	Chlorine,	36	
	Sodium, 2 at.	48	144 Sulphate of soda, 2 equiv.

To prepare Calomel from Corrosive Sublimate.

Pharmaceutic Process.

Materials.			*Products.*
272 Bi-chloride of mercury.	Mercury,	200	236 Calomel.
	Chlorine,	36	
	Chlorine,	36	
200 Mercury,		200	236 Calomel.

To prepare Calomel by Precipitation.

Pharmaceutic Process.

Materials.			*Products.*
60 Chloride of sodium.	Sodium,	24	86 Nitrate of soda.
	Chlorine,	36	
262 Proto-nitrate of mercury.	Nitric acid,	54	
	Oxygen,	8	
	Mercury,	200	236 Calomel.

To prepare Grey Oxide (Protoxide) of Mercury.

Pharmaceutic Process.

Materials.			*Products.*
28 Lime,		28	65 Muriate of lime.
9 Water.	Hydrogen,	1	
	Oxygen,	8	
236 Calomel.	Chlorine,	36	
	Mercury,	200	208 Protoxide of mercury.

To prepare Black Oxide (Protoxide) of Mercury.

Pharmaceutic Process. *Dub.*

Materials.			*Products.*
48 Potash,		48	85 Muriate of potash.
9 Water.	Hydrogen,	1	
	Oxygen,	8	
236 Calomel.	Chlorine,	36	
	Mercury,	200	208 Protoxide of mercury.

To prepare Acetate of Mercury.

Pharmaceutic Process.

Materials.			*Products.*
99 Acetate of potash.	Potash,	48	102 Nitrate of potash.
	Acetic acid,	51	
262 Proto-nitrate of mercury.	Nitric acid,	54	
	Protox. mercury,	208	259 Acetate of mercury.

Decomposition of Acetate of Copper (Verdigris) by Water.

Materials.			*Products.*
131 Verdigris.	Acetic acid,	51	182 Binacetate of copper.
	Perox. copper,	80	
131 Verdigris.	Acetic acid,	51	
	Perox. copper,	80	
131 Verdigris.	Acetic acid,	51	
	Perox. copper,	80	211 Subacetate of copper.

To prepare Carbonate of Iron.

Pharmaceutic Process.

Materials.			*Products.*
54 Carbonate of soda.	Soda,	32	72 Sulphate of soda.
	Carbonic acid,	22	
76 Proto-sulphate of iron.	Sulphuric acid,	40	
	Protox. iron,	36	58 Proto-carbonate of iron.

To obtain Lead from the Ore.

Materials.			*Products.*
120 Sulphuret of lead.	Lead,	104	104 Lead.
	Sulphur,	16	
28 Lime,		28	44 Sulphuret of lime.

Reaction which produces the "Lead Tree."

Materials.			*Products.*
34 Zinc,		34	93 Acetate of zinc.
163 Acetate of lead.	Acetic acid,	51	
	Oxygen,	8	
	Lead,	104	104 Lead.

Test of Lead by Sulphuretted Hydrogen.

Acetate of lead.	Acetic acid,		51	51 Acetic acid.
	Protox. lead.	Oxygen,	8	9 Water.
		Lead,	104	
Sulphuretted hydrogen.		Hydrogen,	1	
		Sulphur,	16	120 Sulphuret of lead.

To prepare Acetate of Zinc.

Pharmaceutic Process.

Materials.			*Products.*
163 Acetate of lead.	Acetic acid,	51	93 Acetate of zinc.
	Protox. lead,	112	
82 Sulphate of zinc.	Oxide of zinc,	42	
	Sulphuric acid,	40	152 Sulphate of lead.

To prepare Subnitrate of Bismuth.

Pharmaceutic Process.

Materials.			*Products.*
54 Nitric acid.	Nitrogen,	14	30 Nitric oxide gas.
	Oxygen, 2 at.	16	
	Oxygen, 3 at.	24	
162 Nitric acid, 3 equivalents,		162	
216 Bismuth, 3 atoms,		216	402 Nitrate of bismuth, 3 equivalents.

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36 Water, 4 equivalents,		36	144 Liquid nitric acid.
402 Nitrate of bismuth, 3 equiv.	Nitric acid, 3 equiv.	108	
	Nitric acid,	54	
	Ox. of bismuth, 3 eq.	240	294 Trisnitrate of bismuth.

Test of Arsenic by the Ammoniacal Nitrate of Silver.

189 Nitrate of ammonia and silver.	Ammonia,	17	71 Nitrate of ammonia.
	Nitric acid,	54	
	Oxide of silver,	118	
50 Arsenious acid,		50	168 Arsenite of silver.

Test of Arsenic by the Ammoniacal Sulphate of Copper.

194 Sulphate of ammonia and copper.	Ammonia, 2 eq.	34	114 Sulphate of ammonia, 2 equiv.
	Sulphuric acid, 2 eq.	80	
	Perox. copper,	80	
50 Arsenious acid,		50	130 Arsenite of cop. (Scheele's green.)

Test of Arsenic by Sulphuretted Hydrogen Gas.

100 Arsenious acid, 2 equiv.	Oxygen, 3 at.	24	27 Water, 3 eq.
	Arsenic, 2 at.	76	
51 Sulphuretted hydrogen, 3 equiv.	Hydrogen, 3 at.	3	
	Sulphur, 3 at.	48	124 Sesqui-sulph. of arsenic, (orpiment,) 2 eq.

Reduction of Arsenious Acid, (Oxide of Arsenic.)

12 Carbon, 2 atoms,		12	36 Carbonic oxide and carbonic acid gases.
100 Arsenious acid, 2 equiv.	Oxygen, 3 at.	24	
	Arsenic, 2 at.	76	76 Arsenic, 2 atoms.

Decomposition of Oxalic Acid by Sulphuric Acid.

Materials.			*Products.*
72 Oxalic acid crystallized.	Carbon,	6	22 Carbonic acid gas.
	Carbon,	6	14 Carbonic oxide gas.
	Oxygen, 2 at.	16	
	Oxygen,	8	
	Water, 4 eq.	36	
40 Sulphuric acid,		40	76 Dilute sulphuric acid.

Conversion of Oxalate of Ammonia into Cyanogen and Water.

Materials.			*Products.*
36 Oxalic acid.	Carbon,	12	26 Cyanogen.
	Oxygen, 3 at.	24	
17 Ammonia.	Nitrogen,	14	
	Hydrogen, 3 at.	3	27 Water, 3 equiv.

Decomposition of Formic Acid by Sulphuric Acid.

Materials.			*Products.*
37 Formic acid.	Carbon, 2 at.	12	28 Carbonic oxide gas, 2 equivalents.
	Oxygen, 2 at.	16	
	Oxygen,	8	
	Hydrogen,	1	
49 Liquid sulphuric acid,		49	58 Dilute sulphuric acid.

To prepare Tartaric Acid.

Pharmaceutic Process.

Materials.			*Products.*
50 Carbonate of lime.	Carbonic acid,	22	22 Carbonic acid gas.
	Lime,	28	94 Tartrate of lime.
180 Bi-tartrate of potash.	Tartaric acid,	66	
	Tartaric acid,	66	
	Potash,	48	114 Tartrate of potash.

114 Tartrate of potash.	Potash,	48	85 Muriate of potash.
	Tartaric acid,	66	
65 Muriate of lime.	Muriatic acid,	37	
	Lime,	28	94 Tartrate of lime.

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94 Tartrate of lime.	Tartaric acid,	66 - - - - -	66 Tartaric acid.
	Lime,	28	
40 Sulphuric acid,		40	68 Sulphate of lime.

Combustion of Tartaric Acid in making Black Flux.

Materials.			*Products.*
24 Oxygen, 3 atoms.	Oxygen,	8	66 Carbonic acid, 3 equiv.
	Oxygen, 2 at.	16	18 Water.
66 Tartaric acid.	Hydrogen, 2 at.	2	
	Oxygen, 5 at.	40	
	Carbon, 3 at.	24	
	Carbon,	6	6 Carbon.

To prepare Tartrate of Potash.

Pharmaceutic Process.

Materials.			*Products.*
70 Carbonate of potash.	Carbonic acid,	22	22 Carbonic acid gas.
	Potash,	48	114 Tartrate of potash.
180 Bitartrate of potash.	Tartaric acid,	66	
	Tartaric acid,	66	
	Potash,	48	114 Tartrate of potash.

To prepare Rochelle Salt.

Materials.				*Products.*
54 Carbonate of soda.	Carbonic acid,	22		22 Carbonic acid gas.
	Soda,	32	98	
180 Bitartrate of potash.	Tartaric acid,	66		212 Tartrate of potash and soda.
	Tartaric acid,	66		
	Potash,	48	114	

To prepare Acetic Acid.

Pharmaceutic Process. *Dub.*

Materials.			*Products.*
49 Liquid sulph. acid.	Sulph. acid,	40	88 Sulphate of potash.
	Water,	9	
17 Acetate of potash.	Water, 2 eq.	18	
	Potash,	48	
	Acetic acid,	51	78 Acetic acid.

To prepare Benzoic Acid.

Pharmaceutic process.

Materials.			*Products.*
40 Sulphuric acid,		40	72 Sulphate of soda.
152 Benzoate of soda.	Soda,	32	
	Benzoic acid,	120	120 Benzoic acid.

To obtain Morphia.

Materials.			*Products.*
313 Meconate of morphia.	Morphia,	290	290 Morphia.
	Meconic acid,	23	
20 Magnesia,		20	43 Meconate of magnesia.

Reaction in preparing Muriate of Morphia.

Materials.			*Products.*
65 Muriate of lime.	Muriatic acid,	37	327 Muriate of morphia.
	Lime,	28	
313 Meconate of morphia.	Morphia,	290	
	Meconic acid,	23	51 Meconate of lime.

To obtain Morphia from the Muriate.

Materials.			*Products.*
17 Ammonia,		17	54 Muriate of ammonia.
327 Muriate of morphia.	Muriatic acid,	37	
	Morphia,	290	290 Morphia.

Change which Sugar suffers in Fermentation.

Materials.			*Products.*
Sugar, 3 equiv.			
24 Oxygen, 3 at.	Oxygen, 2 at.	16	22 Carbonic acid gas.
	Oxygen,	8	
18 Carbon, 3 at.	Carbon,	6	
	Carbon, 2 at.	12	
3 Hydrogen, 3 at.		3	23 Alcohol.

Combustion of Alcohol.

Materials.			*Products.*
23 Alcohol.	Carbon, 2 at.	12	44 Carbonic acid gas.
	Oxygen,	8	
	Hydrogen, 3 at.	3	
48 Oxygen, 6 at.	Oxygen, 3 at.	24	
	Oxygen, 3 at.	24	27 Water, 3 equiv.

To prepare Ether.

Materials.			*Products.*
46 Alcohol, 2 equiv.	Carbon, 4 at.	24	37 Ether.
	Oxygen,	8	
	Oxygen,	8	
	Hydrogen, 5 at.	5	
	Hydrogen,	1	
49 Liquid sulphuric acid,		49	58 Dilute sulphuric acid.

Reaction which produces Ether, on Mr Hennel's view.

Materials.			*Products.*
80 Sulphuric acid, 2 equiv.		80	108 Sulphovinic acid.
46 Alcohol, 2 equiv.	Olefiant gas,	14	
	Olefiant gas,	14	
	Water, 2 equiv.	18	18 Water, 2 equivalents.

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9 Water,		9	37 Ether.
108 Sulphovinic acid.	Olefiant gas,	14	
	Olefiant gas,	14	
	Sulphuric acid, 2 eq.	80	
18 Water, 2 equiv.		18	98 Sulphuric acid.

To prepare Sulphate of Quinia.

Pharmaceutic Process. *Dub.*

Materials.			*Products.*
748 Cinchonate (Kinate) of quinia, 2 equiv.	Cinch. acid, 2 eq.	402 - - - - -	402 Cinchon. acid, 2 eq.
	Quinia, 2 eq.	346	
40 Sulphuric acid,		40	386 Sulphate of quinia, (impure.)

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386 Sulphate of quinia.	Quinia, 2 eq.	346	346 Quinia (pure.)
	Sulphuric acid,	40	
28 Lime,		28	68 Sulphate of lime.

Quinia, 2 equiv.	346	
Sulphuric acid,	40	
Water, 4 equiv.	36	422 Sulphate of quinia crystallized.

To prepare Quinia.

Materials.			*Products.*
374 Cinchonate of quinia.	Cinchonic acid,	201 - - - - -	201 Cinchonic acid.
	Quinia,	173	
37 Muriatic acid,		37	210 Muriate of quinia.

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28 Lime,		28	65 Muriate of lime.
210 Muriate of quinia.	Muriatic acid,	37	
	Quinia,	173	173 Quinia.

Alcohol composed of Olefiant Gas and Water.

14 Olefiant gas.	2 Carbon,	- - - - - 2 Carbon,	12	23 Alcohol.
	2 Hydrogen,	- - - - 3 Hydrogen,	3	
9 Water.	Hydrogen,			
	Oxygen,	- - - - - Oxygen,	8	

Change in the Acetous Fermentation.

Materials.			*Products.*
46 Alcohol, 2 equiv.	Carbon, 4 at.	24	51 Acetic acid.
	Oxygen, 2 at.	16	
	Hydrogen, 6 at.	3	
		3	
32 Oxygen, 4 atoms.	Oxygen,	8	
	Oxygen, 3 at.	24	27 Water.

Conversion of Urea into Carbonate of Ammonia.

Materials.				*Products.*
30 Urea.	Carbon,	6	22 Carbonic acid.	39 Carbonate of Ammonia.
	Oxygen,	8		
	Nitrogen,	14		
	Hydrogen, 2 at.	2		
9 Water.	Oxygen,	8		
	Hydrogen,	1	17 Ammonia.	

Artificial Formation of Urea.

Materials.				*Products.*
17 Ammonia.	Nitrogen,		14	30 Urea.
	Hydrogen, 2 atoms,		2	
	Hydrogen,		1	
9 Water.	Oxygen,		8	
	Hydrogen,		1	
34 Cyanic acid.	Oxygen,		8	
	Cyanogen,	Carbon,	6	
		Carbon,	6	
		Nitrogen,	14	30 Urea.

TABLES.

Table I.—*Of Simple Substances or Elements.*

Element.	*Discovered by*	*Country.*	*Year.*	*Obtained pure by*	*Country.*	*Year.*
Sulphur	Known to the Ancients.					
Carbon						
Gold						
Silver						
Copper						
Iron						
Tin						
Lead						
Mercury						
Antimony	Described by Basil Valentine 15th century.					
Zinc	Described by Agricola 1529.					
Bismuth	Known to Paracelsus 16th century.					
Boron	Homberg	France	1702	Davy	England	1807
Arsenic, Cobalt	Brandt	Hamburgh	1733			
Platinum	Wood	Jamaica	1741			
Nickel	Cronstedt	Sweden	1751	Bergman	Sweden	1775
Aluminum	Margraff	Germany	1754	Wohler	Germany	1828
Magnesium	Black	Scotland	1755	Bussy	France	1829
Hydrogen	Cavendish	England	1766			
Fluorine	Scheele	Sweden	1771	Not as yet		
Nitrogen	Rutherford	Scotland	1772			
Oxygen	Priestley, Scheele	England, Sweden	1774			

Element.	*Discovered by*	*Country.*	*Year.*	*Obtained pure by*	*Country.*	*Year.*
Chlorine	Scheele	Sweden	1774			
Barium	Scheele	Sweden	1774	Davy	England	1807
Manganese	Scheele	Sweden	1774	Gahn	Sweden	1774
Molybdenum	Scheele	Sweden	1778	Hielm	Sweden	1782
Tungsten	Scheele	Sweden	1781	D'Elhuyart		1781
Tellurium	Muller	Reichenstein	1782			
Uranium	Klaproth	Berlin	1789			
Zirconium	Klaproth	Berlin	1789	Berzelius	Sweden	1824
Titanium	Gregor	England	1791	Vauquelin	France	1796
Strontium	Dr Hope Klaproth	Scotland Berlin	1792	Davy	England	1807
Yttrium	Gadolin	Sweden	1794	Wohler	Germany	1828
Chrome	Vauquelin	France	1797			
Glucinum	Vauquelin	France	1797	Wohler	Germany	1828
Columbium	Hatchett	England	1801	Berzelius	Sweden	1824
Palladium Rhodium	Wollaston	England	1803			
Iridium	Tennant Descotils	England France	1803			
Osmium	Tennant	England	1803			
Cerium	Hisinger and Berzelius	Sweden	1804	Vauquelin	France	
Potassium Sodium Calcium	Davy	England	1807			
Iodine	Courtois	France	1811			
Cadmium	Stromeyer	Germany	1817			
Selenium	Berzelius	Sweden	1818			
Lithium	Arfwedson	Sweden	1818			
Silicium				Berzelius	Sweden	1824
Bromine	Balard	France	1826			
Thorinum	Berzelius	Sweden	1828	Berzelius		1828
Vanadium	Sefstrom	Sweden	1830	Berzelius		1830

Remarks. The above Table exhibits a list of the 54 simple bodies or *elements* which are at present known to us, with the names of the individuals by whom they were discovered, and the dates of their discovery. It has happened in a number of cases, that an element (in a state of combination) has been pointed out as a peculiar body, long before it was obtained in a pure form; hence it is proper to give the name both of the chemist who first shewed the substance to be peculiar, and to whom strictly belongs the merit of the discovery, and of him who first reduced it to its simplest state.

Table II.—*Atomic Weights and Symbols of Elementary Substances.*

Substance.	*At. W.*	*Symbol.*	*Substance.*	*At. W.*	*Symbol.*
Hydrogen	1	H	Potassium	40	Po
Carbon	6	C	Selenium	40	Se
Lithium *	6	L	Strontium	44	Sr
Oxygen	8	O	Cerium *	46	Ce
Boron	8	B	Molybdenum	48	Mo
Silicium	8	Si	Rhodium *	52	R
Aluminum	10	A	Palladium	54	Pd
Magnesium	12	M	Cadmium	56	Cd
Nitrogen	14	N	Tin	58	Sn
Sulphur	16	S	Thorinum	60	Th
Phosphorus	16	P	Copper	64	Cu
Fluorine *	18	F	Antimony	64	Sb
Glucinum	18	G	Barium	68	Ba
Calcium	20	Ca	Vanadium	68	V
Zirconium *	22	Z	Bismuth	72	Bi
Sodium	24	So	Bromine *	80	Br
Nickel	26	Ni	Platinum	96	Pt
Cobalt	26	Cb	Iridium	98	Ir
Titanium	26	Ti	Osmium	100	Os
Iron	28	Fe	Tungsten	100	Tu
Manganese	28	Mn	Lead	104	Pb
Chrome	28	Cr	Silver	110	Ag
Tellurium	32	Te	Iodine *	124	I
Zinc	34	Zn	Columbium *	182	Co
Chlorine	36	Cl	Mercury	200	Hg
Yttrium *	36	Y	Gold	200	Au
Arsenic	38	As	Uranium *	216	U

Remarks. This Table is founded on the principle suggested by Dr Prout, that the atomic weight of every simple substance is a multiple of that of hydrogen, so that if the latter be taken as a standard, and considered as unity, the combining weight of all substances will be whole numbers. Dr Thomson has endeavoured farther to shew, that the atomic weights of all simple bodies are multiples of two atoms of hydrogen, and that their equivalents are therefore in all cases even numbers. It must be confessed that this principle is hypothetical, and that, with respect to several substances in the above Table, the equivalents afforded by our average of experimental results are not whole numbers. Still it may be urged, that with regard to the greater number of substances, and these the best known, the rule is correct; their atomic weights being exact multiples of that of hydrogen, that it is highly probable some such simple relation should exist between the atomic magnitudes of elements; and, lastly, that if there be such, it is most likely to subsist in reference to the atom of hydrogen, that being the smallest which is known, and the first therefore in the scale. For these reasons, I have thought it best to follow those authorities who assign whole numbers as the equivalents of substances in relation to hydrogen.

In the coloured Table, fronting the title page, I have meant to exhibit the principle of the atomic theory, that the difference of equivalent numbers is owing to difference in the magnitude of the ultimate atoms. The more important elements (including all those used in medicine) are represented in it by spheres, the solidity of which bears the same relation as the attached numbers. Thus, the atom of oxygen is inferred to be of 8 times the size and weight of that of hydrogen, the atom of mercury to be 200 times the size of that of hydrogen : accordingly, spheres of the diameters represented in the Table would be of those proportional magnitudes. It is not implied that the atoms of bodies must necessarily be spheres ; but that whatever be their form, their relative size must be as here represented. In the combination of two bodies, we have to suppose an atom of the one placed beside an atom of the other, and these will represent the compound, and the sum of their atomic weights will make up its equivalent.

In the present Table, the substances marked with an asterisk (*) are those of which the atomic weights are doubtful.

The symbol of each substance is the first letter of its Latin name ; where this is not sufficient to demonstrate it, the next letter or the next consonant is added.

Table III.—*Composition, Equivalents, and Symbols of Compound Substances.*

Remarks. This Table includes the more important compound substances. The number of atoms is stated of each element, with the weights of those atoms, and their sum, making up the equivalent * of the compound. The combinations are all regular ; but in some cases there is an apparent deviation, where the proportion of half of an atom is involved. The use of such an expression is merely for convenience : we may avoid it by doubling the proportions of each element, so that the compound of an atom of one body, with an atom and a-half of another, correctly stated, will be one of two atoms of the former, and three of the latter. But to do so would double the equivalent number ; and hence it is judged preferable to employ the expression of half an atom, this explanation being understood.

The symbolic formulæ are made up from the symbols of the elements : thus ammonia consists of three atoms of hydrogen and one of nitrogen, and its symbol is 3HN. Berzelius, who is followed by the German chemists, expresses the number of atoms in a different manner, the composition of Ammonia being stated thus, H^3N ; but as this kind of formula is opposed to the usual algebraic notation,

* In these pages I follow a rule, which I have been in the habit of observing in my lectures, to apply the term *atom* to the combining proportion of a simple body, the term *equivalent* to the combining proportion of a compound substance. The propriety of this rule is obvious ; for, if the term *atom* has any meaning, how can it be applied, for example, to morphia, which consists of sixty atoms of different elements ? By its definition an atom cannot be compound.

(converting what should be a coefficient into an exponent,) British chemists prefer placing the number which indicates the atoms immediately before the symbol of the body. Atoms of oxygen in a compound are denoted by points above the letters. Thus, $\dot{M}$ is Magnesia, $\dot{Zn}$ is Oxide of Zinc, $\ddot{Mo}$ Deutoxide of Molybdenum, $\dddot{S}$ Sulphuric Acid. The only compounds which it is difficult to express by symbols are those in which half an atom of oxygen is involved ; such, for example, as arsenic acid, which consists of an atom of arsenic, and $2\frac{1}{2}$ atoms of oxygen. We may double the proportions, and make the symbol $2\overset{\cdot\cdot\cdot\cdot\cdot}{As}$; but this would double the equivalent, making it 116, whereas it is commonly estimated at 58 : hence it is necessary to modify the symbol into $\frac{1}{2}(2\overset{\cdot\cdot\cdot\cdot\cdot}{As})$, a correct, though inelegant formula.

In the combinations of elements I shall merely place their symbols together, as in SH, (sulphuretted hydrogen) : in combinations of the second order, or where compounds unite with compounds, I shall interpose the sign of union + between the compounds, to prevent confusion.

The term aq. means an equivalent of water.

Substance.	*Composition.*		*Equivalent.*	*Symbol.*
Acid, arsenic,	1 Arsenic, $2\frac{1}{2}$ Oxygen,	38 20	58	$\frac{1}{2}(2\overset{\cdot\cdot\cdot\cdot\cdot}{As})$
arsenious,	1 Arsenic, $1\frac{1}{2}$ Oxygen,	38 12	50	$\frac{1}{2}(2\dddot{As})$
boracic,	1 Boron, 2 Oxygen,	8 16	24	$\ddot{B}$
crystallised, 2 aq.			42	$\ddot{B}$2aq.
bromic,	1 Bromine, 5 Oxygen,	80 40	120	$\overset{\cdot\cdot\cdot\cdot\cdot}{Br}$
carbonic,	1 Carbon, 2 Oxygen,	6 16	22	$\ddot{C}$
chloric,	1 Chlorine, 5 Oxygen,	36 40	76	$\overset{\cdot\cdot\cdot\cdot\cdot}{Cl}$
chromic,	1 Chrome, 3 Oxygen,	28 24	52	$\dddot{Cr}$
cyanic,	1 Cyanogen, 1 Oxygen,	26 8	34	$2\dot{CN}$
cyanuric,	$1\frac{1}{2}$ Cyanogen, $1\frac{1}{2}$ Hydrogen, 3 Oxygen,	39 1.5 24	64.5	$1\frac{1}{2}(2\ddot{CNH})$
ferro-cyanic,	3 Cyanogen, 1 Iron, 2 Hydrogen,	78 28 2	108	$3\overline{2CN}$ 2HFe
fluoric,	1 Fluorine, 1 Hydrogen,	18 1	19	HF
fluo-silicic,	1 Fluorine, 1 Silicium,	18 8	26	FSi
hydriodic,	1 Iodine, 1 Hydrogen,	124 1	125	HI
hydro-bromic,	1 Bromine, 1 Hydrogen,	80 1	81	HBr
hydro-cyanic,	1 Cyanogen, 1 Hydrogen,	26 1	27	H2CN

Substance.	*Composition.*		*Equivalent.*	*Symbol.*
Acid, hypo-nitrous,	1 Nitrogen,	14	36	$\overset{\cdot\cdot\cdot}{N}$
	3 Oxygen,	24		
hypo-phosphorous	2 Phosphorus,	32	40	$\overset{\cdot}{2P}$
	1 Oxygen,	8		
hypo-sulphurous,	1 Sulphur,	16	24	$\overset{\cdot\cdot}{2S}$
	1 Oxygen,	8		
hypo-sulphuric,	2 Sulphur,	32	72	$\overset{\cdot\cdot\cdot\cdot\cdot}{2S}$
	5 Oxygen,	40		
iodic,	1 Iodine,	124	164	$\overset{\cdot\cdot\cdot\cdot\cdot}{I}$
	5 Oxygen,	40		
manganesious or manganic,	1 Manganese,	28	52	$\overset{\cdot\cdot\cdot}{Mn}$
	3 Oxygen,	24		
manganesic or per-manganic,	1 Manganese,	28	56	$\frac{1}{2}(\overset{\cdot\cdot\cdot\cdot\cdot\cdot\cdot}{2Mn})$
	$3\frac{1}{2}$ Oxygen,	28		
muriatic,	1 Chlorine,	36	37	HCl
	1 Hydrogen,	1		
nitric,	1 Nitrogen,	14	54	$\overset{\cdot\cdot\cdot\cdot\cdot}{N}$
	5 Oxygen,	40		
liquid, (sp. gr. 1.5,) 2 aq.			72	$\overset{\cdot\cdot\cdot\cdot\cdot}{N}$ 2aq.
nitrous,	1 Nitrogen,	14	46	$\overset{\cdot\cdot\cdot}{N}$
	4 Oxygen,	32		
perchloric,	1 Chlorine,	36	92	$\overset{\cdot\cdot\cdot\cdot\cdot\cdot\cdot}{Cl}$
	7 Oxygen,	56		
phosphorous,	1 Phosphorus,	16	28	$\frac{1}{2}(\overset{\cdot\cdot\cdot}{2P})$
	$1\frac{1}{2}$ Oxygen,	12		
phosphoric and pyro-phosphoric,	1 Phosphorus,	16	36	$\frac{1}{2}(\overset{\cdot\cdot\cdot\cdot\cdot}{2P})$
	$2\frac{1}{2}$ Oxygen,	20		
selenious,	1 Selenium,	40	56	$\overset{\cdot\cdot}{Se}$
	2 Oxygen,	16		
selenic,	1 Selenium,	40	64	$\overset{\cdot\cdot\cdot}{Se}$
	3 Oxygen,	24		
sulpho-cyanic,	1 Cyanogen,	26	59	2CNH2S
	2 Sulphur,	32		
	1 Hydrogen,	1		
sulphovinic,	1 Sulphuric acid,	80	108	$\overset{\cdot\cdot\cdot}{2S}$4C4H
	2 Olefiant gas,	28		
sulphuric,	1 Sulphur,	16	40	$\overset{\cdot\cdot\cdot}{S}$
	3 Oxygen,	24		
liquid, (sp. gr. 1.85,) 1 aq.			49	$\overset{\cdot\cdot\cdot}{S}$1aq.
sulphurous,	1 Sulphur,	16	32	$\overset{\cdot\cdot}{S}$
	2 Oxygen,	16		
tungstic,	1 Tungsten,	100	124	$\overset{\cdot\cdot\cdot}{Tv}$
	3 Oxygen,	24		
Alumina,	1 Aluminum,	10	18	$\overset{\cdot}{A}$
	1 Oxygen,	8		
Ammonia,	1 Nitrogen,	14	17	3HN
	3 Hydrogen,	3		
Antimony, sesqui-chloride,	1 Antimony,	64	118	Sb$1\frac{1}{2}$Cl
	$1\frac{1}{2}$ Chlorine,	54		
perchloride,	1 Antimony,	64	154	Sb$2\frac{1}{2}$Cl
	$2\frac{1}{2}$ Chlorine,	90		
protoxide,	1 Antimony,	64	76	$\frac{1}{2}(\overset{\cdot\cdot\cdot}{2Sb})$
	$1\frac{1}{2}$ Oxygen,	12		
deutoxide, (antimonious acid,)	1 Antimony,	64	80	$\overset{\cdot\cdot}{Sb}$
	2 Oxygen,	16		

Substance.	*Composition.*		*Equivalent.*	*Symbol.*
Antimony, peroxide, (antimonic acid,)	1 Antimony, 2½ Oxygen,	64 20	84	½(2$\overset{\cdot\cdot\cdot\cdot\cdot}{\text{Sb}}$)
sesqui-sulphuret,	1 Antimony, 1½ Sulphur,	64 24	88	Sb1½S
persulphuret,	1 Antimony, 2½ Sulphur,	64 40	104	Sb2½S
Arsenic, deutoxide, (arsenious acid,)	1 Arsenic, 1½ Oxygen,	38 12	50	½(2$\overset{\cdot\cdot\cdot}{\text{As}}$)
sulphuret, (realgar,)	1 Arsenic, 1 Sulphur,	38 16	54	AsS
sesqui-sulphuret, (orpiment),	Arsenic, 1½ Sulphur,	38 24	62	As1½S
Barium, chloride,	1 Barium, 1 Chlorine,	68 36	104	BaC
oxide, (barytes,)	1 Barium, 1 Oxygen,	68 8	76	$\dot{\text{Ba}}$
peroxide,	1 Barium, 2 Oxygen,	68 16	84	$\ddot{\text{Ba}}$
sulphuret,	1 Barium, 1 Sulphur,	68 16	84	BaS
Barytes, hydrate, 1 aq.	1 Barytes, 1 aq.	76	85	$\dot{\text{Ba}}$1aq
crys. 20 aq.	1 Barytes, 20 aq.		256	$\dot{\text{Ba}}$20aq
Bismuth, chloride,	1 Bismuth, 1 Chlorine,	72 36	108	BiCl
oxide,	1 Bismuth, 1 Oxygen,	72 8	80	$\dot{\text{Bi}}$
Cadmium, chloride,	1 Cadmium, 1 Chlorine,	56 36	92	CdCl
oxide,	1 Cadmium, 1 Oxygen,	56 8	64	$\dot{\text{Cd}}$
Calcium, oxide, (lime,)	1 Calcium, 1 Oxygen,	20 8	28	$\dot{\text{Ca}}$
chloride,	1 Calcium, 1 Chlorine,	20 36	56	CaCl
sulphuret,	1 Calcium, 1 Sulphur,	20 16	36	CaS
Carbon, chloride,	1 Carbon, 1 Chlorine,	6 36	42	CCl
sesqui-chloride,	1 Carbon, 1½ Chlorine,	6 54	60	C1½Cl
di-chloride,	2 Carbon, 1 Chlorine,	12 36	48	2CCl
hydro-chloride, (chloric ether,)	1 Olefiant gas, 1 Chlorine,	14 36	50	Cl2C2H
hydriodide,	1 Olefiant gas, 1 Iodine,	14 124	138	I2C2H
hydruret, (paraffine,)	1 Carbon, 1 Hydrogen,	6 1	7	CH
bi-hydruret,	1 Carbon, 2 Hydrogen,	6 2	8	C2H
bi-sulphuret,	1 Carbon, 2 Sulphur,	6 32	38	C2S
Carbonic oxide,	1 Carbon, 1 Oxygen,	6 8	14	$\dot{\text{C}}$

Substance.	*Composition.*		*Equivalent.*	*Symbol.*
Cerium, oxide,	1 Cerium, 1 Oxygen,	46 8	54	$\dot{\mathrm{Ce}}$
peroxide,	1 Cerium, 1½ Oxygen,	46 12	58	½(2$\dddot{\mathrm{Ce}}$)
Chlorine, hydrate, 10 aq.	1 Chlorine, 36, 10 aq.		126	Cl10aq
oxide, (euchlorine,)	1 Chlorine, 1 Oxygen,	36 8	44	$\dot{\mathrm{Cl}}$
peroxide,	1 Chlorine, 4 Oxygen,	36 32	68	$\ddddot{\mathrm{Cl}}$
Chrome, sesqui-chloride,	1 Chrome, 1½ Chlorine,	28 54	82	Chr1½Cl
perchloride,	1 Chrome, 3 Chlorine,	28 108	136	Cr3Cl
terfluoride,	1 Chrome, 3 Fluorine,	28 54	82	Cr3F
oxide,	1 Chrome. 1½ Oxygen,	28 12	40	½(2$\dddot{\mathrm{Cr}}$)
Cobalt, oxide,	1 Cobalt, 1 Oxygen,	26 8	34	$\dot{\mathrm{Cb}}$
peroxide,	1 Cobalt, 1½ Oxygen,	26 12	38	½(2$\dddot{\mathrm{Cb}}$)
Columbium, oxide,	1 Columbium, 2 Oxygen,	182 16	198	$\ddot{\mathrm{Co}}$
peroxide, (columbic acid,)	1 Columbium, 3 Oxygen,	182 24	206	$\dddot{\mathrm{Co}}$
Copper, (32 Thomson,)			64	Cu
Chloride,	1 Copper, 1 Chlorine,	64 36	100	CuCl
bi-chloride,	1 Copper, 2 Chlorine,	64 74	136	Cu2Cl
protoxide,	1 Copper, 1 Oxygen,	64 8	72	$\dot{\mathrm{Cu}}$
peroxide,	1 Copper, 2 Oxygen,	64 16	80	$\ddot{\mathrm{Cu}}$
sulphuret,	1 Copper, 1 Sulphur,	64 16	80	CuS
bi-sulphuret,	1 Copper, 2 Sulphur,	64 32	96	Cu2S
Corrosive sublimate,	1 Mercury, 2 Chlorine,	200 72	272	HgCl
Cyanogen,	1 Nitrogen, 2 Carbon,	14 12	26	2CN
Euchlorine,	1 Chlorine, 1 Oxygen,	36 8	44	$\dot{\mathrm{Cl}}$
Glucina,	1 Glucinum, 1 Oxygen,	18 8	26	$\dot{\mathrm{G}}$
Gold, chloride,	1 Gold, 1 Chlorine,	200 36	236	AuCl
ter-chloride,	1 Gold, 3 Chlorine,	200 108	308	Au3Cl
oxide,	1 Gold, 1 Oxygen,	200 8	208	$\dot{\mathrm{Av}}$
ter-oxide,	1 Gold, 3 Oxygen,	200 24	224	$\dddot{\mathrm{Au}}$
Hydrogen, arseniuretted,	1 Arsenic, 1½ Hydrogen,	38 1.5	39.5	AsH

Substance.	*Composition.*		*Equivalent.*	*Symbol.*
Hydrogen, carburetted, (light,)	1 Carbon,	6	8	C2H
	2 Hydrogen,	2		
carburetted, (heavy olefiant gas,)	2 Carbon,	12	14	2C2H
	2 Hydrogen,	2		
ter-carburetted, (super-olefiant gas,)	3 Carbon,	18	21	3C3H
	3 Hydrogen,	3		
quadro-carburetted,	4 Carbon,	24	28	4C4H
	4 Hydrogen,	4		
sexto-carburetted (naphtha,)	6 Carbon,	36	42	6C6H
	6 Hydrogen,	6		
bi-carburet of,	2 Carbon,	12	15	2C3H
	3 Hydrogen,	3		
ter-carburet of, (naphthaline,)	3 Carbon,	18	19	3CH
	1 Hydrogen,	1		
deutoxide,	1 Hydrogen,	1	17	$\ddot{H}$
	2 Oxygen,	16		
phosphuretted & paraphosphuretted,	1 Phosphorus,	16	17.5	P$1\frac{1}{2}$H
	$1\frac{1}{2}$ Hydrogen,	1.5		
seleniuretted,	1 Selenium,	40	41	SeH
	1 Hydrogen,	1		
sulphuretted,	1 Sulphur,	16	17	SH
	1 Hydrogen,	1		
bi-sulphuretted,	2 Sulphur,	32	33	2SH
	1 Hydrogen,	1		
telluretted,	1 Tellurium,	32	33	TeH
	1 Hydrogen,	1		
Iron, chloride,	1 Iron,	28	64	FeCl
	1 Chlorine,	36		
perchloride,	1 Iron,	28	82	Fe$1\frac{1}{2}$Cl
	$1\frac{1}{2}$ Chlorine,	54		
oxide,	1 Iron,	28	36	$\dot{Fe}$
	1 Oxygen,	8		
peroxide,	1 Iron,	28	40	$\frac{1}{2}(2\dddot{Fe})$
	$1\frac{1}{2}$ Oxygen,	12		
iodide,	1 Iron,	28	152	FeI
	1 Iodine,	124		
sulphuret,	1 Iron,	28	44	FeS
	1 Sulphur,	16		
bisulphuret,	1 Iron,	28	60	Fe2S
	2 Sulphur,	32		
Lead, chloride,	1 Lead,	104	140	PbCl
	1 Chlorine,	36		
oxide, (massicot,)	1 Lead,	104	112	$\dot{Pb}$
	1 Oxygen,	8		
sesqui-oxide,	1 Lead,	104	116	$\frac{1}{2}(2\dddot{Pb})$
	$1\frac{1}{2}$ Oxygen,	12		
peroxide,	1 Lead,	104	120	$\ddot{Pb}$
	2 Oxygen,	16		
sulphuret,	1 Lead,	104	120	PbS
	1 Sulphur,	16		
Lithia,	1 Lithium,	6	14	$\dot{L}$
	1 Oxygen,	8		
Magnesia,	1 Magnesium,	12	20	$\dot{M}$
	1 Oxygen,	8		

Substance.	*Composition.*		*Equivalent.*	*Symbol.*
Magnesium, chloride,	1 Magnesium, 1 Chlorine,	12 36	48	MCl
Manganese, chloride,	1 Manganese, 1 Chlorine,	28 36	64	MnCl
protoxide,	1 Manganese, 1 Oxygen,	36 8	44	$\dot{\mathrm{Mn}}$
deutoxide,	1 Manganese, 1½ Oxygen,	36 12	48	$\frac{1}{2}(2\dddot{\mathrm{Mn}})$
red oxide,	3 Manganese, 4 Oxygen,	84 32	116	$3\ddddot{\mathrm{Mn}}$
varvicite,	4 Manganese, 7 Oxygen,	112 56	168	$4\overset{.\cdot.\cdot.\cdot.}{\mathrm{Mn}}$
peroxide,	1 Manganese, 2 Oxygen,	28 16	44	$\ddot{\mathrm{Mn}}$
Mercury, chloride, (calomel,)	1 Mercury, 1 Chlorine,	200 36	236	HgCl
bichloride, (corros. sub.)	1 Mercury, 2 Chlorine,	200 72	272	Hg2Cl
iodide,	1 Mercury, 1 Iodine,	200 124	324	HgI
per-iodide,	1 Mercury, 2 Iodine,	200 248	448	Hg2I
protoxide,	1 Mercury, 1 Oxygen,	200 8	208	$\dot{\mathrm{M}}$
peroxide,	1 Mercury, 2 Oxygen,	200 16	216	$\ddot{\mathrm{M}}$
sulphuret,	1 Mercury, 1 Sulphur,	200 16	216	MS
bisulphuret, (cinnabar,)	1 Mercury, 2 Sulphur,	200 32	232	M2S
Molybdenum, oxide,	1 Molybdenum, 1 Oxygen,	48 8	56	$\dot{\mathrm{Mo}}$
deutoxide,	1 Molybdenum, 2 Oxygen,	48 16	64	$\ddot{\mathrm{Mo}}$
peroxide, (molybdic acid,)	1 Molybdenum, 3 Oxygen,	48 24	72	$\dddot{\mathrm{Mo}}$
Naphtha,	6 Carbon, 6 Hydrogen,	36 6	42	6C6H
Nickel, oxide,	1 Nickel, 1 Oxygen,	26 8	34	$\dot{\mathrm{N}}$
sesqui-oxide,	1 Nickel, 1½ Oxygen,	26 12	38	$\frac{1}{2}(2\dddot{\mathrm{N}})$
Nitrogen, bi-carburet of, (cyanogen,)	2 Carbon, 1 Nitrogen,	12 14	26	2CN
chloride,	1 Nitrogen, 4 Chlorine,	14 144	158	N4Cl
oxide,	1 Nitrogen, 1 Oxygen,	14 8	22	$\dot{\mathrm{N}}$
deutoxide,	1 Nitrogen, 2 Oxygen,	14 16	30	$\ddot{\mathrm{N}}$
Olefiant gas,	2 Carbon, 2 Hydrogen,	12 2	14	2C2H
Oil of wine,	2 Sulphuric acid, 8 Carbon, 8 Hydrogen,	80 48 8	136	$2\dddot{\mathrm{S}}8\mathrm{C}8\mathrm{H}$

Substance.	*Composition.*		*Equivalent.*	*Symbol.*
Palladium, oxide,	1 Palladium, 1 Oxygen,	54 8	62	$\dot{\mathrm{Pd}}$
deutoxide,	1 Palladium, 2 Oxygen,	54 16	70	$\ddot{\mathrm{Pd}}$
Phosphorus, chloride,	1 Phosphorus, 1½ Chlorine,	16 54	70	P1½Cl
perchloride,	1 Phosphorus, 2½ Chlorine,	16 90	106	P2½Cl
Platinum, chloride,	1 Platinum, 1 Chlorine,	96 36	132	PtCl
bi-chloride,	1 Platinum, 2 Chlorine,	96 72	168	PtCl
oxide,	1 Platinum, 1 Oxygen,	96 8	104	$\dot{\mathrm{Pt}}$
peroxide,	1 Platinum, 2 Oxygen,	96 16	112	$\ddot{\mathrm{Pt}}$
Potassium, chloride,	1 Potassium, 1 Chlorine,	40 36	76	PoCl
iodide,	1 Potassium, 1 Iodine,	40 124	164	PoI
oxide, (potash,)	1 Potassium, 1 Oxygen,	40 8	48	$\dot{\mathrm{Po}}$
peroxide,	1 Potassium, 3 Oxygen,	40 24	64	$\dddot{\mathrm{Po}}$
sulphuret,	1 Potassium, 1 Sulphur,	40 16	56	PoS
Rhodium, oxide,	1 Rhodium, 1 Oxygen,	52 8	60	$\dot{\mathrm{R}}$
peroxide,	1 Rhodium, 1½ Oxygen,	52 12	64	½(2$\dddot{\mathrm{R}}$)
Selenium, oxide,	1 Selenium, 1 Oxygen,	40 8	48	$\dot{\mathrm{Se}}$
Silica,	1 Silicium, 1 Oxygen,	8 8	16	$\dot{\mathrm{Si}}$
Silver, chloride,	1 Silver, 1 Chlorine,	110 36	146	AgCl
iodide,	1 Silver, 1 Iodine,	110 124	234	AgI
oxide,	1 Silver, 1 Oxygen,	110 8	118	$\dot{\mathrm{Ag}}$
sulphuret,	1 Silver, 1 Sulphur,	110 16	126	AgS
Sodium, chloride,	1 Sodium, 1 Chlorine,	24 36	60	SoCl
iodide,	1 Sodium, 1 Iodine,	24 124	148	SoI
oxide,	1 Sodium, 1 Oxygen,	24 8	32	$\dot{\mathrm{So}}$
peroxide,	1 Sodium, 1½ Oxygen,	24 12	36	½(2$\dddot{\mathrm{So}}$)
sulphuret,	1 Sodium, 1 Sulphur,	24 16	40	SoS
Strontium, oxide (strontia,)	1 Strontium, 1 Oxygen,	44 8	52	$\dot{\mathrm{Sr}}$
Sulphur, chloride,	1 Sulphur, 1 Chlorine,	16 36	52	SCl

Substance.	*Composition.*		*Equivalent.*	*Symbol.*
Tellurium, chloride,	1 Tellurium, 1 Chlorine,	32 36	68	TeCl
bi-chloride,	1 Tellurium, 2 Chlorine,	32 72	104	Te2Cl
oxide,	1 Tellurium, 1 Oxygen,	32 8	40	$\dot{\text{Te}}$
peroxide, (acid,)	1 Tellurium, $1\frac{1}{2}$ Oxygen,	32 12	44	$\frac{1}{2}(2\dddot{\text{T}})$
Tin, chloride,	1 Tin, 1 Chlorine,	58 36	94	SnCl
bi-chloride,	1 Tin, 2 Chlorine,	58 72	130	Sn2Cl
oxide,	1 Tin, 1 Oxygen,	58 8	66	$\dot{\text{Sn}}$
peroxide,	1 Tin, 2 Oxygen,	58 16	74	$\ddot{\text{Sn}}$
sulphuret,	1 Tin, 1 Sulphur,	58 16	74	SnS
bi-sulphuret,	1 Tin, 2 Sulphur,	58 32	90	Sn2S
Titanium, oxide,	1 Titanium, 1 Oxygen,	26 8	34	$\dot{\text{Ti}}$
peroxide, (titanic acid,)	1 Titanium, 2 Oxygen,	26 16	42	$\ddot{\text{Ti}}$
Tungsten, oxide,	1 Tungsten, 2 Oxygen,	100 16	116	$\ddot{\text{Tu}}$
peroxide, (tungstic acid,)	1 Tungsten, 3 Oxygen,	100 24	124	$\dddot{\text{Tu}}$
Vanadium, bi-chloride,	1 Vanadium, 2 Chlorine,	68 72	140	V2Cl
ter-chloride,	1 Vanadium, 3 Chlorine,	68 108	176	V3Cl
oxide,	1 Vanadium, 1 Oxygen,	68 8	76	$\dot{\text{V}}$
deutoxide,	1 Vanadium, 2 Oxygen,	68 16	84	$\ddot{\text{V}}$
peroxide, (vanadic acid,)	1 Vanadium, 3 Oxygen,	68 24	92	$\dddot{\text{V}}$
Uranium, oxide,	1 Uranium, 1 Oxygen,	216 8	224	$\dot{\text{U}}$
peroxide,	1 Uranium, $1\frac{1}{2}$ Oxygen,	216 12	228	$\ddot{\text{U}}$
Water,	1 Hydrogen, 1 Oxygen,	1 8	9	$\dot{\text{H}}$
Yttria,	1 Yttrium, 1 Oxygen,	36 8	44	$\dot{\text{Y}}$
Zinc, chloride,	1 Zinc, 1 Chlorine,	34 36	70	ZnCl
oxide,	1 Zinc, 1 Oxygen,	34 8	42	$\dot{\text{Zn}}$
Zirconia,	1 Zirconium, 1 Oxygen,	22 8	30	$\dot{\text{Z}}$

TABLE IV.—*Composition, Equivalents, and Symbols of Salts.*

Remarks. In this Table the first column presents the name of the salt, the second the equivalent of the base, whatever it be, alkali, earth, or metallic oxide, the third the equivalent of the acid, the fourth the equivalent of water, the fifth the sum of these, or the equivalent of the salt, and the sixth its symbolic formula. In salts to which the terms *bi, ter, quadro* are prefixed, denoting that they contain two, three or four proportions of acid to one of base, the equivalent of acid is multiplied by those numbers. In the few instances of an opposite kind, where the terms *di, tris* are used to denote two or three proportions of base to one of acid, it is the equivalent of the base which is multiplied. In proto-salts the base is the protoxide of a metal ; in per-salts, it is the peroxide of the metal : thus, in the proto-sulphate of iron the base is the protoxide of iron, of which the equivalent is 36 ; in per-sulphate of iron it is peroxide of iron, of which the equivalent is 40.

In the symbolic formulæ the symbol of the base is placed first, and is connected by the sign + with the symbols of the acid, and the water of crystallization.

Salt.	*Base.*	*Acid.*	*Water, 1 eq.=9*	*Equiv. of Salt.*	*Symbol.*
Alumina, acetate, 1 aq.	18	51	9	78	$\dot{A}+(4\dddot{C}3H)$
sulphate,	18	40		58	$\dot{A}+\dddot{S}$
7 aq.	18	40	63	121	$\dot{A}+\dddot{S}+7$ aq.
sulph. of potash,	54+48	160		262	$3\dot{A}+\dot{Po}+4\dddot{S}$
sulph. of potash cryst. 25 aq. (alum.)	54+48	160	225	487	$3\dot{A}+Po+4\dddot{S}+25$ aq.
Ammonia, acetate,	17	51		68	$3HN+(4\dddot{C}3H)$
crystallized, 7 aq.	17	51	63	131	$3HN+(4\dddot{C}3H)7$ aq.
carbonate,	17	22		39	$3HN+\ddot{C}$
sesqui-carbonate, 1 aq.	17	33		50	$3HN+1\frac{1}{2}\ddot{C}+1$ aq.
bi-carbonate,	17	44		61	$3HN+2\ddot{C}$
1 aq.	17	44	9	70	$3HN+2\ddot{C}+1$ aq.
hydriodate,	17	125		142	$3HN+HI$
muriate,	17	37		54	$3HN+HCl$
nitrate,	17	54		71	$3HN+\overset{\cdot\cdot\cdot\cdot\cdot}{N}$
1 aq.	17	54	9	80	$3HN+\overset{\cdot\cdot\cdot\cdot\cdot}{N}+1$ aq.
oxalate, c. 2 aq.	17	36	18	7	$3HN+(2\dddot{C})+2$ aq.

Salt.	*Base.*	*Acid.*	*Water, 1 eq = 9*	*Equiv. of Salt.*	*Symbol.*
Ammonia, phosphate, 2 aq.	17	36	18	71	$3HN+\frac{1}{2}(2\overset{\cdot\cdot\cdot\cdot\cdot}{P})+2$ aq.
sulphate, 1 aq.	17	40	9	66	$3HN+\dddot{S}+1$ aq.
Antimony, tartrate of pot. (or tartar-emetic) 3 aq.	152+48	132	27	359	$2\dddot{Sb}+Po+2(\overset{\cdot\cdot\cdot\cdot\cdot\cdot}{4C2H})+$ 3aq.
Barytes, carbonate,	76	22		98	$\dot{Ba}+\ddot{C}$
chlorate,	76	76		152	$Ba+\overset{\cdot\cdot\cdot\cdot\cdot}{Cl}$
ferro-cyanate,	76	108		184	$\dot{Ba}+3,\overline{2CN}\ 2HFe$
hypo-sulphate, 2 aq.	76	72	18	166	$\dot{Ba}+2\overset{\cdot\cdot\cdot\cdot\cdot}{S}+2$ aq.
muriate, 1 aq.	76	37		113	$\dot{Ba}+HCl$
nitrate,	76	54		130	$\dot{Ba}+\overset{\cdot\cdot\cdot\cdot\cdot}{N}$
oxalate, 3 aq.	76	36	27	139	$\dot{Ba}+2\dddot{C}$
phosphate,	76	36		112	$\dot{Ba}+\frac{1}{2}(2\overset{\cdot\cdot\cdot\cdot\cdot}{P})$
sulphate,	76	40		116	$\dot{Ba}+\dddot{S}$
Bismuth, nitrate, c. 3 aq.	80	54	27	161	$\dot{Bi}+\overset{\cdot\cdot\cdot\cdot\cdot}{N}+3$ aq.
trisnitrate,	240	54		294	$3\dot{Bi}+\overset{\cdot\cdot\cdot\cdot\cdot}{N}$
tartrate, 5 aq.	80	66	45	191	$\dot{Bi}+(\overset{\cdot\cdot\cdot\cdot\cdot\cdot}{4C2H})+5$ aq.
Cadmium, carbonate,	64	22		86	$\dot{Cd}+\ddot{C}$
Cerium, sulphate, 3 aq.	54	40	27	121	$\dot{Ce}+\dddot{S}+3$ aq.
Cobalt, arseniate, 4 aq.	34	58	36	128	$\dot{Cb}+\frac{1}{2}(2\overset{\cdot\cdot\cdot\cdot\cdot}{AS})$
carbonate, 1 aq.	34	22	9	65	$\dot{Cb}+\ddot{C}+1$ aq.
muriate, 4 aq.	34	37	36	107	$\dot{Cb}+HCl+4$ aq.
nitrate, 6 aq.	34	54	54	142	$\dot{Cb}+\overset{\cdot\cdot\cdot\cdot\cdot}{N}+6$ aq.
sulphate, c. 7 aq.	34	40	63	137	$\dot{Cb}+\dddot{S}+7$ aq.
Copper, acetate,	80	51		131	$\ddot{Cu}+(\dddot{4C3H})$
c. 6 aq. (verdigris,)	80	51	54	185	$\ddot{Cu}+(\dddot{4C3H})+6$ aq.
binacetate, c. 3 aq. (distilled verdigris,)	80	102	27	209	$\ddot{Cu}+2(\dddot{4C3H})+3$ aq.
subacetate,	160	51		211	$2\ddot{Cu}+(\dddot{4C3H})$
carbonate,	80	22		102	$\ddot{Cu}+\ddot{C}$

Salt.	*Base.*	*Acid.*	*Water, 1 eq.=9*	*Equiv. of Salt.*	*Symbol.*
Copper, carbonate, 1 aq. (malachite,)	80	22	9	111	$\overset{\cdot\cdot}{Cu}+\overset{\cdot\cdot}{C}+1$ aq.
nitrate, c. 7 aq.	80	54	63	197	$\overset{\cdot\cdot}{Cu}+\overset{\cdot\cdot\cdot\cdot\cdot}{N}+7$ aq.
binitrate, c. 7 aq.	80	108	63	251	$\overset{\cdot\cdot}{Cu}+2\overset{\cdot\cdot\cdot\cdot\cdot}{N}+7$ aq.
subnitrate, (1 acid, 4 base,)	320	54		374	$4\overset{\cdot\cdot}{Cu}+\overset{\cdot\cdot\cdot\cdot\cdot}{N}$
phosphate,	80	36		116	$\overset{\cdot\cdot}{Cu}+\frac{1}{2}(2\overset{\cdot\cdot\cdot\cdot\cdot}{P})$
bi-sulphate,	80	80		160	$\overset{\cdot\cdot}{Cu}+2\overset{\cdot\cdot\cdot}{S}$
c. 10 aq. (blue vitriol,)	80	80	90	250	$\overset{\cdot\cdot}{Cu}+2\overset{\cdot\cdot\cdot}{S}+10$ aq.
Glucine, sulphate,	18	40		58	$\dot{G}+\overset{\cdot\cdot\cdot}{S}$
bi-sulphate, 5 aq.	18	80	45	103	$\dot{G}+2\overset{\cdot\cdot\cdot}{S}+5$ aq.
Iron, carbonate,	36	22		58	$\dot{Fe}+\overset{\cdot\cdot}{C}$
muriate, 3 aq.	36	37	27	110	$\dot{Fe}+HCl+3$ aq.
nitrate, c. 7 aq.	36	54	63	153	$\dot{Fe}+\overset{\cdot\cdot\cdot\cdot\cdot}{N}+7$ aq.
sesqui-pernitrate, 8 aq.	40	81	72	193	$\frac{1}{2}(2\overset{\cdot\cdot}{Fe}+1\frac{1}{2}\overset{\cdot\cdot\cdot\cdot\cdot}{N}+8$ aq.
per-succinate,	40	50		90	$\frac{1}{2}(2\overset{\cdot\cdot}{Fe})+(4\overset{\cdot\cdot\cdot}{C}2H)$
sulphate,	36	40		76	$\dot{Fe}+\overset{\cdot\cdot\cdot}{S}$
c. 7 aq. (green vitriol,)	36	40	63	139	$\dot{Fe}+\overset{\cdot\cdot\cdot}{S}+7$ aq.
sesqui-persulphate,	40	60		100	$\frac{1}{2}(2\overset{\cdot\cdot\cdot}{Fe})+1\frac{1}{2}\overset{\cdot\cdot\cdot}{S}$
Lead, acetate, c. 3 aq.	112	51	27	190	$Pb+(4\overset{\cdot\cdot\cdot}{C}3H)+3$ aq.
diacetate,	224	51		275	$2\dot{Pb}+(4\overset{\cdot\cdot\cdot}{C}3H)$
trisacetate, (Goulard's extract,)	336	51		387	$3\dot{Pb}+(4\overset{\cdot\cdot\cdot}{C}3H)$
carbonate,	112	22		134	$\dot{Pb}+\overset{\cdot\cdot}{C}$
chromate,	112	52		164	$\dot{Pb}+\overset{\cdot\cdot\cdot}{Cr}$
sub-chromate,	224	52		276	$2Pb+\overset{\cdot\cdot\cdot}{Cr}$
nitrate,	112	54		166	$\dot{Pb}+\overset{\cdot\cdot\cdot\cdot\cdot}{N}$
sulphate,	112	40		152	$\dot{Pb}+\overset{\cdot\cdot\cdot}{S}$
Lime, acetate,	28	51		79	$\dot{Ca}+(4\overset{\cdot\cdot\cdot}{C}3H)$

Salt.	*Base.*	*Acid.*	*Water, 1 eq.=9*	*Equiv. of Salt.*	*Symbol.*
Lime, 6 aq.	28	51	54	133	$\dot{Ca}+(4\overset{\cdots}{C3H})+6$ aq.
carbonate,	28	22		50	$\dot{Ca}+\ddot{C}$
chloride,	28	36		64	$\dot{Ca}+Cl$
di-chloride, 6 aq.	56	36	54	146	$2\dot{Ca}+Cl+6$ aq.
citrate,	28	58		86	$\dot{Ca}+(4\overset{\cdot\cdot\cdot\cdot}{C2H})$
hypo-sulphite,	28	48		76	$\dot{Ca}+2\ddot{S}$
muriate, c. 6 aq.	28	37	54	119	$\dot{Ca}+HCl+6$ aq.
nitrate, 3 aq.	28	54	27	109	$\dot{Ca}+\overset{\cdot\because\cdot}{N}+3$ aq.
oxalate,	28	36		64	$\dot{Ca}+2\dddot{C}$
2 aq.	28	36	18	82	$\dot{Ca}+2\dddot{C}+2$ aq.
phosphate,	28	36		58	$\dot{Ca}+\frac{1}{2}(2\overset{\cdot\because\cdot}{P})$
sulphate,	28	40		68	$\dot{Ca}+\dddot{S}$
c. 2 aq.	28	40	18	86	$\dot{Ca}+\dddot{S}+2$ aq.
tartrate, 4 aq.	28	66	36	120	$\dot{Ca}+(4\overset{\cdot\cdot\cdot\cdot\cdot}{C2H})$
tungstate,	28	124		152	$\dot{Ca}+\dddot{Tu}$
Lithia, carbonate,	14	22		36	$\dot{L}+\ddot{C}$
sulphate, 1 aq.	14	40	9	63	$\dot{L}+\dddot{S}+1$ aq.
Magnesia, carbonate,	20	22		42	$\dot{M}+\ddot{C}$
c. 3 aq.	20	22	27	69	$\dot{M}+\ddot{C}+3$ aq.
muriate,	20	37		57	$\dot{M}+HCl$
c. 5 aq.	20	37	45	102	$\dot{M}+HCl+5$ aq.
nitrate, c. 6 aq.	20	54	54	128	$\dot{M}+\overset{\cdot\because\cdot}{N}+6$ aq.
oxalate,	20	36		56	$\dot{M}+2\dddot{C}$
phosphate,	20	36		56	$\dot{M}+\frac{1}{2}(2\overset{\cdot\because\cdot}{P})$
c. 7 aq.	20	36	63	119	$\dot{M}+\frac{1}{2}(2\overset{\cdot\because\cdot}{P})+7$ aq.
phosphate of ammonia, and	20+17	72		109	$\dot{M}+3HN+2\overset{\cdot\because\cdot}{P}$
sulphate,	20	40		60	$\dot{M}+\dddot{S}$

Salt.	*Base.*	*Acid.*	*Water, 1 eq.=9*	*Equiv. of Salt.*	*Symbol.*
Magnesia, sulphate, c. 7 aq.	20	40	63	123	$\dot{M}+\dddot{S}+7$ aq.
Manganese, carbonate,	36	22		58	$\dot{Mn}+\ddot{C}$
c. 2 aq.	36	22	18	76	$\dot{Mn}+\ddot{C}+2$ aq.
muriate, c. 4 aq.	36	37	36	109	$\dot{Mn}+HCl+4$ aq.
nitrate, c. 7 aq.	36	54	63	153	$\dot{Mn}+\overset{\cdot\cdot\cdot\cdot\cdot}{N}+7$ aq.
sulphate,	36	40		76	$\dot{Mn}+\dddot{S}$
c. 5 aq.	36	40	45	121	$Mn+\dddot{S}+5$ aq.
Mercury, acetate, 4 aq.	208	51	36	295	$\dot{Hg}+(4\dddot{C}3H)+4$ aq.
chlorate,	208	76		284	$\dot{Hg}+\overset{\cdot\cdot\cdot\cdot\cdot}{Cl}$
chromate,	208	52		260	$\dot{Hg}+\dddot{Cr}$
proto-nitrate, 2 aq.	208	54	18	280	$\dot{Hg}+\overset{\cdot\cdot\cdot\cdot\cdot}{N}+2$ aq.
per-nitrate,	216	54		270	$\ddot{Hg}+\overset{\cdot\cdot\cdot\cdot\cdot}{N}$
proto-sulphate,	208	40		248	$\dot{Hg}+\dddot{S}$
c. 2 aq.	208	40	18	266	$\dot{Hg}+\dddot{S}+2$ aq.
bi-persulphate,	216	80		296	$\ddot{Hg}+2\dddot{S}$
c. 1 aq.	216	80	9	305	$\ddot{Hg}+2\dddot{S}+1$ aq.
Nickel, muriate, 5 aq.	34	37	45	116	$\dot{Ni}+HCl+5$ aq.
nitrate, 5 aq.	34	54	45	133	$\dot{Ni}+\overset{\cdot\cdot\cdot\cdot\cdot}{N}+5$ aq.
Potash, acetate,	48	51		99	$\dot{Po}+(4\dddot{C}3H)$
binacetate, c. 6 aq.	48	102	54	204	$\dot{Po}+2(4\dddot{C}3H)+6$ aq.
arseniate,	48	58		106	$\dot{Po}+\frac{1}{2}(2\overset{\cdot\cdot\cdot\cdot\cdot}{As})$
binarseniate, c. 1 aq.	48	116	9	163	$\dot{Po}+2\overset{\cdot\cdot\cdot\cdot\cdot}{As}+1$ aq.
arsenite,	48	50		138	$\dot{Po}+\frac{1}{2}(2\dddot{As})$
benzoate,	48	120		168	$\dot{Po}+(15\dddot{C}6H)$
c. 3 aq.	48	120	27	195	$\dot{Po}+(15\dddot{C}6H)+3$ aq.
carbonate,	48	22		70	$\dot{Po}+\ddot{C}$
c. 2 aq.	48	22	18	88	$\dot{Po}+\ddot{C}+2$ aq.
bi-carbonate,	48	44		92	$\dot{Po}+2\ddot{C}$

Salt.	*Base.*	*Acid.*	*Water, 1 eq=9*	*Equiv. of Salt.*	*Symbol.*
Potash, bi-carbonate, c. 1 aq.	48	44	9	101	$\dot{Po}+2\ddot{C}+1$ aq.
chlorate,	48	76		124	$\dot{Po}+\overset{\cdot\cdot\cdot\cdot\cdot}{Cl}$
chromate,	48	52		100	$\dot{Po}+\dddot{Cr}$
bi-chromate,	48	104		152	$\dot{Po}+2\dddot{Cr}$
citrate,	48	58		106	$\dot{Po}+(\overset{\cdot\cdot\cdot\cdot}{4C2H})$
ferro-cyanate, 1 aq.	96	108	9	213	$2Po+3(\overline{2CN2}HFe)$
hydriodate,	48	125		273	$\dot{Po}+HI$
hydro-bromate,	48	81		129	$\dot{Po}+HBr$
iodate,	48	164		212	$\dot{Po}+\overset{\cdot\cdot\cdot\cdot\cdot}{I}$
nitrate, (nitre,)	48	54		102	$\dot{Po}+\overset{\cdot\cdot\cdot\cdot\cdot}{N}$
oxalate, c. 1 aq.	48	36	9	93	$\dot{Po}+2\dddot{C}+1$ aq.
binoxalate, c. 2 aq.	48	72	18	138	$\dot{Po}+2(2\dddot{C}+2$ aq.
quadroxalate, c. 7 aq.	48	144	63	255	$\dot{Po}+4(2\dddot{C})+7$ aq.
per-chlorate,	48	89		140	$\dot{Po}+\overset{\cdot\cdot\cdot\cdot\cdot\cdot\cdot}{Cl}$
phosphate, c. 1 aq.	48	36	9	93	$\dot{Po}+\frac{1}{2}(2\overset{\cdot\cdot\cdot\cdot\cdot}{P})+1$ aq.
sulphate,	48	40		88	$\dot{Po}+\dddot{S}$
bi-sulphate, c. 2 aq.	48	80	18	146	$\dot{Po}+2\dddot{S}+2$ aq.
tartrate, c. 2 aq.	48	66	18	122	$\dot{Po}+(\overset{\cdot\cdot\cdot\cdot\cdot}{4C2H})+2$ aq.
bi-tartrate, c. 2 aq. (cream of tartar,)	48	132	18	198	$\dot{Po}+2(\overset{\cdot\cdot\cdot\cdot\cdot}{4C2H})+2$ aq.
Quinia, disulphate? + 4 aq.	344	40	36	420	$2(21\frac{1}{2}C16HN)+\dddot{S}+4$aq
Silver, arsenite,	118	50		168	$\dot{Ag}+\frac{1}{2}(2\dddot{AS})$
nitrate, (lunar caustic,)	118	54		172	$\dot{Ag}+\overset{\cdot\cdot\cdot\cdot\cdot}{N}$
Soda, acetate, c. 6 aq.	32	51	54	137	$\dot{So}+(4C3H)+6$ aq.
bi-borate, (borax,)	32	48		80	$\dot{So}+2\ddot{B}$
carbonate, c. 10. aq.	32	22	90	144	$\dot{So}+\ddot{C}+10$ aq.
sesqui-carbonate, c. 2 aq.	32	33	18	83	$\dot{So}+1\frac{1}{2}\ddot{C}+2$ aq.

Salt.	*Base.*	*Acid.*	*Water, 1 eq.=9*	*Equiv. of Salt.*	*Symbol.*
Soda, bi-carbonate, c. 1 aq.	32	44	9	85	$\dot{So}+2\ddot{C}+1$ aq.
nitrate,	32	54		86	$\dot{So}+\overset{\cdot\cdot\cdot\cdot\cdot}{N}$
phosphate, c. 12 aq.	32	36	108	176	$\dot{So}+\frac{1}{2}(2\overset{\cdot\cdot\cdot\cdot\cdot}{P})$
sulphate, c. 10 aq.	32	40	90	162	$\dot{So}+\dddot{S}+10$ aq.
tartrate of potash, and 8 aq. (Rochelle salt,)	32+48	132	72	284	$\dot{So}+\dot{Po}+2(\overset{\cdot\cdot\cdot\cdot\cdot}{4C2H})+8$aq.
urate, 1 aq.	32	72	9	113	$\dot{Po}+(\overset{\cdot}{6C2N})+1$ aq.
Strontites, carbonate,	52	22		74	$\dot{Sr}+\ddot{C}$
muriate, c. 5 aq.	52	37	45	134	$\dot{Sr}+HCl+5$ aq.
nitrate,	52	54		106	$\dot{Sr}+\overset{\cdot\cdot\cdot\cdot\cdot}{N}$
sulphate,	52	40		92	$\dot{Sr}+\dddot{S}$
Tin, bi-permuriate, 3 aq.	74	74	27	175	$\ddot{Sn}+2HCl+3$ aq.
Uranium, sesqui-pernitrate,	228	81		309	$\dddot{U}+1\frac{1}{2}\overset{\cdot\cdot\cdot\cdot\cdot}{N}$
sesqui-persulphate, 4 aq.	228	60	36	324	$\dddot{U}+1\frac{1}{2}\dddot{S}$
Zinc, acetate, c. 7 aq.	42	51	63	156	$\dot{Zn}+(4\overset{\cdot\cdot\cdot}{C3H})+7$ aq.
carbonate, 1 aq.	42	22	9	73	$\dot{Zn}+\ddot{C}+1$ aq.
muriate,	42	37		79	$\dot{Zn}+HCl$
sulphate, c. 7 aq. (white vitriol,)	42	40	63	145	$\dot{Zn}+\dddot{S}+7$ aq.

Remarks. The four following Tables exhibit the composition of the chief products of the vegetable and animal kingdoms.

In Table V. there are placed, first, some principles in which the oxygen and hydrogen are in the proportion constituting water; namely, an atom of the one to each atom of the other, and those principles are neither acid nor volatile. Next are principles that contain an excess of hydrogen, and which are accordingly volatile and highly inflammable, of an oily, resinous, or spirituous nature.

Table VI. includes the chief vegetable acids, in most of which oxygen is in excess. They are placed in the order of the degree of oxygenation, which also marks, pretty nearly, their comparative energy. The principle named Tannin is closely allied with these, in containing an excess of oxygen as well as in properties.

Table VII. exhibits the complicated constitution of the vegetable alkalies. All of these contain nitrogen as an element. Their atomic composition has been only of late investigated, and is still doubtful.

Table VIII. includes the chief animal products. Most of these contain nitrogen, and are also very complex in their atomic constitution. Gelatin, Albumen, and Fibrin are the three principal constituents of the animal body.

TABLE V.—*Composition of Vegetable Principles.*

Substance.	*Carbon.*	*Oxygen.*	*Hydrogen.*	*Equiv.*	*Symbol.*
Sugar, -	3 atoms = 18	3 atoms = 24	3 atoms = 3	45	$(3\dddot{C}3H)$
Starch, -	6 —— = 36	6 —— = 48	6 —— = 6	90	$(6\overset{\cdot\cdot\cdot\cdot\cdot\cdot}{C}6H)$
Gum, -	6 —— = 36	6 —— = 48	6 —— = 6	90	$(6\overset{\cdot\cdot\cdot\cdot\cdot\cdot}{C}6H)$
Lignin, -	7 —— = 42	4 —— = 32	4 —— = 4	78	$(7\ddddot{C}4H)$
Wax, -	13 —— = 78	1 —— = 8	12 —— = 12	97	$(13\dot{C}12H)$
Fixed oil, -	10 —— = 60	1 —— = 8	11 —— = 11	79	$(10\dot{C}11H)$
Oil of turpentine,	14 —— = 84	1 —— = 8	10 —— = 10	102	$(14\dot{C}10H)$
Camphor, -	10 —— = 60	1 —— = 8	9 —— = 9	77	$(10\dot{C}9H)$
Resin, -	8 —— = 48	1 —— = 8	7 —— = 7	63	$(8\dot{C}7H)$
Ether, -	4 —— = 24	1 —— = 8	5 —— = 5	37	$(4\dot{C}5H)$
Alcohol, -	2 —— = 12	1 —— = 8	3 —— = 3	23	$(2\dot{C}3H)$
Pyro-acetic spirit,	3 —— = 18	1 —— = 8	3 —— = 3	29	$(3\dot{C}3H)$
Pyroxilic spirit,	6 —— = 36	4 —— = 32	7 —— = 7	75	$(6\ddddot{C}7H)$

Table VI.—*Composition of Vegetable Acids.*

Acid.	*Carbon.*	*Oxygen.*	*Hydrogen.*	*Eq.*	*Symbol*
Oxalic Acid,	2 atoms =12	3 atoms =24		36	2C
Croconic Acid,	5 —— =30	4 —— =32		62	5C
Mellitic Acid,	4 —— =24	3 —— =24		48	4C
Formic Acid,	2 —— =12	3 —— =24	1 atom =1	37	2CH
Tartaric Acid,	4 —— =24	5 —— =40	2 —— =2	66	4C2H
Saccholactic Acid,	6 —— =36	8 —— =64	5 —— =5	105	6C5H
Citric Acid,	4 —— =24	4 —— =32	2 —— =2	58	4C2H
Malic Acid,	4 —— =24	4 —— =32	3 —— =3	59	4C3H
—— —— (Liebig,)	4 —— =24	4 —— =32	1 —— =1	57	4CH
Succinic Acid,	4 —— =24	3 —— =24	2 —— =2	50	4C2H
Acetic Acid,	4 —— =24	3 —— =24	3 —— =3	51	4C3H
Gallic Acid,	6 —— =36	3 —— =24	3 —— =3	63	6C3H
Benzoic Acid,	15 —— =90	3 —— =24	6 —— =6	120	15C6H
—— —— (Berzelius,)	14 —— =84	3 —— =24	5 —— =5	113	14C5H
Tannin,	6 —— =36	4 —— =32	3 —— =3	71	6C3H

Table VII.—*Composition of Vegetable Alkalies.*

Alkali.	*Carbon.*	*Oxygen.*	*Hydrogen.*	*Nitrogen.*	*Eq.*	*Symbol.*
Cinchonia,	21 at. =126	1 at. = 8	11 at. =11	1 at. =14	159	21C11HN
Quinia,	21½ — =129	2 — =16	12 — =12	1 — =14	172	21½C12HN
Strychnia,	30½ — =183	3 — =24	16 — =16	1 — =14	237	30½C16HN
Brucia,	33 — =198	6 — =48	18 — =18	1 — =14	278	33C18HN
Morphia,	35 — =210	6 — =48	18 — =18	1 — =14	290	35C18HN
Veratria,	26 — =156	7 — =56	24 — =24	1 — =14	250	26C24HN
Emetia,	37½ — =225	10 — =80	27 — =27	1 — =14	346	37½C27HN

Table VIII.—*Composition of Animal Principles.*

	Carbon.	Oxygen.	Hydrogen.	Nitrogen.	Eq.	Symbol.
Gelatin,	15 at. = 90	6 at. =48	14 at. =14	2 at. =28	180	15C14H2N
Albumen,	17 — =102	6 — =48	13 — =13	2 — =28	191	17C13H2N
Fibrin,	18 — =108	5 — =40	14 — =14	3 — =42	204	18C14H3N
Urea,	1 — = 6	1 — = 8	2 — = 2	1 — =14	30	C2HN
Pyro-uric acid,	2 — = 12	2 — =16	1 — = 1	1 — =14	43	2CHN
Uric acid,	6 — = 36	1 — = 8		2 — =28	72	6C2N
Picromel,	5 — = 30	3 — =24		1 — =14	68	5CN
Oil, train,	12 — = 72	2 — =16	17 — =17		105	12C17H
—— sperm,	10 — = 60	1 — = 8	9 — = 9		77	10C9H

Table IX.—*Specific Gravities of Gases and Vapours, stated in reference to the specific gravities of Hydrogen Gas and of Atmospheric Air.*

Remarks. There is no principle more clearly established in chemistry than this, that gases combine in simple proportions, estimated by volume. Hydrogen gas, for example, combines with chlorine in the proportion of equal volumes; a cubic inch of the one just saturates a cubic inch of the other: other gases unite in proportions of one volume or measure of the one, to one, two, three or more volumes of the other; but in all cases the combining proportions by volume are precise and simple. This will be apparent from examination of the diagrams that follow this table, in which the constitution of compound gases is developed.

But we also know that the combinations of substances are in the proportions indicated by their atomic weights: that hydrogen, for instance, combines with chlorine in the proportion, by weight, of 1 part of hydrogen to 36 parts of chlorine.

Consequently the volumes of gases must have relative weights, the same with the weights of their atoms; and thus we arrive at the conclusion, first deduced by Dr Prout, that the specific gravities of gases are proportional to their atomic weights, that the specific gravity of chlorine gas, for example, will be 36 times that of hydrogen gas, the atom of chlorine being 36 times heavier than that of hydrogen, and such it is found to be by experiment.

This principle has received greater extension, by supposing, that when solid bodies unite with gases, forming gaseous compounds, the solid bodies are to be regarded as assuming the state of vapour, and in that condition unite with the gases in the simple proportions, by volume, in which gases unite with each other.

Hence, from the atomic weight of a solid substance we can infer the specific gravity of its vapour: thus, the atomic weight of sulphur is 16 times that of hydrogen; whence, we infer, that the vapour of sulphur will be 16 times heavier than hydrogen gas, and when hydrogen and sulphur combine, that their compound will have a specific gravity of $16 + 1 = 17$ times that of hydrogen gas. And such is the case, the density of sulphuretted hydrogen gas being exactly 17 times that of hydrogen gas.

This highly interesting relation has not been generally appreciated, from the specific gravities of gases being commonly stated in reference to atmospheric air. To exhibit it in a distinct manner, I have, in the following Table, given a column of the specific gravities of gases and vapours in comparison with that of hydrogen gas, and when thus stated, the relation is obvious.

The general truth is, with respect to *simple* gases and vapours, that their specific gravities are exactly proportional to their atomic weights. There is only one exception, and that is in the case of oxygen gas, of which the atom is 8 times, while its density is 16 times that of hydrogen gas. We can account for this only by supposing that oxygen gas contains twice as many atoms in the same volume as any other simple gas.

With regard to *compound* gases the same rule is in most cases just: two gases, when they unite, are condensed into the bulk of one, and the density of the compound is the sum of the densities of the elements, as its atomic weight is the sum of their atoms. But in some instances the degree of condensation is less or greater, and affects the density. In the following gases, nitric oxide, prussic acid, muriatic acid, chloro-cyanic acid, hydriodic acid, hydrobromic acid, ammonia, the degree of condensation is only one-half of what it usually is, and their specific gravities are half of what the rule would assign. On the other hand, in fluosilicic acid the condensation of the elements appears to be twice as great, and its density therefore double what the rule would indicate.

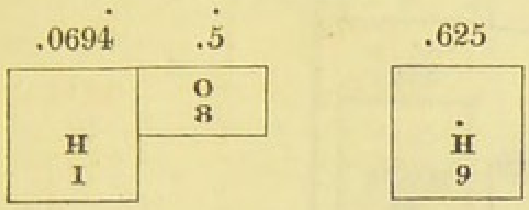
The specific gravity of atmospheric air has lately been ascertained with great care by Dr Prout; and it is in conformity to the result which he obtained, that the last column of the table, shewing the weight of 100 cubic inches of each elastic fluid, has been calculated. The gases and the *vapours, when in combination*, are understood to be at the temperature of 60°; but if uncombined, the vapours are supposed to be at the temperature at which they are given off in ebullition.

In the diagrams that follow, each square space indicates at once a volume and an atom of the aërial fluid, excepting in the case of oxygen, an atom of which is represented by half a volume, as has just been explained. The degree of condensation, the densities, the atomic weights and symbols, are shewn in each diagram.

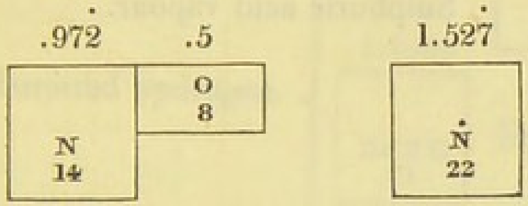
Gas or vapour.	*Equi.*	*Sp. gr. of hyd. gas* = 1.	*Sp. gr. of air* = 1.	*Weight of* 100 *cubic inches in grains.*
Hydrogen, -	1	1	0.0694̇	2.1536
Carbon vapour, -	6	6	0.41̇6	12.92
Bi-hydruret of carbon,	8	8	0.5̇	17.23
Ammonia, -	17	$8\frac{1}{2}$	0.5902̇7	18.3
Watery vapour, -	9	9	0.625	19.38

Gas or vapour.	*Equi.*	*Sp. gr. of hyd. gas = 1.*	*Sp. gr. of air = 1.*	*Weight of 100 cubic inches in grains.*
Prussic acid vapour,	27	13½	0.937$\dot{4}$	29.07
Carbonic oxide,	14	14	0.97$\dot{2}$	30.15
Nitrogen, -	14	14	0.97$\dot{2}$	30.15
Olefiant gas, -	14	14	0.97$\dot{2}$	30.15
Atmospheric air,		14.39	1.	31.0117
Nitric oxide, -	30	15	1.041$\dot{6}$	32.3
Oxygen, -	16	16	1.$\dot{1}$	34.45
Sulphur vapour, -	16	16	1.$\dot{1}$	34.45
Phosphorus vapour,	16	16	1.$\dot{1}$	34.45
Sulphuretted hydrogen,	17	17	1.180$\dot{5}$	36.61
Muriatic acid, -	37	18½	1.2847$\dot{2}$	39.84
Super-olefiant gas, -	21	21	1.458$\dot{3}$	45.22
Carbonic acid, -	22	22	1.52$\dot{7}$	47.37
Nitrous oxide, -	22	22	1.52$\dot{7}$	47.37
Alcohol vapour, -	23	23	1.5927$\dot{2}$	49.53
Cyanogen, -	26	26	1.80$\dot{5}$	55.99
Sulphurous acid, -	32	32	2.$\dot{2}$	68.9
Euchlorine, -	44	35⅓	2.$\dot{4}$	75.8
Chlorine, -	36	36	2.5	77.5
Ether, - -	37	37	2.569$\dot{4}$	79.68
Arsenic vapour, -	38	38	2.63$\dot{8}$	81.83
Bi-sulphuret of carbon,	38	38	2.63$\dot{8}$	81.83
Sulphuric acid vapour,	40	40	2.$\dot{7}$	86.14
Fluo-silicic acid, -	26	52	3.61	111.98
Nitric acid vapour,	54	54	3.75	116.29
Hydriodic acid vapour,	125	62½	4.34	134.6
Iodine vapour,	124	124	8.61	267.04

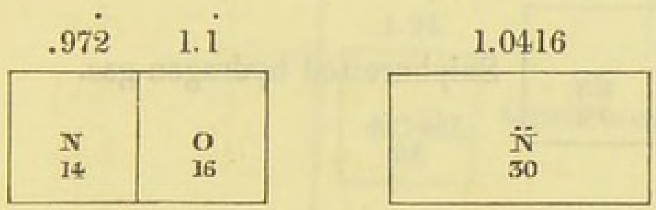
Table X.—*Composition of Gases and Vapours by volume, shewing the degree of condensation, the specific gravities, and equivalents.*



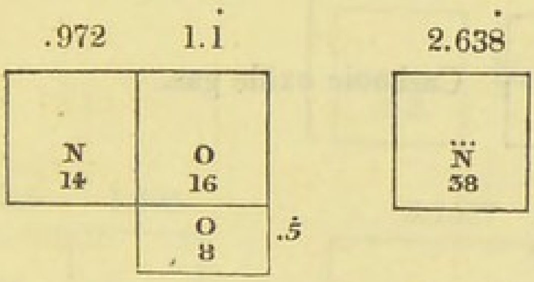
Watery vapour.



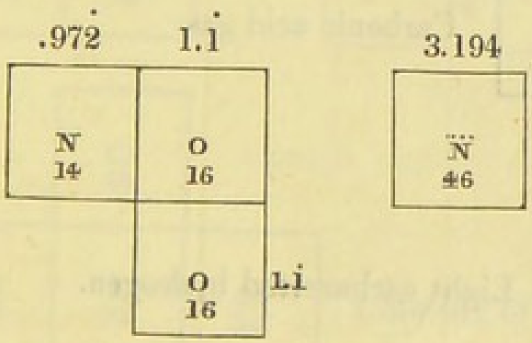
Nitrous oxide gas.



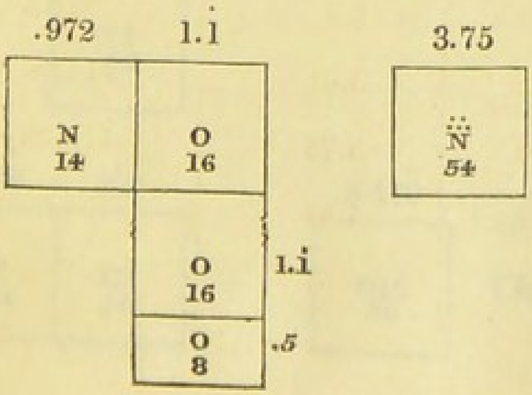
Nitric oxide gas.



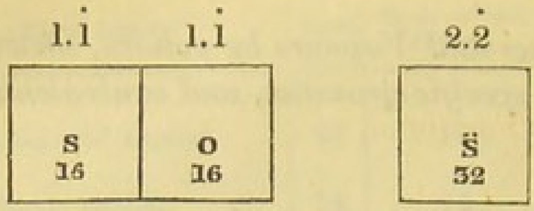
Hypo-nitrous acid vapour.



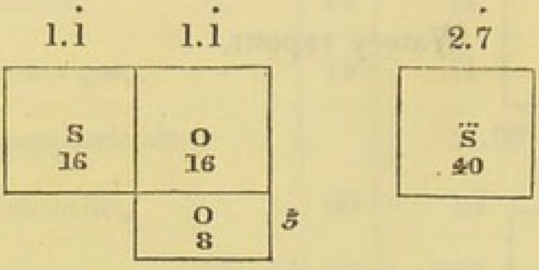
Nitrous acid vapour.



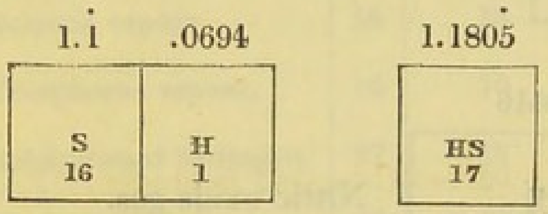
Nitric acid vapour.



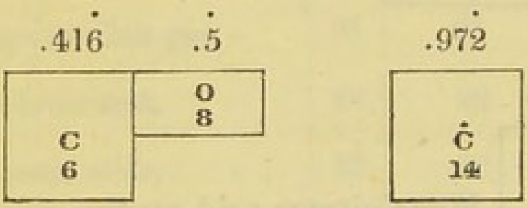
Sulphurous acid gas.



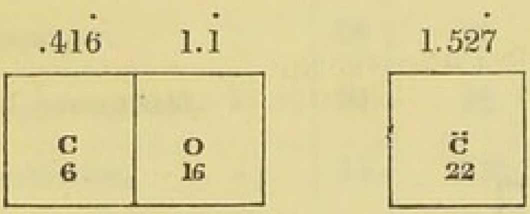
Sulphuric acid vapour.



Sulphuretted hydrogen gas.

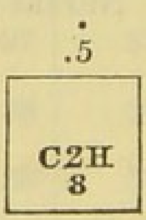


Carbonic oxide gas.



Carbonic acid gas.

Bi-hydruret of carbon.



Light carburetted hydrogen.

Carburetted hydrogen.

.4861	CH	7	Paraffine?
.972	2C2H	14	Olefiant gas.
1.4583	3C3H	21	Super-olefiant gas.
1.94	4C4H	28	Quadro-carburetted hydrogen.
2.916	6C6H	42	Naphtha vapour.

2.5	1.805		2.1527	
Cl 36	2CN 26		Cl2CN 62	Chloride of cyanogen.

	Cl 36		
Cl 36	N 14	Cl 36	Chloride of nitrogen.
	Cl 36		

.972	2.5		3.472	
Ċ 14	Cl 36		ClĊ 50	Chloro-carbonic acid gas.

8.61	.0694		4.34027	
I 124	H 1		HI 125	Hydriodic acid gas.

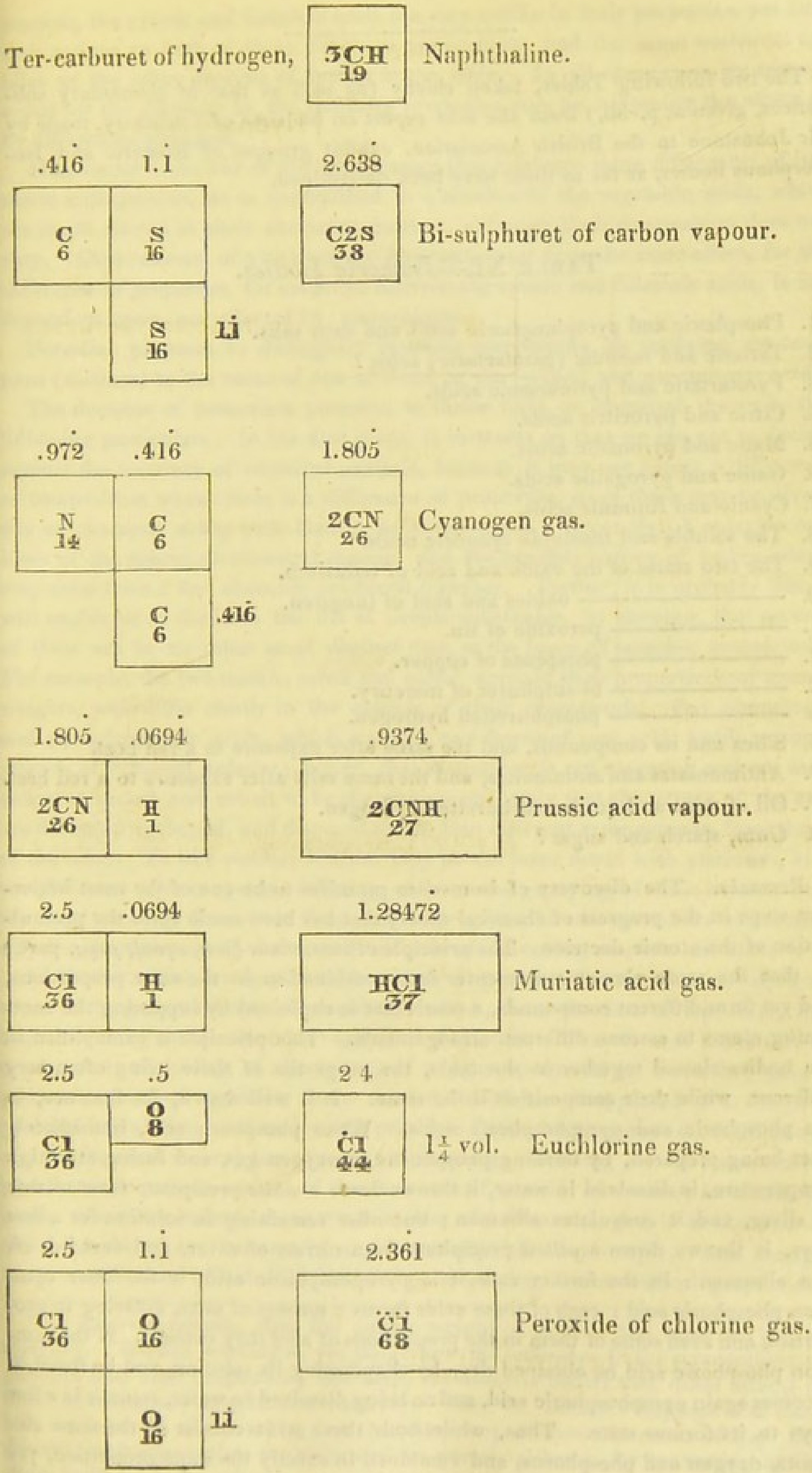
5.5	.0694		2.81247	
Br 80	H 1		H Br 81	Hydro-bromic acid gas.

.972	.0694		.59027	
N 14	H 1		N3H 17	Ammonia.
H 1	H 1			
.0694	.0694			

.972	.625		1.597	
2C2H 14	H 9		2C3H 23	Alcohol vapour.

.972	.625		2.594	
2C2H 14	H 9		4C5H 37	Ether vapour.
2C2H 14				
.972				

	2.7083
Bi-carburette of hydrogen.	6C3H 39


Ter-carburet of hydrogen,
3CH 19
Naphthaline.
.416
1.1
2.638
C 6
S 16
C2S 38
Bi-sulphuret of carbon vapour.
S 16
1.1
.972
.416
1.805
N 14
C 6
2CN 26
Cyanogen gas.
C 6
.416
1.805
.0694
.9374
2CN 26
H 1
2CNH 27
Prussic acid vapour.
2.5
.0694
1.28472
Cl 36
H 1
HCl 37
Muriatic acid gas.
2.5
.5
2 4
O 8
Cl 36
Cl 44
$1\frac{1}{4}$ vol.
Euchlorine gas.
2.5
1.1
2.361
Cl 36
O 16
Cl 68
Peroxide of chlorine gas.
O 16
1.1

The two following Tables, taken chiefly (as well as that of elementary substances, given at p. 36,) from the able report on the state of Chemistry, made by Mr Johnstone to the British Association, exhibit groupes of Isomeric and Isomorphous bodies, as far as these have been determined.

Table XI.—*Isomeric Bodies.*

1. Phosphoric and pyrophosphoric acids and their salts.
2. Tartaric and racemic (paratartaric) acids ?
3. Pyrotartaric and pyroracemic acids.
4. Citric and pyrocitric acids.
5. Malic and pyromalic acids.
6. Gallic and pyrogallic acids.
7. Cyanic and fulminic acids.
8. The soluble and insoluble cyanuric acids.
9. The two states of the oxide and acid of tellurium.
10. ——————— oxides and acid of tungsten.
11. ——————— peroxide of tin.
12. ——————— phosphate of copper.
13. ——————— bi-sulphuret of mercury.
14. ——————— phosphuretted hydrogen.
15. Silica and its compounds, and the same after exposure to a red heat.
16. Antimoniates and antimonites, and the same salts after exposure to a red heat.
17. Oil of wine and quadro-carburetted hydrogen.
18. Gum, starch and sugar ?

Remarks. The discovery of isomerism promises to be one of the most important steps in the progress of chemical theory that has been made since the promulgation of the atomic doctrine. The principle of isomerism (*ἴσος, equal, μέρος,* part,) is, that the same elements may enter into combination in the same proportions, and yet form different compounds, a result that is explained by supposing the combining atoms to assume different arrangements. This principle is exemplified in the bodies classed together in the table, the properties of these being often very different, while their composition is the same. It is well shewn, for instance, in the phosphoric and pyrophosphoric acids. When phosphoric acid, immediately after being prepared, by burning phosphorus in oxygen gas, and fusing at a high temperature, is dissolved in water, it throws down a *white* precipitate from nitrate of silver, and it coagulates albumen ; but after remaining in solution for a few days, it throws down a *yellow* precipitate from nitrate of silver, and does not affect albumen : in the former case it is pyrophosphoric acid, in the latter common phosphoric acid : each of these acids forms a serious of salts, differing in properties, and even some of them in the proportions of acid they contain. If the common phosphoric acid be obtained dry, by evaporating its solution, and be fused, it becomes again pyrophosphoric acid, and on being dissolved in water, returns in a few days to its former state. Thus, while both these acids consist of the same elements, oxygen and phosphorus, and combined in exactly the same proportion, yet they are as dissimilar as if they were composed of different elements. In like manner, the cyanic and fulminic acids are very unlike in their properties, yet analysis assigns to both of them the same composition, and the same statement applies to the other groupes of bodies in the table. In all these cases we can account for the diversity in the resulting properties only by supposing the atoms to be differently arranged.

Heat seems to be one of the chief causes that produces those differences of isomeric arrangement, as is exemplified in a number of the vegetable acids, which are much altered in their characters by heat, although their composition does not vary. Other causes, of which we are ignorant, must have the same effect, for the difference of properties, for instance, between the cyanic and fulminic acids, is not dependent upon, nor affected by, temperature.

Berzelius proposes to distinguish isomeric compounds, by prefixing the term *para* (distinct) to the name of one of them, as the *tartaric* and *paratartaric* acids.

The doctrine of isomerism promises to throw light on chemical theory in the following particulars: In the first place, it instructs us that we are not to decide against the accuracy of chemical analysis, because it may not detect a difference of composition where there is a difference of properties, since there may be diversity of character along with identity of composition. Secondly, it enlarges our ideas of the sphere of chemical change, and the possible variety of bodies which may arise from a few elements combined together. Farther, it is probable that it will enable us to diminish the list of simple substances, by shewing, that several of these are in no other sense distinct than as the bases of isomeric compounds. For example, the two metals, *cobalt* and *nickel*, agree in their properties and atomic weights, and differ chiefly in the colours of their compounds. But phosphoric and pyrophosphoric acids, which are only two forms of one acid, produce compounds of different colours; hence, that distinction is not essential, and we may conceive nickel and cobalt to be the same metal, only that the atoms of the one are differently grouped, and disposed to run into different arrangements from those of the other. In like manner iridium may be the same metal with platinum, and molybdenum with tungsten, differing only in the grouping of their atoms; and we may, ere long, discover in these and other gases the circumstances which modify the arrangement of atoms, and methods of converting one into the other *.

In the last place, we may hope from a developement of isomerism an improvement in the general theory of chemistry, which, since the time of Lavoisier, has been becoming more and more vague and disjointed. The views of the nature of combustion, of acidity, of the agency of oxygen, proposed by Lavoisier, gave a premature form of regularity to the science, which has disappeared with the progress of knowledge, and no leading principle (with the exception of the dubious electro-chemical theory) has appeared in its place. Nothing can be more unsettled than our present notions of the character of an acid, of a metal, an alkali, an earth, or a salt; indeed, there is not a class of substances, simple or compound, which chemistry can connect by any accurately defined principle. And though we possess a mass of valuable knowledge respecting the numerical proportions

* It deserves remark, that the atomic weight of gold is the same as that of mercury. We can scarcely as yet judge how far difference in the arrangement of particles may alter properties; but there are isomeric bodies that differ almost as much in characters as gold and mercury. May we therefore suppose that these may be forms of one element, that chemistry may discover the cause of their difference, and may realise the visions of its parent, alchemy, by converting one of those bodies into the other?

which are observed in chemical combination, we cannot in any case trace the laws which give rise to the properties of compounds; while we can predict the exact quantities of elements which will enter into combination, we can form no conjecture as to the characters which will result.

In these respects, chemistry, regarded as a science, has returned nearly to that first stage where generalisation commences, where a store of accumulated facts waits the application of some guiding principle, to be moulded into form and erected into a system. Now, it seems likely, that investigations connected with isomerism will contribute to this result. The effect of difference in the arrangement of atoms is a new and important element added to chemical theory; it introduces more refined views of combination, and tends to give a clearer insight into the nature of compound substances. When farther developed, it may unfold to us the cause of properties, as the atomic doctrine explains the origin of proportions: in one arrangement of particles we may find the cause of acidity: another arrangement may produce an alkali, another a salt; and with the assistance which may be expected from isomorphism, in detecting the particular forms and arrangements of particles, we may be enabled to solve the problem of combination in all its extent, and to carry through the details of chemistry a general system more comprehensive and more just than any that has yet appeared.

Table XII.—*Isomorphous Bodies.*

Chlorine, . .	Cl	Sulphuric acid, . .	$\overset{\cdot\cdot\cdot}{S}$
Iodine, . . .	I	Selenic acid, . .	$\overset{\cdot\cdot\cdot}{Se}$
Bromine, . .	Br	Chromic acid, . .	$\overset{\cdot\cdot\cdot}{Cr}$
Fluorine, . .	F	Manganic acid, . .	$\overset{\cdot\cdot\cdot}{Mn}$
Manganese, . .	Mn	Vanadic acid? . .	$\overset{\cdot\cdot\cdot}{V}$
Chloric acid, . .	$\overset{\cdot\cdot\cdot\cdot\cdot}{Cl}$	Arsenic, . . .	As
Iodic acid, . .	$\overset{\cdot\cdot\cdot\cdot\cdot}{I}$	Phosphorus, . .	P
Bromic acid, . .	$\overset{\cdot\cdot\cdot\cdot\cdot}{Br}$	Antimony, . .	Sb
Perchloric acid, . .	$\overset{\cdot\cdot\cdot\cdot\cdot\cdot\cdot}{Cl}$	Arsenic acid, . .	$\frac{1}{2}(\overset{\cdot\cdot\cdot\cdot\cdot}{2AS})$
Permanganic acid, .	$\overset{\cdot\cdot\cdot\cdot\cdot\cdot\cdot}{2Mn}$	Phosphoric acid, .	$\frac{1}{2}(\overset{\cdot\cdot\cdot\cdot\cdot}{2P})$
		Antimonic acid, .	$\frac{1}{2}(\overset{\cdot\cdot\cdot\cdot\cdot}{2Sb})$
Sulphur, . .	S		
Selenium, . .	Se	Barium, . .	Ba
Chrome, . . .	Cr	Strontium, . .	Sr
Manganese, . .	Mn	Calcium, . .	Ca
Vanadium? . .	V	Lead, . . .	Pb

Barytes, . . .	$\dot{\mathrm{Ba}}$
Strontites, . .	$\dot{\mathrm{Sr}}$
Lime, . . .	$\dot{\mathrm{Ca}}$
Protoxide of lead, .	$\dot{\mathrm{Pb}}$

Manganese, . .	Mn
Iron, . . .	Fe
Aluminum, . .	A
Zinc, . . .	Zn
Nickel, . . .	Ni
Cobalt, . . .	Co
Copper, . . .	Cu
Magnesium, . .	M
Calcium, . .	Ca
Lead, . . .	Pb

Protoxide of manganese,	$\dot{\mathrm{Mn}}$
Protoxide of iron, .	$\dot{\mathrm{Fe}}$
Oxide of zinc, .	$\dot{\mathrm{Zn}}$
Oxide of nickel, .	$\dot{\mathrm{Ni}}$
Oxide of cobalt, .	$\dot{\mathrm{Co}}$
Oxide of copper, .	$\dot{\mathrm{Cu}}$
Magnesia, . .	$\dot{\mathrm{M}}$
Lime, . . .	$\dot{\mathrm{Ca}}$
Protoxide of lead, .	$\dot{\mathrm{Pb}}$

Peroxide of iron, .	$\frac{1}{2}(2\dddot{\mathrm{Fe}})$
Peroxide of manganese,	$\frac{1}{2}(2\dddot{\mathrm{Mn}})$
Alumina, . .	$\frac{1}{2}(2\ddot{\mathrm{A}})$?
Oxide of chrome, .	$\frac{1}{2}(2\dddot{\mathrm{Cr}})$
Glucine, . .	$\frac{1}{2}(2\dddot{\mathrm{G}})$?

Tungstic acid, . .	$\dddot{\mathrm{Tu}}$
Molybdic acid, . .	$\dddot{\mathrm{Mo}}$

Oxide of tin, . .	$\ddot{\mathrm{Sn}}$
Titanic acid, . .	$\ddot{\mathrm{Ti}}$

Sodium, . . .	So
Silver, . . .	Ag
Gold, . . .	Au

Soda, . . .	$\dot{\mathrm{So}}$
Oxide of silver, .	$\dot{\mathrm{Ag}}$

Platinum, . .	Pt
Palladium, . .	Pd
Iridium, . .	Ir
Osmium, . .	Os

Potash, . . .	$\dot{\mathrm{Po}}$
Ammonia, with 2 eq. of water, . .	3HN+2 aq.

Ammonia, . .	3HN
Arseniuretted hydrogen,	$\frac{1}{2}$(3HAs)
Phosphuretted hydrogen,	$\frac{1}{2}$(3HP)

Remarks. The principle of isomorphism, (ἴσος, equal, and μορφὴ, form,) stated in general terms, is this, that certain bodies have the property of assuming the same crystalline form, and may be substituted for each other in combination, without altering that form. Thus, the substances of each groupe, in the preceding tables, may replace one another in crystallised compounds, without changing either the external figure of the crystals, or the internal form developed by cleavage. The phosphoric and arsenic acids, for example, are isomorphous, or the salts which the one acid forms with bases are of exactly the same form and structure as those of the other. The seleniate of soda is identical in form with Glauber salt. Alumina and peroxide of iron in like manner replace each other, so that we can, for instance, produce, with sulphate of potash and persulphate of iron, crystals perfectly resembling those of alum, but which do not contain a particle of alumina.

When the law of isomorphism was first announced by its discoverer, Mitscherlich, it was explained by him, on the supposition that the elements of isomorphous compounds have atoms of the same form, and that these atoms are grouped in a similar manner, and in equal numbers; or, as it was expressed by him, " The same number of atoms, combined in the same way, produces the same crystalline form, and the crystalline form is independent of the chemical nature of the atoms, and is determined only by their number and relative position." Phosphoric acid and arsenic acid, for instance, are composed each of two atoms of base and three of oxygen; hence, assuming that phosphorus and arsenic have their ultimate atoms of the same shape, it is obvious, that these being united with an equal number of atoms of oxygen, will form isomorphous acids, and these again combining with similar equivalents of a base and of water, will form salts of the same crystalline figure. As this explanation seemed to be satisfactory, it became a part of the doctrine, that isomorphous compounds always contain an equal number of elementary atoms, and that when their elements replace each other, still the number of atoms remains constant. So surely was this supposed to be established, that chemists even modified their statements of the atomic composition of bodies to agree with the doctrine: thus Berzelius inferred alumina to consist of two atoms of aluminum and three of oxygen, because it is isomorphous with peroxide of iron, which is known to have that composition. But this extension of the principle does not accord with facts; and one of the groupes in the table which Mitscherlich himself determined is an evidence of this. He found that potash is isomorphous with ammonia and two equivalents of water; that is, a dry salt of potash will crystallise in the same form as a salt of ammonia containing two atoms of water. Now, potash ($\dot{P}o$) consists of only two atoms, one of potassium and one of oxygen, while ammonia, (3HN,) with two equivalents of water, 2($\dot{H}$,) contain eight elementary atoms, or we have two atoms forming a compound isomorphous with one of eight atoms. Nitric acid also, which consists of six atoms, is in some cases isomorphous with carbonic acid, which is composed of only three.

This part of the doctrine, therefore, cannot be maintained, and we must be satisfied with the general fact, that certain elements have a disposition to arrange themselves into isomorphous groupes, and that in most cases those groupes contain the same number of constituent atoms.

It is also to be remarked, that while many of the groupes enumerated in the table are strictly isomorphous, some are only *plesiomorphous*, (πλησιος, near,) or the crystalline forms to which they give rise are very near to each other, but not identical, the measurement of the angles sometimes differing to an extent of two degrees. But this difficulty may be in a great degree obviated by reference to some facts lately established by Mitscherlich, and by Breithaupt. They have ascertained that crystals of the *same* substance occasionally differ in the measurement of their angles to an amount of from half a degree to a degree, and that even the symmetric angles of the same crystal are liable to vary to an amount of three degrees. Another important fact is, that many crystals expand unequally, from heat increasing more in one of their dimensions than in another: thus, when calcareous spar is heated from 32° to 212°, it becomes less rhombic, or approaches to the cube. It is, therefore, conceivable, that there may be a certain zero point of temperature at which plesiomorphous groupes are truly isomorphous, and that it is unequal expansion from the heat present in them, at ordinary temperature, which in some produces change of form. Mitscherlich is of opinion, that isomorphism is also occasionally modified by chemical affinity.

Isomorphous bodies, besides their conformity in figure, are commonly allied by resemblance of their other properties; thus a close resemblance exists between phosphorus and arsenic, between sulphur and selenium.

The principle of isomorphism is of essential importance in mineralogy. It shews that crystallographic measurement cannot indicate chemical composition; it also warns the analyst of the substances which may replace each other in a mineral, and which he might fail to discriminate; and it shews, that in the chemical classification which must ultimately prevail in mineralogy, a mineral species must not be too strictly limited as to individual ingredients, but must be represented by a formula that will admit different isomorphous bodies, a kind of framework, the compartment of which may be filled up with equivalent substances, as these may happen to replace one another.

What the influence of this doctrine may be on chemistry we can scarcely yet judge, but it seems likely to unfold some very important relations; and the speculation may be indulged, that by the aid of the atomic theory, which teaches us the relative magnitude of atoms, of *isomorphism*, that aims at the discovery of their form and arrangements, and of *isomerism*, which shews the effect of the arrangement on properties, we may at length erect a perfect theory of combination; so that the chemist, when the problem is proposed to him, of the union of given elements, shall be able to state what will be their relative proportions, and what the structure and properties of the compound,—a splendid result, if it shall ever be attained!

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