By placing a compound, one, for instance, of oxygen and an inflammable body, in connexion with the metallic wires proceeding from each end of a galvanic battery, the oxygen is attracted by the wire that is in the positive state, and repelled by that which is negative; while, at the same time, the inflammable is attracted by the negative wire, and repelled by the other. Hence the components are separated, and obtained in an insulated state. In the decompositions thus effected, substances can be conveyed to a distance, and even through interposed ponderable matter, by the galvanic influence; a result which, however singular, is well ascertained.

Galvanism, like electricity, acts as a stimulus to the living system. Its effects on the animal body are a sensation of light when applied to the eye; a sensation of acidity on the tongue; and the excitement of strong muscular action.

It would be entering too much into hypothetical discussion to attempt an explanation of the phænomena of galvanism; particularly as philosophers are not yet agreed upon the subject. Galvanism has not yet been employed as a pharmaceutical agent.

On the forces of attraction and of repulsion every chemical, and consequently every pharmaceutical effect, more or less depends. A knowledge, therefore, of the laws which regulate these powers is of the greatest importance, and forms the basis of all chemical science.

SECTION II.[1]

EVERY substance, whether it be regarded generally as forming a part of the mass of this globe, or particularly as an object of science, may be arranged in one or other of the three following classes; *Solids*, *Fluids*, and *Gaseous Bodies*. We shall now examine each of these classes separately, and endeavour to describe the constitutions and combinations of the substances composing them, inasmuch as they are objects of pharmacy.

I. SOLIDS.

SOLID bodies are masses of homogeneous particles combined and held together by the attraction of aggregation or cohesion. The arrangement of the particles with regard to each other is

[1] In drawing up this section, I have borrowed very freely from the third book of Thomson's System of Chemistry, 4th edition.

often such as to produce regular figures, in which case the solids are said to be crystallized. Cohesion and crystallization have been already considered.

A. CONSTITUTIONS OF SOLIDS.

Arrangement of the principal Solids according to their Composition.

I. SIMPLE, *or* UNDECOMPOUNDED.

Sulphur. *Carbon.* *Metals.*

II. COMPOUNDS.

Phosphorus.
Oxide of Sulphur.
——— *Phosphorus.*
Charcoal.
Metallic Oxides.
Sulphurets of Metals.
——— *fixed Alkalies.*
——— *Earths.*
Phosphurets of Carbon.
——— *Metals.*
——— *Earths.*
Carburets of Iron.
Alloys.
Solid Acids.
Earths.
——— *with Earths.*
——— *metallic Oxides.*
——— *fixed Alkalies.*
Salts and Hydrosulphurets.
Metallic Oxides with Alkalies.
Bitumens.
Soaps.
Most vegetable Substances.
Many animal Substances.

SIMPLE SOLIDS.

a. SULPHUR. Although the experiments of Sir H. Davy have unequivocally proved that hydrogen is always present in sulphur as we obtain it; yet, they afford no positive conclusion that it is an essential ingredient of sulphur. I have therefore followed Dr. Thomson in regarding it as a simple solid. For its properties, see PART ii. p. 389.

b. CARBON. The diamond is this substance in a state of purity; and, although, charcoal in its ordinary state almost invariably contains either hydrogen or water, yet, from the experiments of Messrs. Allen and Pepys, it is probable that charcoal is essentially as pure carbon as the diamond, and that the hydrogen it evolves depends on water which it always absorbs on the shortest exposure to the air. Carbon is a constituent of almost all vegetable and animal substances.

c. METALS are simple inflammable bodies, of great specific gravity, density, and opacity; and, as the result of these qualities, possess great brilliancy or lustre from their power of reflecting almost all the light which falls upon their surface. Their colours are generally shades of white, gray, or yellow; their hardness is considerable, and according to its degree they are more or less elastic: one only, mercury, is in a fluid state at the ordinary heat of the air. Many of them possess considerable tenacity, and are hence malleable and ductile; but some are extremely brittle. Metals are sapid and odorous when heated or rubbed; their fracture is generally hackly; their texture fibrous or foliated; and many of them are sonorous. They are excellent conductors of caloric, electricity, and galvanism. When exposed to the action of caloric, they expand and are melted; but differ greatly with regard to fusibility; some of them are volatilized at known temperatures. When fused, their surface is convex and globular; and in cooling they generally crystallize. They are very susceptible of oxidizement.

The following metals are used as pharmaceutical agents.

I. MALEABLE.

1. Silver. (*See Part* ii. p. 43.)
2. Mercury. (*Ibid.* p. 204.)
3. Copper. (*Ibid.* p. 145.)
4. Iron. (*Ibid.* p. 171.)
5. Tin. (*Part* ii. p. 384.)
6. Lead. (*Ibid.* p. 310.)
7. Zinc. (*Ibid.* p. 417.)

III. BRITTLE AND EASILY FUSED.

1. Bismuth.
2. Antimony. (*Part* ii. p. 39.)
3. Arsenic. (*Part* ii. p. 48.)

III. BRITTLE AND DIFFICUTLY FUSED.

1. Manganese. (*Part.* ii. p. 247.)

Bismuth is a reddish white coloured metal of a lamellar texture. Its specific gravity is 9·822. It fuses at 476° Fah. and crystallizes on cooling; in a higher temperature volatilizes; and on the access of air burns with a blue flame, emitting a yellow smoke, which is an oxide of the metal. The mineral acids act on it; and it readily combines with sulphur and most of the other metals.

a. BORON is obtained from the decomposition of boracic acid, in the form a deep olive coloured powder, insipid and inodorous. It undergoes no change at any temperature when heated in close vessels; but takes fire and burns like charcoal, when heated in the air to about 600°. During combustion it attracts oxygen and is converted into boracic acid. It is also converted into the acid by decomposing sulphuric and nitric acids when it is treated with them. It combines with the alkalies and sulphur. Sir H. Davy conceives it is a compound; and that one of its ingredients which enters into alloy with potassium and with iron, is the real basis of boracic acid.

b. COMPOUNDS OF SULPHUR.

1. *Oxide of Sulphur* is formed on the surface of sulphur which is kept for some time in a state of fusion. It has a violet colour, and a fibrous texture; is austere to the taste, tough; and its specific gravity is 2·325. It contains rather less than 7 per cent. of oxgen.
2. *Sulphurets of metals* are compounds of sulphur and metals, inodorous and insipid, often possessed of metallic brilliancy, brittle; and are conductors of electricity. Three of them only are officinal.

Table of Officinal Sulphurets of Metals.

Sulphurets.	Colours of the Sulphurets.	Specific Gravity.	Sulphur United to 100 metal.
Mercury	1. Black - -	8·16	8
	2. Red - -		16
Iron - -	1. Yellow -	4·518	57·1
	2. Yellow -	4·83	114·2
Antimony	Leaden gray	4·368	37·25

3. *Sulphurets of fixed alkalies* are opaque, solid bodies, of a brownish red or liver colour; decomposable by caloric, water, and acids; and which, by exposure to the air, are converted into hydrogureted sulphurets.
   Officinal. Sulphuret of potash, (*Part* ii. *p.* 562.)
4. *Sulphurets of earths* resemble the alkaline sulphurets in their properties.
5. *Hydrosulphurets* are compounds of sulphureted hydrogen with alkalies and earths. They are soluble in water, crystallizable, and are decomposed by the atmosphere and acids.

b. PHOSPHORUS is semitransparent, of a yellowish red colour, and a waxy consistence, but when perfectly pure is colourless and transparent. Its specific gravity is 1·770. It may be cut with a knife, is brittle at a temperature under 32°, but above that point softens, and under 90° is very ductile. It melts at 90°; in close vessels is volatized at 219°; and boils at 55°. When heated in the air to 148° it inflames, and emits a white smoke, which has an alliaceous odour, and condenses to an acid. It is obtained from urine, bones and other animal matters; and by Sir H. Davy's experiments appears to be a compound of an unknown base with hydrogen.[1]

1. *Oxide of phosphorus* produced by the exposure of phosphorus to dry air, has the appearance of fine white flakes, which take fire when slightly heated, and burn with a very vivid flame: by the further exposure to the air they attract moisture, and are converted into an acid.
2 *Phosphuret of carbon* (the substance which remains in the leather through which new-made phosphorus is strained, purified by exposure to heat in a retort,) is a light flocculent powder, of a bright orange, or rather red colour, insipid, and inodorous. It burns rapidly when heated in the air, and leaves charcoal behind.
Phosphurets of metals are generally brittle, and have a metallic lustre. (Vide *Annales de Chimie*, tom. i. & xiii.)
4. *Phosphurets of earths* have a brown colour; are generally luminous in the dark; insoluble in water, but decompose that fluid, furnishing phospureted hydrogen gas.

c. CHARCOAL? (*Part* ii. p. 87.)

d. METALLIC COMPOUNDS.

1. *Alloys* are compounds of two or more metals. They have generally lustre, hardness, tenacity, ductility, and other properties of the metals; but these properties in alloys differ from those of the metals from which they are formed. The compounds of mercury with other metals are named *amalgams*.
2. *Metallic oxides* are generally in the form of powders, or friable fragments not at all resembling the metals; sometimes laminated and crystallized; of various colours, determinate with regard to the metals and their treatment; heavier than the metals; and refractory, or fusible into glass. Some are insipid, others acrid and styptic; in general they are insoluble in water, and combine with acids, or with alkalies, or with both at the same time. They are reducible by light, by caloric, hydrogen, carbon, oils, &c.[2]

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[1] For experiment, the simplest mode of obtaining phosphorus is to mix a solution of phosphate of soda with a solution of acetate of lead, in the proportion of one part of the former salt to one quarter of the latter. This will yield a precipitate of phosphate of lead, from which phosphorus may be obtained by distillation.
Henry's Elements of Chemistry, ii. p. 7.

[2] As the same metal is susceptible of different degrees of oxidizement, it has been found necessary to designate the oxides thus formed by distinct appellations, indicative

Table of officinal metallic oxides, showing the quantity of oxygen united to 100 of metal by weight in each.

Metals.	Colour of Oxides.	Oxygen in 100 parts.	Metals.	Colour of Oxides.	Oxygen in 100 parts.
Silver - -	Olive	7·925	Zinc - -	White	24·41
Mercury	Black	4	Bismuth -	White	11·28
	Red	8	Antimony	Yellow	18·60
Iron - -	Black	29·5	Arsenic	White	34·93
	Red	44·25		Do.	52·4
Lead - -	Yellow	7·70			
	Red	11·08			
	Brown	15·60			

3. *Carburet of iron* (*plumbago*) is of a dark blue or gray colour; has some degree of metallic lustre, a greasy feel, is soft, and blackens the fingers. It is not altered by water or by air, nor affected by the most violent heat, if air be excluded; the acids do not affect it; it detonates with nitrate of potash, and reduces the metallic oxides. 100 parts appear to consist of 5 of iron, and 95 of carbon; with, perhaps, a minute proportion of hydrogen.
4. *Metallic phosphurets.*
5. *Metallic sulphurets.* Metals combine with different quantities of sulphur. The sulphurets are brittle, generally destitute of lustre, and differing in colour from the metals that form their basis.
6. *Metallic oxides with alkalies.*
7. *Earths.* (*Part* iii. p. 479.)

   Earths with earths.

   ——— *metallic oxides.*

   ——— *alkalies.*

e. SOLID ACIDS *and* SALTS in a crystallized state, contain a portion of water in their composition. The following are objects of pharmacy, or officinal:

1. *Phosphoric acid* is solid, colourless, transparent, and resembles glass in appearance; is inodorous, very acid, reddens vegatables blues, and deliquesces when exposed to the air. Its specific gravity in a state of dryness is 2·687. It is very soluble in water, dissolving with a

of the comparative quantity of oxygen with which the metals thus formed are combined. The terms *protoxide*, *deutoxide*, *tritoxide*, and *peroxide*, imply that a metal is in its first, second, third and ultimate stage of oxidizement. — These terms were proposed by Dr. Thomson.

hissing noise; and is decomposed at a high temperature by carbon, hydrogen, and several of the metals: 100 parts consist of 46·72 of phosphorus, and 53·28 of oxygen.[1]

Phosphate of lime constitutes the basis of bones, from which it is procured in the state of a white powder by calcination, and solution in muriatic acid, from which it is precipitated by ammonia. It is inodorous, insipid, insoluble in water, but is decomposed by several of the acids: exposed to a heat of 378° Wedgewood, it softens, and changes to an enamel: 100 parts contain about 50·8 of acid, and 40·2 of lime.

Subspecies. 2. *Bi-phosphate of lime.*
Subspecies. 3. *Quadri-phosphate of lime.*
Subspecies. 4. *Sub-phosphate of lime.*[2]
Phosphate of soda. (*Part* iii. p. 477.)

2. *Boracic acid* is obtained in the form of white thin hexagonal scales, greasy to the feel. It reddens vegetable blues, is inodorous, but has a sour bitterish taste, leaving a cooling, sweet impression in the mouth. Its specific gravity is 1·479. It is fixed in the fire, but melts into a hard transparent glass. Boiling water dissolves only two parts of boracic acid: alcohol dissolves it, and the solution burns with a green flame; and oils also dissolve it with the assistance of heat. It oxidizes only iron, zinc, and perhaps copper? Its components are, according to the experiments of Sir H. Davy, one part by weight of borax, and two of oxygen.
Sub-borate of soda. (*Part* iii. p. 371.)
3. *Benzoic acid.* (*Part* iii. p. 427.)
4. *Succinic acid.* (*Part* iii. p. 442.)
5. *Oxalic acid*, generally obtained by treating sugar with nitric acid, is in the form of white, transparent, shining, four-sided prisms, which have a very acid taste, redden vegetable blues, and are soluble in their own weight of boiling water. Exposed to heat in open vessels, it is decomposed. According to Berzelius, 100 parts contain 52 of real acid, and 48 of water; and the acid Dr. Thomson[3] found to be a compound.
6. *Tartaric acid* is obtained in white, irregular, hard, semitransparent crystals, the specific gravity of which is 1·5962. It readily dissolves in water; is capable of oxidizing iron, zinc, and mercury; and combines with

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[1] Rose. [2] *Thomson's System of Chemistry*, 5th edit. vol. ii. p. 459.
[3] *Ibid.* p. 155.

alkalies, earth, and metallic oxides, forming tartrates. The crystallized acid consists of real acid 100 parts, water 13·43, and 100 parts of the acid of oxygen 64, carbon 32, hydrogen 4—100; are composed of 59·882 of oxygen, 34·167 of carbon, and 3·951 of hydrogen.[1]

Tartrate of potash. (*Part* iii. p. 469.)

Variety. *Supertartrate of potash.* (*Part* ii. p. 391.)

Tartrate of potash and soda. (*Part* iii. p. 471.)

7. *Citric acid.* (*Part* iii. p. 429.)

For descriptions of the remaining solid salts, (see *Part* iii.)

f. BITUMENS. (*Part* ii. p. 70.)

g. SOAPS. The true nature of these compounds has been illustrated by Chevruel. He found that the fatty matter they contain consists of two distinct substances, which he has named *Steärin* and *Elaïn.* These, by the action of salifiable bases, are converted into two acids, the *margaritic* and the *oleïc*; and soaps are merely combinations of one or both with alkaline, earthy, or metallic bases. The alkaline soaps have a peculiar, unpleasant odour and taste, form a milky solution with water, and a transparent one with alcohol; are powerfully detergent, and are decomposed by the earthy and the metallic salts. 2. The earthy soaps are insoluble in water, and not detergent. 3. Metallic soaps are likewise insoluble in water, but some of them are soluble in alcohol, and others in oil.

1. *Hard soap.* (*Part* ii. p. 360.)

2. *Soft soap.* (*Ibid.* p. 361.)

Variety. *Liniment of ammonia.* (*Part* iii. p. 735).

3. *Liniment of lime-water.* (*Part* iii. p. 735.)

h. SOLID VEGETABLE SUBSTANCES. It is necessary to notice in this place the solid proximate principles only of the vegetable substances which are officinal, or employed as pharmaceutical agents. The constituents of the whole of them are—carbon, hydrogen, oxygen, and azote, in different proportions.

1. *Sugar.* (*Part* ii. p. 351.) It is soluble in nitric acid, and yields oxalic acid.

Variety. *Manna?* besides common sugar, contains mucilage and a nauseous substance to which it owes its purgative properties. When digested with nitric acid, it yields saclactic as well as oxalic acid. It does not ferment like sugar.

2. *Sarcocoll* is usually in oblong, semitransparent, yellow, globules, which have a bitter sweet taste, and an odour resembling in some degree that of anise seed. It does not

[1] Berzelius.

crystallize. Soluble in water and alcohol. Treated with nitric acid yields oxalic acid.

Variety. *Liquorice?* Dissolves in nitric acid, and forms tannin; and when treated with sulphuric acid yields about one-fourth of its weight of charcoal. It is not susceptible of fermentation.

3. *Gum.* (*Part* ii. p. 4.)

Officinal. Acacia Gum.

Variety. *Mucus.* Inodorous, insipid, soluble in water, insoluble in alcohol; not precipitated by silicated potash, but precipitated by alcohol in a fibrous state.

Officinal. Linseed mucus, quince seed mucus, marsh mallow mucus.

4. *Cerasin.* This substance, which was formerly confounded with gum, is the produce of the astragalus *tragacantha.* For its physical properties, see (*Part* ii. p. 64.) With nitric acid it yields saclactic, malic, and oxalic acids.

Varieties. *Cherry tree gum? Congo gum; Dominica gum.*

Officinal. Tragacanth.

5. *Ulmin*[1]. This is a spontaneous exudation from the elm; but, as Berzelius has hinted, is probably a component of every bark. It is solid, black, hard, shining, and insipid. Soluble in water, but does not form mucilage; insoluble in alcohol; precipitated by nitric and oxymuriatic acids in the state of resin.

6. *Inulin* is obtained from the Inula *helenium* in the form of a white powder, which is insoluble in cold water and in alcohol. It is soluble in boiling water, forming a mucilaginous solution; but precipitates as the solution cools. Treated with nitric acid it yields malic and oxalic acids.

Officinal. Elecampane root.

7. *Starch.* (*Part* ii. p. 400.)

Varieties. *Potatoe starch; Salop; Tapioca.*

8. *Gluten* is of a gray colour, nearly insipid and inodorous, very tenacious, ductile, and elastic; partially soluble in water, and soluble in acetic and muriatic acid. Insoluble in alcohol and ether. When treated with nitric acid it yields oxalic acid.

9. *Fibrin* is tasteless, fibrous, elastic, and resembles gluten. It is insoluble in water, alcohol, and diluted alkali: but is soluble in acids, particularly nitric acid. It soon putrefies.

10. *Extractive* is obtained by evaporating aqueous vegetable infusions to dryness. It has a strong taste; and is

[1] So named by Dr. Thomson.

soluble in water; but insoluble in alcohol and ether, unless when the extractive is united with resin. It is precipitated from its solutions by oxymuriatic acid, muriate of tin, and muriate of alumina; but not by gelatin.

Officinal. Catechu, most barks, &c.

11. *Emetin.* This substance is obtained from ipecauanha and some other roots which have an emetic property. It is in the form of brownish-red transparent scales, inodorous, but having a bitter and slightly acrid taste. It is very soluble in water, alcohol, and acetic acid, but insoluble in ether. Nitric acid converts it into oxalic acid. Half a grain, when swallowed, excites full vomiting.[1]

Officinal. Ipecacuanha root.

12. *Nicotin* is obtained from the leaves of several species of nicotiana. It is colourless, acrid, and has the odour of tobacco; is soluble in water and alcohol; and approaches the volatile oils in its properties. It is extremely poisonous.

Officinal. Tobacco leaves.

13. *Tannin* has a bitterish, astringent taste; is soluble in water, and in alcohol of 0·810. It is precipitated by the muriates of tin and of alumina, and by gelatins.

Officinal. Galls, uva ursi, tormentil, rhubarb, cinchona barks, swietenia, simarouba, kino, catechu, willow bark.

14. *Wax* is a fixed oil saturated with oxygen. (*Part* ii. p. 102.)

15. *Camphor.* The ultimate components are probably carbon and hydrogen, the proportion of carbon being greater than in oils. (*Part* ii. p. 226.)

16. *Scillitin.* This substance is procured from the bulb of the squill. It is white, transparent, and pulverulent: has an intensely bitter taste leaving a sweetish impression on the palate. It is soluble in water and alcohol, and when heated swells and exhales the odour of caromel.

Officinal. The bulb of the squill.

17. *Resins* are brittle, semitransparent, yellowish substances, inodorous, and having an acrid taste. Their specific gravity varies from 1·0452 to 1·2289. They melt when heated, inflame in a higher temperature, and burn with a strong

[1] To obtain *Emetin* treat powder of ipecacuanha with ether at 60°, as long as it acts upon it: then boil the powder several times with fresh quantities of alcohol at 40°, and filter the boiling solutions, which will throw down as they cool a white flocculent precipitate: filter again and evaporate the clear solution in a water-bath. Melt the reddish residue which will be obtained, with cold water, and add magnesia, which will precipitate the *Emetin* that may be now obtained in a state of purity by dissolving the precipitate in alcohol, and evaporating the solution to dryness.

yellow flame, emitting much smoke. They are insoluble in water; but soluble in alcohol, ether, alkalies, and acetic acid. Nitric acid converts them into artificial tannin.

Officinal. Amber, copal, pine resins, mastiche.

18. *Guaiacum* differs from resins in being soluble in nitric acid, and yielding, when treated with it, oxalic acid, and no tannin.

19. *Picrotoxine* is procured from the fruit of Menispermum cocculus, in white, four-sided prismatic crystals; of an intensely bitter taste, soluble in twenty-five times its weight of water, and in three times its weight of alcohol and of ether. It is insoluble in oils. Nitric acid converts it into oxalic acid. It is intoxicating, and poisonous when swallowed.

Officinal. Cocculus Indicus.

20. *Morphia.* This is an alkaline substance procured from opium. It is in white pyramidal crystals, scarcely soluble in boiling water, but very soluble in alcohol and ether. It combines with the acids forming neutral salts. It acts with great energy on the animal economy.

Officinal. Opium, lactucarium.

21. *Balsams* resemble resins in their appearance; have a strong aromatic odour; yield benzoic acid when heated, or dissolved in sulphuric acid; and when treated with nitric acid yield artificial tannin.

Officinal. Balsams of tolu, benzoin, storax.

22. *Gum resins* resemble resins in their appearance; but are odorous, form milky solutions with water, and transparent solutions with alcohol. They are soluble in alkalies; and are converted into tannin by nitric acid.

Officinal. Ammoniacum, galbanum, scammony, assafœtida, myrrh, sagapenum.

23. *Wood* which forms the support of all vegetables, is composed of tasteless fibres, insoluble in water and alcohol; but soluble in weak alkaline ley; and in nitric acid yielding oxalic acid. When distilled *per se*, at a red heat, it leaves much charcoal.

i. SOLID ANIMAL MATTERS.

1. *Gelatin.* (*Part* ii. p. 12.)

2. *Albumen* when dried is a brittle, transparent, glassy substance, resembling gum in appearance. It is soluble in cold water, and when the solution consists of one part of dry albumen and 9 of water, heat coagulates it into a firm white solid mass: alcohol, ether, and the strong acids also coagulate the solution.

Officinal. White of egg.

3. *Solid oils* are composed, like the other fixed oils, of a

solid and a fluid substance which Chevreul has named *Stearin* and *Elain*.

Varieties — *a. Spermaceti.* (*Part* ii. p. 296.)

b. Fat is an odorous, insipid, white crystalline substance; greasy to the touch; melts at 140°; vaporized at 400°, the vapour being inflammable. Insoluble in water, alcohol, and ether; combines with alkalies, and forms soap; and is decomposed by strong acids.

Officinal. Lard, mutton suet, fat.

4. *Castor.* (*Part* ii. p. 94.)
5. *Musk.* (*Part* ii. p. 259.)
6. *Bones* and *Shells.* (*Part* ii. p. 278.)
7. *Horn.* (*Part* ii. p. 104.)

COMBINATION OF SOLIDS WITH SOLIDS.

Although solid bodies may be made to enter into combination with each other, yet all do not combine in the same manner, and under similar circumstances. Thus, some unite in any proportion; and some in certain determinate proportions only; while others will not combine with each other in any manner.

1. TABLE *of the principal Solids which have been ascertained to be capable of uniting in any Proportion.*

Sulphur with phosphorus.
Carbon with iron?
Metals with most metals.
Protoxide of antimony with sulphuret of antimony.
Earths with earths.
Earths with some metallic oxides.
Some earths with fixed alkalies.
Solid oils with each other, and with bitumen.

All the products are solids, except that of the first, which is liquid.

None of these solids combine spontaneously, even although placed in contact; but require to be mixed, and exposed to a degree of heat capable of melting one or both of them; in which case the caloric breaking the force of the cohesive attraction which retains the particles of the solids in the aggregate state, the atoms of the one substance are brought into immediate contact with those of the other, or within the sphere of the attraction of affinity, which consequently acts and produces the new compound. The compounds do not very materially differ in their properties from their constituents, except the compounds of iron with carbon, and some of the earths with each other. The combination, however, is generally accompanied with a change of density.

2. TABLE *of the principal Solids which have been observed to unite only in determinate proportions.*

Sulphur with metals.
———— some metallic oxides.
———— earths.
———— fixed alkalies?
Phosphorus with carbon.
———— metals.
———— some earths.
Acids with alkalies.
———— earths.
———— metallic oxides, &c.

These enter into more intimate union than the preceding. They, however, do not unite when both bodies remain in the solid state; "except sulphur and the fixed alkaline[1] hydrates, some acids, and a few hydrates of metallic oxides, and perhaps some of the acids, and the fixed alkaline hydrates:" hence they are brought into union, either by *fusion*, or by *solution in water*, or some other liquid menstruum. By the first mode, "sulphur is made to combine with metals, earths and fixed alkalies, and phosphorus with metals:" by the second, the acids are combined with the alkalies, earths, and metallic oxides. The mode of union resembles that of liquids with solids in every respect.

It is important to ascertain the *proportions* in which these bodies unite, and their *change of density*. Berthollet is of opinion, that sulphur may unite indefinitely with the metals, the proportion of sulphur varying indefinitely in many native sulphurets; but Dr. Thomson[2] maintains the contrary opinion, owing to the circumstance "that when sulphur and a metal are fused together, we obtain always the two bodies combined in determinate proportions."

The following Table (drawn up by the latter) compares the results of the analysis of metallic sulphurets, with a calculation founded on the supposition that the metals and sulphur unite atom to atom; that the weight of an atom of sulphur is 13; and that of an atom of the respective metals is as stated in the first column. The second column gives the weight of sulphur united to 100 parts of the metal by calculation; the third by analysis.

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[1] Alkalies in the crystalline form, or containing water solidified.
[2] *System of Chemistry*, 4th edit. iii. 136.

Metals.	Weight of a metallic atom.	Weight of sulphur combined.	
		By calculation.	By experiment.
Silver	95·7	14	17·6
Bismuth	93·7	14	17·5
Arsenic	54·5	24	25·
Copper	48·0	27	14 to 30
Mercury	120·0	10·8	17·6
Tin	48·0	27	17·6
Lead............	150·0	8·7	12 to 25
Antimony......	80·0	16·2	33·3
Iron	32·4	40	60 to 112

The metallic sulphurets are rarer than the mean of their components, owing to the substances expanding during their union sometimes more than one-fifth of the whole. Pyrites, however, is an exception, its specific gravity being greater than the mean.

Nothing precise is known of the other combinations of sulphur, or of those of phosphorus with solid bodies.

The combinations of the acids with alkalies, earths, and metallic oxides are well understood. When an acid and an alkali are mixed together, we find that, after several small additions of the alkali to the acid, diluted with a little water, the mixture still retains acid properties; but by continuing to add the alkali these disappear, and alkaline properties are acquired by the next addition that is made: the acid or the alkaline properties of the compound, therefore, predominate according to the proportions of each; but there are certain proportions, according to which they destroy, by their union, the properties of each other, so that neither predominates. In this case they are said to *neutralize* each other; the products are named *neutral salts*, and the proportions in which the acids and alkalies unite to form neutrals are fixed and determinate.

All salts, however, are not neutrals; but in some the proportions of the acid, in others, that of the base, predominate. The former, which are named *super-salts*, are supposed to be compounds of two atoms of the acid with one of the base; and the latter, which are named *sub-salts*, of two atoms of the base with one of the acid.[1] Thus supertartrate of potash consists of one atom of potash united to two of tartaric acid; or by weight, of 5·23 parts of base, and 100 of acid[2]: while carbon-

[1] For an account of the Atomic Theory, I must refer my readers to Mr. Dalton's writings, and Thomson's *Annals of Philosophy*, passim.

[2] Berzelius.

ate of potash consists of two atoms of potash and one of carbonic acid; or by weight, of 2·75 of acid and 6·00 of base. *Triple salts*, are salts composed of one acid united to two bases at the same time, — as the tartaric acid, for instance, with potash and soda, to form the tartrate of potash and soda.

The metalline salts are seldom neutral, having generally an excess either of acid or base.

II. LIQUIDS.

It has been already observed, that by throwing caloric into a solid body, or, in other words, heating it, the force of the attraction of cohesion which preserved it in the solid state is gradually weakened, and finally overcome. When the particles of a body which were at a low temperature immoveable relatively to each other, are separated by interposed caloric, so as to move easily upon each, but are yet within the limits of the sphere of the attraction of aggregation, the body is denominated a *liquid*, provided it remain in this state under the medium temperature of the atmosphere. Thus *Ice*, when brought into a place the temperature of which exceeds 32°, loses its solidity and becomes a liquid or water, which form it retains in every degree of temperature between 32° and 212° on the scale of Fahrenheit's thermometer. Let us now examine the constitution of liquids; their combinations with other liquids; and their combination with solids.

1. OF THE CONSTITUTION OF LIQUIDS.

Liquids may be regarded as compounds of caloric with a solid base. Their parts move easily upon each other, and yield to the smallest impression; but they are not sensibly elastic. The greater or smaller degree of liquidity of different substances depends upon a difference of the force of cohesion exerted between their particles, which may be regarded as placed in the limit between attraction and repulsion: thus the cohesion of mercury is greater than that of water. Liquids differ very much in specific gravity[1]; and the degree of this bears a relation to their density. "The distances of the atoms are so regulated, that the attraction and repulsion by which they are at once actuated just balance one another; while their form is such, that they can move freely among each other without altering these distances. It is this which seems to constitute the real cause of liquidity."

All liquids may be arranged into two great classes. "The following Table[2] exhibits a list of almost the whole of them arranged according to their composition."

[1] See No. IV. of Appendix to Part I.

[2] *Thomson's Chemistry*, 5th edit. iii. p. 84.

I. SIMPLE.

Mercury. (*Part* ii. p. 203.)

II. COMPOUND.

a. Simple gases combined.

Water.

Nitric acid. (*Part* iii. p. 436.)

b. Gases with a solid base.

Sulphuric acid. (*Part* ii. p. 8.)

Alcohol. (*Part* iii. p. 636.)

Ethers. (*Ibid.* p. 665.)

Volatile oils. (*Ibid.* p. 576.)

Fixed oils. (*Ibid.* p. 70.)

Petroleum. (*Part* ii. p. 70.)

Supersulphuret of hydrogen.

Oxymuriate of tin.

c. Solidis combined.

Phosphuret of sulphur.

Sulphuret of carbon.

If mercury be excepted, all the known liquids are compounds; and the greater number of them contain water as an ingredient.

Water. The ordinary appearances and properties of this liquid are too well known to require description. Its maximum of density is at the temperature of 36°. A cubic foot of it, at 30 inches of the barometer, and 55° of the thermometer, weighs 998·74 avoirdupoise ounces of 437·5 grains troy each. It specific gravity is supposed = 1·000, and it is made the standard of unity in the measurement of the gravity of every other liquid. The gravity of ice is less than that of liquid water. In the form of steam it occupies 1800 times the space which it does in the form of water. It is not decomposed by heat alone; nor altered by light: but is decomposed by iron, zinc, antimony, and tin, when assisted by heat. It readily absorbs air and gases [1]; and is a constituent of all gases. It is a compound of oxygen and hydrogen, 100 grains containing 88·286 of oxygen, and 11·714 of hydrogen.[2] It liquefies a great number of solid bodies, its solvent power being increased by diminishing the pressure of the atmosphere; and, as has been already stated, the greater number of liquids contain it as an ingredient.

Supersulphuret of hydrogen is a transparent, colourless liquid

[1] From Mr. Dalton's experiments, it appears that water absorbs its own bulk of carbonic acid gas, of sulphureted hydrogen gas, and of nitrous oxide, $\frac{1}{27}$ of oxygen gas, nitrous gas and carbureted hydrogen; and $\frac{1}{8}$ of carbonic oxide, azotic gas and hydrogen gas. [2] Biot and Arago.

when pure, but more frequently has a greenish-yellow tinge. It has a strong peculiar odour, and a pungent yet cooling taste. Its specific gravity is 1·3. It burns like spirit of wine, and during the combustion emits a sulphurous odour. It is a compound of 96·75 parts of sulphur, and 3·25 of hydrogen.

Oxymuriate of tin is a transparent liquid, which exhales a very heavy dense smoke when exposed to the air. Twenty-two parts of it united with seven of water condense into a solid mass. It yields by evaporation small crystals, which are deliquescent, and sublime in a moderate heat.

Phosphuret of Sulphur is of a yellowish colour, and exceedingly inflammable.

Sulphuret of Carbon is a transparent colourless liquid, having an acrid, pungent, slightly aromatic taste and fœtid odour. It is very inflammable, burning with a blue flame, and emitting fumes of sulphurous acid. It is a compound of 84·83 parts of sulphur, and 15·17 of carbon.

2. COMBINATION OF LIQUIDS WITH EACH OTHER.

When liquids are mixed together they either unite in any proportions, or in certain determinate proportions only, or they cannot be united, but separate, howsoever carefully they be mixed together; or they decompose each other.

I. TABLE *of Liquids which unite when mixed together in any proportions, and do not afterwards spontaneously separate.*

Water with alcohol.
———— nitric acid.
———— sulphuric acid.
Alcohol with ether.
Sulphuric acid with nitric acid.
Fixed oils with petroleum.
———— volatile oils.
———— fixed oils.
Valatile oils with petroleum.
———— *volatile oils.*

When these liquids are mixed together, such a mutual penetration takes place, that every portion of the mixture contains the same proportions of both ingredients; and this is the case although there may be the greatest difference in the specific gravity of the individual liquids. Agitation assists the rapidity of this effect very much, but the mixture is never perfect until some time afterwards. If, on the contrary, agitation be not employed, the mixture is always more quickly effected when the denser liquid is added to the rarer; for in the opposite case a long period often elapses before it be completed. A partial muddiness occurs when even transparent liquids of different densities are mixed together, and continues until the mixture be perfect; but when it is complete, the compound is homogeneous, and the liquids do not afterwards separate from each other.

As the density and specific gravity of a compound thus formed are always greater than the mean, caloric is evolved during the mixture. In some cases the quantity is scarcely sensible; but in other cases it is capable of affecting considerably the thermometer: thus, if fixed and volatile oils, be mixed, the temperature is not very sensibly raised; but if four parts of sulphuric acid and one part of water, both at 32°, be mixed together, the temperature rises to 212°. When equal parts of sulphuric acid and water are mixed, the density is augmented by 13 per cent.; of nitric acid and water, the increase is equal to one-twelfth; and when water and pure alcohol are mixed, it is rather more than one-twenty-eighth of the whole weight. These mixtures are cases of real chemical combination; the force which holds them combined being that of chemical attraction exerted between the integrant particles of the two liquids.

II. TABLE *exhibiting a list of the Liquids that unite with each other only in certain proportions.*

Water with ether.
———— volatile oils.
———— sulphuret of carbon.
———— oxymuriate of tin.
Alcohol with volatile oils.
———— petroleum.
———— supersulphureted oxygen?
———— phosphuret of sulphur?
Ether with volatile oils.
———— petroleum.
Volatile oils with petroleum.

Water dissolves rather less than one-tenth of its bulk of sulphuric ether; and the proportion of volatile oil it takes up is also very minute; being scarcely more than is sufficient to communicate its odour to that liquid, without any other of its properties. It has been already stated, that twenty-two parts of the fuming oxymuriate of tin mixed with seven of water unite and condense into a solid mass. Although alcohol unites readily with the volatile oils, yet the quantity of each is limited: and the proportion of petroleum which alcohol dissolves is also very small. The proportions of volatile oils and petroleum which ether dissolves are considerable.

The affinity of the compounds of this table is much weaker than of those of the former; which, " with the difference between the cohesion of the particles of the two liquids, limits the combination to certain proportions." They are also more easily decomposed; for, if a spirituous solution of volatile oil be poured into water, the alcohol leaves the volatile oil to unite with the water, while the greater part of the separated oil swims on the surface of the new compound.

III. TABLE *exhibiting the principal Liquids which do not sensibly combine in any proportion.*

Water with petroleum.
———— fixed oils.
———— supersulphureted hydrogen.
Fixed oils with alcohol.
———— ether.
Mercury with water.
———— alcohol.
———— ether.
———— volatile oils.
———— petroleum.

In these cases the affinity between the two liquids is not sufficient to overcome the cohesion between the particles of each liquid. The spreading of oil, however, upon the surface of water, and adhering to it, is supposed to depend on the exertion of some degree of affinity, although less than is requisite to produce a combination of the two liquids.

If a liquid have an affinity for one of the constituents of another liquid, although not for the liquid itself, it frequently decomposes it, and forms new compounds.

IV. TABLE *of the principal Liquids which decompose each other.*

Water, by phosphuret of sulphur.

Nitric acid, by all the liquids, except water and sulphuric acid.

Sulphuric acid, by all the liquids, except nitric acid and water.

During the first case of decomposition, which is facilitated by a high temperature, sulphureted and phosphureted hydrogen exhale, and sulphuric and phosphoric acids are formed.

The combinations of solids, reduced to the liquid state, are regulated by the very same laws as those of proper liquids.

3. OF THE COMBINATION OF LIQUIDS WITH SOLIDS.

The principal liquids, the action of which upon solids has been examined, are *water*, *alcohol*, *ether*; *petroleum*, *volatile oils*, *fixed oils*, *mercury*, and the *acids*, which have been already noticed.

a. Water enters into combination with solid bodies in two states. In the first the proportion of solid matter exceeds that of water, and the liquid becomes a part of the solid body without rendering it liquid; in the second, the solid is much exceeded by the quantity of fluid, which liquefies it, and imposes its peculiar form upon the compound. The products of the first state are denominated *hydrates*; the second constitutes *solutions*.

I. TABLE *of hydrates or compounds of solid bodies and water, still retaining the solid form.*

1. *Sulphur* is found native in the state of a hydrate; but the hydrate most generally known is precipitated sulphur, (*Part* iii. p. 389.)
2. *Metallic oxides*, when in the state of hydrates, are powders possessed of very intense colour, having usually a strong taste, and being easily acted upon by acid or alkaline solutions.
3. *Earthy hydrates* are powders, and sometimes crystals.
4. *Alkaline hydrates* are what are commonly termed the crystals of alkalies.
5. *Acid hydrates* are those acids which are generally procured in a solid state, and known under the name of crystallized acids.
6. *Saline hydrates* comprehend the whole class of saline preparations, whether assuming the form of crystals, powders, or solid masses.
7. *Hydrates of hydrosulphurets* are the crystallized hydrosulphurets.
8. *Soaps* are hydrates, water being always present in them as a constituent.
9. *Tannin* and many animal and vegetable solids.

In the two last classes the proportion of combined water does not appear to be determinate, although this is the case with all the others.

Solution.—During solution, both bodies, or the solid and the liquid, act mutually upon each other at the same time; and the force exerted by each is equal to its mass. The action goes on at the point of contact only: hence, as far as the mass is concerned, the quantity of liquid has no effect in hastening the solution. When a solid body is plunged into a liquid, if the affinity between them be weak, the combination of the two goes on as long only as the force of the affinity is able to overcome the force of cohesion of the particles of the solid; when it stops, the compound remains solid, and is consequently a *hydrate*. But if the affinity be strong, the cohesion of the solid is gradually destroyed, and its particles being united with those of the liquid are dispersed equally through it, forming a *solution*. By the addition, however, of new portions of the solid, the action of the liquid is gradually weakened; and at length, being unable to overcome the cohesion of the solid, no more of it is dissolved. In this case, the sums of the force of the attraction of affinity exerted between the solid and the liquid, and of the force of the cohesive attraction of the particles of the solid for each other, are balanced; and the liquid is said to be *saturated.* The union of the two bodies is effected by chemical combination. If a portion of the liquid be now abstracted, (as for example by evaporation,) the force of the cohesive attraction of the particles of the solid becomes again superior to the force of the affinity which separated them, so that the solid is reproduced. When this is slowly accomplished, it produces crystallization, the phænomena of which have been already noticed.

In the formation of hydrates the increase of density is often very great, and much caloric is evolved. Thus, hydrate of lime is specifically heavier than pure lime. Hydrate of alum, which is simply crystallized alum, has a specific gravity of 1·7065; but when its water is driven off by calcination, the gravity is reduced to 0·4229; and crystallized nitrate of potash, or hydrate of nitre, is of the specific gravity 1·9639; but nitre deprived of its water of crystallization is only 1·7269.

The density of solutions is greater than the mean, when pure solids are employed; but when it is the hydrates which are dissolved, the specific gravity is more generally less than the mean. The following useful Tables, drawn up by Hassenfratz, show the specific gravity of saline solutions containing different proportions of salt, at 55°.[1] By consulting them we can readily know the exact quantity of salt contained in any saline solution of a specific gravity corresponding with the numbers marked in the tables; and when the gravity of the solution is not found in the tables, its saline contents can still be found by calculation.

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[1] The salts were generally in the crystallized state. The column belonging to each salt terminates at the point of saturation, at the temperature of 55°.

TABLE OF SALINE SOLUTIONS.

Weight of Salt in 100 parts of the Solution.	Sulphate of Soda.	Sulphate of Potash.	Alum.	Weight of Salt in 100 parts of the Solution.	Sulphate of Magnesia.	Sulphate of Iron.	Sulphate of Zinc.	Sulphate of Copper.
1	1·0039	1·0086	1·0047	2	1·0096	1·0096	1·0080	1·0141
2	1·0078	1·0171	1·0094	4	1·0192	1·0203	1·0165	1·0280
3	1·0116	1·0257	1·0142	6	1·0286	1·0314	1·0255	1·0413
4	1·0154	1·0343	1·0189	8	1·0379	1·0436	1·0345	1·0539
5	1·0192	1·0429	1·0236	10	1·0470	1·0560	1·0440	1·0660
6	1·0230	1·0515		12	1·0555	1·0696	1·0540	1·0795
7	1·0268			14	1·0646	1·0829	1·0665	1·0938
8	1·0306			16	1·0711	1·0961	1·0790	1·1083
9	1·0344			18	1·0771	1·1095	1·0915	1·1230
10	1·0381			20	1·0860	1·1220	1·1040	1·1380
11	1·0418			22	1·0976	1·1358	1·1165	1·1513
12	1·0455			24	1·1092	1·1498	1·1290	1·1747
13	1·0492			26	1·1178	1·1638	1·1420	
14	1·0528			28	1·1324	1·1781	1·1550	
15	1·0564			30	1·1440	1·1920	1·1680	
16	1·0598			32	1·1557	1.2031	1·1820	
				34	1·1675	- -	1·1960	
				36	1·1789	- -	1·2100	
				38	1·1905	- -	1·2240	
				40	1·2122	- -	1·2380	
				42	1·2262	- -	1·2525	
				44	1·2302	- -	1·2680	
				46	1·2432	- -	1·2855	
				48	1·2562	- -	1·3045	
				50	1·2683	- -	1·3310	
				52	1·2833	- -	1·3485	
				54	1·2973	- -	1·3565	

TABLE OF SALINE SOLUTIONS—*continued.*

Weight of Salt in 100 parts of the Solution.	Muriate of Soda.	Muriate of Potash.	Hyperoxymuriate of Potash.	Muriate of Ammonia.	Muriate of Barytes.	Weight of Salt in 100 parts of the Solution.	Muriate of Magnesia.	Muriate of Lime.
1	1·0064	1·0047	1·0055	1·0029	1·0073	2	1·0068	1·0125
2	1·0128	1·0095	1·0105	1·0059	1·0146	4	1·0136	1·0212
3	1·0192	1·0143	1·0150	1·0089	1·0217	6	1·0204	1·0319
4	1·0256	1·0192	1·0193	1·0118	1·0289	8	1·0274	1·0429
5	1·0320	1·0240	1·0220	1·0149	1·0360	10	1·0340	1·0540
6	1·0384	1·0288	1·0301	1·0179	1·0430	12	1·0408	1·0650
7	1·0448	1·0338	1·0376	1·0209	1·0503	14	1·0476	1·0759
8	1·0502	1.0388	1·0461	1·0239	1·0575	16	1·0554	1·0870
9	1·0576	1·0438	1·0567	1·0269	1·0647	18	1·0612	1·0979
10	1·0640	1·0490	- -	1·0300	1·0720	20	1·0681	1·1000
12	1·0775	1·0612	- -	1·0358	1·0919	22	1·0751	1·1212
14	1·0910	1·0701	- -	1·0416	1·1014	24	1·0823	1·1323
16	1·1045	1·0801	- -	1·0474	1·1309	26	1·0895	1·1445
18	1·1182	1·0901	- -	1·0532	1·1504	28	1·0967	1·1547
20	1·1320	1·1000	- -	1·0590	1·1700	30	1·1040	1·1670
22	1·1462	1·1090	- -	1·0642	1·1901	32	1·1114	1·1803
24	1·1608	1·1178	- -	1·0693	1·2227	34	1·1190	1·1935
26	1·1760	1·1264	- -	- -	1·2363	36	1·1266	1·2067
28	1·1920	1·1344	- -	- -	1·2600	38	1·1343	1·2198
30	1·2100	1·1420				40	1·1420	1·2330
						42	1·1507	1·2478
						44	1·1597	1·2528
						46	1·1686	1·2789
						48	1·1777	1·2949
						50	1·1870	1·3120
						52	1·1963	1·3310
						54	1·2068	
						56	1·2164	
						58	1·2261	
						60	1·2380	
						62	1·2507	
						64	1·2646	

TABLE OF SALINE SOLUTIONS—*continued.*

Weight of Salt in 100 parts of the Solution.	Nitrate of Potash.	Acetate of Lead.	Acetate of Iron.	Tar-trate of Soda.	Tar-trate of Potash.	Phos-phate of Soda.	Borax.	Soda of Com-merce.	Ameri-can Potash.
1	1·0063	1·0070	1 0035	1·0034	1·0050	1·0040	1·0040	1·0042	1·0050
2	1·0125	1·0140	1·0075	1·0072	1·0102	1·0081	1·0084	1·0086	1·0102
3	1·0186	1·0211	1·0112	1·0108	1·0153	1·0120	1·0122	1·0130	1·0156
4	1·0244	1·0283	1·0150	1·0148	1·0212	1·0166	- -	1·0175	1·0212
5	1·0302	1·0366	1·0188	1·0190	1·0258	1·0200	- -	1·0220	1·0269
6	1·0353	1·0430	1·0225	1·0231	1·0311	1·0237	- -	1·0264	1·0327
7	1·0408	1·0505	1·0264	1·0272	1·0363	1·0270	- -	1·0310	1·0385
8	1·0468	1·0580	1·0302	1·0313	1·0417	1·0300	- -	1·0356	1·0443
9	1·0531	1·0655	1·0341	1·0355	1·0470	- -	- -	1·0403	1·0503
10	1·0595	1·0731	1·0380	1·0397	1·0525	- -	- -	1·0458	1·0563
12	1·0722	1·0891	1·0458	1·0481	1·0634	- -	- -	1·0544	1·0684
14	1·0850	1·1055	1·0537	1·0567	1·0744	- -	- -	1·0640	1·0807
16	1·0984	1·1221	1·0616	1·0655	1·0856	- -	- -	1·0736	1·0930
18	1·1119	1·1330	1·0697	1·0745	1·0968	- -	- -	1·0833	1·1053
20	1·1235	1·1560	1·0780	1·0837	1·1080	- -	- -	1·0930	1·1179
22	1·1389	1·1740	1·0863	1·1032	1·1196	- -	- -	1·1031	1·1307
24	1·1520	1·1928	1·0948	1·1153	1·1317	- -	- -	1·1135	1·1438
26	- -	- -	1·1045	1·1283	1·1447	- -	- -	1·1241	1·1571
28	- -	- -	1·1140	1·1436	1·1569	- -	- -	1·1349	1·1724
30	- -	- -	1·1224	1·1600	1·1700	- -	- -	1·1460	1·1840
32	- -	- -	1·1323	1·1801	1·1838	- -	- -	- -	1·1989
34	- -	- -	- -	- -	1·1978	- -	- -	- -	1·2142
36	- -	- -	- -	- -	1·2118	- -	- -	- -	1·2304
38	- -	- -	- -	- -	1·2259	- -	- -	- -	1·2478
40	- -	- -	- -	- -	1·2400	- -	- -	- -	1·2660
42	- -	- -	- -	- -	1·2547	- -	- -	- -	1·2882
44	- -	- -	- -	- -	1·2696				
46	- -	- -	- -	- -	1·2861				
48	- -	- -	- -	- -	1·3015				
50	- -	- -	- -	- -	1·3180				
52	- -	- -	- -	- -	1·3351				
54	- -	- -	- -	- -	1·3527				
56	- -	- -	- -	- -	1·3707				
58	- -	- -	- -	- -	1·3902				
60	- -	- -	- -	- -	1·4120				

If a new substance be added to the saturated solution of another substance, the result is different according to the nature of the matters employed. Sometimes the second substance is not dissolved: thus a saturated solution of muriate of lime at 60° cannot dissolve any common salt. Sometimes the whole, or a part of the new solid, is dissolved without any of the already combined solid being lost or precipitated: thus a saturated solution of nitrate of potash at 51° can dissolve more muriate of soda than pure water, and the same is the case with nitrate of soda; but in the latter case, a great portion of the nitrate is precipitated. Sometimes the new solid is dissolved at the expence of the whole of the substance already dissolved, which is consequently precipitated: thus, if a sufficient quantity of muriate of soda be added to a saturated solution of muriate of ammonia at 61°, the former salt is dissolved, but the whole of the latter precipitates during its solution. This last result, however, does not take place at every degree of temperature; for at a boiling heat muriate of soda is separated by those very salts which it precipitates at a low temperature.

b. Alcohol acts less extensively upon solids than water; and it forms no solid combinations similar to the hydrates.

Table of the solids which Alcohol is capable of dissolving.

1. Sulphur.
2. Phosphorus, and its compounds.
3. Fixed alkalies.
4. Some of the alkaline earths in minute portions.
5. Most of the solid acids.
6. Many salts.
7. Alkaline sulphurets.
8. Alkaline soaps.
9. Tannin, and many vegetable substances.

A mixture of water and alcohol appears to possess greater energy as a solvent in many cases than either of them in a separate state.

c. The action of ether upon solids is still more limited than that of alcohol.

d. The action of mercury as a liquid is altogether confined to the metals, for many of which it has a considerable affinity, and forms compounds with them which are denominated *amalgams.* None of these are objects of pharmacy.

III. GASES.

Gases are aëriform fluids possessed of very different properties, but all agreeing in that peculiar kind of elasticity which constitutes aërial bodies.

1. CONSTITUTION OF GASES.

The particles of *gases,* like those of liquids, are moveable upon each other; but *gases differ from liquids* in possessing elasticity, or that power which allows them to be compressed into a smaller bulk; and by which, however large a portion of any gas contained in a vessel be taken away, the small portion which is left is enabled to expand so as to fill the vessel. The bulk of common air may be thus easily reduced or increased 3000 times; and indeed there does not appear to be any limit to expansion. These properties of airs depend on the repulsion which exists between their component particles; and the force of which, according to Newton, is always inversely as the distance of their centres from each other. As gases contain a larger proportion of combined caloric than any other class of bodies, it is very probable that caloric is the cause of the repulsion which exists between their particles, or of their elasticity; and hence the addition of sensible heat to gases increases their elasticity, while the abstraction of it, or the application of cold, diminishes it. No degree of compression, nor abstraction of caloric, can alter the constitution of real gases or airs; but by these means, others and all the vapours can be reduced to the liquid or even the solid state.

Arrangement of the known gases according to their composition.[1]

I. SIMPLE GASES.

1. Oxygen gas.
2. Hydrogen gas.
3. Azotic gas.
4. Oxymuriatic acid gas (Chlorine.)
5. Sulphur vapour.
6. Iodine vapour.

II. COMPOUND GASES.

a. Simple gases combined.

7. Hydriodic acid.
8. Hyperoxymuriatic acid gas (protoxide of chlorine.)
9. Nitrous gas (protoxide of azote.)
10. Nitrous oxide (deutoxide of azote.)
11. Muriatic acid gas.
12. Steam.[2]
13. Ammonia.

b. Oxygen and a solid base.

14. Carbonic oxide.
15. Carbonic acid gas.
16. Sulphurous acid gas.
17. Sulphuric acid vapour.

c. Hydrogen and a solid base.

18. Cyanogen.
19. Olefiant gas.
20. Carbureted hydrogen gas.
21. Phosphureted hydrogen gas, hydroguret of phosphorus.
22. Bihydroguret of phosphorus.

d. Fluorine, chlorine, cyanogen, with a base.

23. Fluoboric acid.
24. Chlorocyanic acid.
25. Hydrocyanic (Prussic) acid.
26. Chlorocarbonic acid.

e. Triple or quadruple compound gases.

27. Hydriodic ether.
28. Chloric ether.
29. Sulphuric ether.
30. Muriatic ether.
31. Vapour of alcohol.
32. ——— of oil of turpentine.

All these gases are invisible, except the oxymuriatic acid and the hyperoxymuriatic acid, which have a yellowish green

[1] *Thomson's Chemistry*, 4th edit. iii. 437.

[2] Steam is not, in strict language, a gas; but a condensable vapour.

colour; but when gases of very different specific gravity are mixed together, they become in a certain degree visible. With respect to the specific gravity of gases, there is a greater difference between them under the same pressure, and at an equal temperature, than exists between liquid substances; a circumstance which must depend either on a difference of the repulsive force, or of the weight of the atoms in different gases.

A Table of the density and weight of 100 *cubic inches of the gases at the temperature of* 60°, *and a barometric pressure of* 30°.

	Specific Gravity.	Weight of 100 cubic Inches.		Specific Gravity.	Weight of 100 cubic Inches.
Air - -	1·000	30·5	Olefiant Gas -	0·974	29·720
Oxygen -	1·111	33·888	Carbureted hydrogen	0·555	16·99
Hydrogen -	0·0694	2·117			
Azote - -	0·9722	29·652	Hydroguret of Phosphorus - -	0·9022	27·517
Chlorine - -	2·500	76·250			
Sulphur Vapour -	1·111	33·888	Bihydroguret of Phosphorus -	0·9716	29·634
Vapour of Iodine -	8·678	264·679	Fluoboric Acid -	2·3709	72·312
Hydriodic Acid -	4·375	133·434			
Protoxide of Chlorine	2·440	74·420	Chlorocyanic acid vapour - - -	2·152	65·636
Protoxide of Azote -	1·5278	46·598			
Deutoxide of Azote	1·0416	31·769	Hydrocyanic acid vapour - - -	0·9368	28·572
Muriatic Acid -	1·284	39·162	Chlorocarbonic Acid	3·472	105·896
Steam - -	0·625	19·062	Hydriodic Ether -	5·475	156·987
Ammonia -	0·590	18·000	Chloric Ether -	3·474	105·957
Carbonic Oxide -	0·9722	29·652	Sulphuric ether vapour	2·586	78·873
Carbonic Acid -	1·527	46·373	Muriatic Ether -	2·219	67·679
Sulphurous Acid	2·222	67·771	Alcohol Vapour -	1·6133	49·206
Sulphuric Acid -	2·777	84·698			
Cyanogen -	1·804	55·028	Oil of Turpentine Vapour - -	5·013	152,896

Water is a constituent of almost every gaseous body; and the quantity of it contained in each depends upon the bulk, not the density, of the gas. It also appears probable, that the weight of it contained in 100 inches of all gases under the same pressure, and at the same temperature, is very nearly the same. It can be separated, in a great degree, by very dry alkalies, lime, and other matters which have a powerful attraction for water; but the whole of the moisture cannot be absorbed by these substances; and it does not appear that gases cannot exist independent of the presence of water. The quantity present in any gas is regulated, in a great degree, by the temperature: for, if this be high, a much larger proportion of moisture can be retained in the elastic form; but in a low temperature it is deposited.

Vapours differ from gases in several particulars. Their "elasticity does not increase as the pressure, like that of gases;" they can be condensed by pressure, and by the abstraction of caloric, into liquids. By the latter mode, also, some of those bodies which are regarded as real gases, such as ammonia and oxymuriatic gas, are reduced to the liquid form. The elasticity of the majority of vapours is sensible at a high temperature only; but some become sensibly elastic at the common temperature.

2. OF THE MIXTURE OF GASES WITH GASES.

1. Gases may be mixed together in the same manner as liquids, and with nearly similar results. Some never intimately combine, or are merely mechanically mingled, while others unite closely, and form new chemical compounds, possessing properties very different from those of their components.

TABLE *of gases which may be mixed together without any apparent change in their state.*

i. Gases that may be mixed, but which do not combine.
- Oxygen with fluoboric, fluosilic, and carbonic acid gases.
- Hydrogen with muriatic acid, fluoboric acid, and fluosilic acid; carbonic oxide, olefiant gas, carbureted hydrogen, phosphureted hydrogen, sulphureted hydrogen, and ammoniacal gas.
- Azote, with almost all the other gases.
- Fluoboric acid and fluosilic acid, with all the other gases.

ii. Gases which mix without any change, but may be made to combine.
- Oxygen with oxymuriatic acid, iodine, hydrogen, azote, carbonic oxide, sulphurous acid, and nitrous oxide.
- Hydrogen with oxymuriatic acid, iodine, and azote.

iii. Gases which mix without change, but may be made to decompose each other.
- Oxygen with carbureted hydrogen, bihydroguret of phosphorous, olefiant gas, sulphureted hydrogen, cyanogen, and ammonia.
- Hydrogen with carbonic acid, nitrous gas, nitrous oxide, and sulphurous acid.

Although these gases, when simply mixed, do not chemically combine, or act on each other, yet the mixtures, even independent of agitation, are homogeneous compounds, or the gases do not arrange themselves according to their gravities, but are all equally diffused throughout the mixtures, and when once mixed never afterwards separate. The bulk also, after mixture, is exactly equal to the sum of the bulks of the gases which have been mixed; or each gas occupies the same space as when separate; and the specific gravity of the mixture is exactly the mean of that of the gases mixed. Hence the mixture of these gases appears to be a species of combination, similar to that which takes place in mixing together vinegar and water, or similar liquids.

Vapours and gases unite in nearly the same manner as gases and gases; and this combination enables the vapour to sustain the pressure of the incumbent atmosphere, without being condensed, which it could not otherwise support. They are also retained together by a species of affinity, sufficient to cause their intimate and uniform mixture, but not strong enough to produce chemical combination.

2. Of the gaseous bodies which chemically unite when they are mixed, "some combine in all circumstances by mere mixture; others unite only in particular states."

TABLE *of the gases which unite by simple mixture, and of the products formed by the combinations.*

Names of gases.	*Products.*
Oxygen with nitrous gas	Nitrous acid. Nitric acid.
Ammoniacal gas with vapour	Liquid ammonia.
——— ————-- muriatic acid......	Muriate of ammonia.
——————-- fluoboric acid	Fluoborate of ammonia
——————-- carbonic acid	Carbonate of ammonia
——————-- sulphurous acid	Sulphite of ammonia
——————-- sulphureted hydrogen	Hydrosulphuret of ammonia.

The two first of these products are vapours, the third is a liquid, and the rest are solid bodies.

a. Oxygen and nitrous acid unite in two different proportions; or 100 volumes of oxygen gas is capable of uniting with 133, and also with 200 volumes of nitrous gas. The first proportions produce nitric acid, which, as nitrous gas is a compound of $66\frac{2}{3}$ volumes of azote, and $66\frac{2}{3}$ of oxygen, therefore, appears to be a compound of $166\frac{2}{3}$ volumes of oxygen combined with $66\frac{2}{3}$ of azote; the second produce nitrous acid, or nitric acid saturated with nitrous gas, which appears on the same principles to be a compound of 200 volumes of oxygen united to 100 of azote. It is, however, probable, that these gases will combine in different proportions from the above, and produce nitric acid, containing various proportions of nitrous gas in solution. The immediate effect of their combination is the formation of a yellow-coloured vapour.

b. Ammoniacal gas and *aqueous vapour* combine the moment they are brought into contact, and are condensed to a liquid; but the exact proportions are unknown.

c. Ammoniacal gas and *muriatic acid gas* unite when equal volumes of each are brought into contact; and the result of the mixture is a mutual condensation into a white powder, or muriate of ammonia. If 100 cubic inches of muriatic acid gas, therefore, weigh 59·80, and the same bulk of ammoniacal gas 18·67 grains troy, muriate of ammonia must be a compound of 3 parts of muriatic acid by weight, united to 1 part of ammonia.

d. Ammoniacal gas and *carbonic acid* unite in equal volumes, and condense into a solid salt, which is carbonate of ammonia. The combinations of this gas with the *fluoboric acid* are more varied, while with *sulphurous acid* and sulphureted hydrogen it also unites in equal volumes, and forms solid compounds.

TABLE *of gases which mix without chemically combining, but may be made to combine; and of the products formed by the combinations.*

Names of gases.	*Products.*
Oxygen with hydrogen	Water.
——— carbonic oxide	Carbonic acid.
——— azotic gas	Nitric acid.
——— muriatic acid	Oxymuriatic acid?
——— oxymuriatic acid	Hyperoxymuriatic acid?
——— sulphurous acid	Sulphuric acid.
——— nitrous oxide	Nitric acid.

a. The two first combinations may be effected by combustion, and the third by electricity. It has been supposed that the heat in these cases acts indirectly only, and produces the combination by forcibly expanding one portion of the gas, and thence producing a sudden compression in the neighbouring portions, so that some of the atoms of the two gases, being brought within the sphere of action of the attraction of affinity, combine; while the caloric evolved by this union occasioning the same expansion to be constantly renewed, the whole gaseous mixture is by degrees combined. This theory is confirmed by the experiments of Biot, which proved that oxygen and hydrogen gases can be made to combine by simple pressure.

b. The combination of *oxygen gas* with *muriatic* and *oxymuriatic acids* has been rendered at least problematical by the experiments of Sir H. Davy: but as the question is still *sub judice*, I have retained the old opinions.[1]

c. *Oxygen gas* and *sulphurous acid gas* probably combine when simply mixed together, but the fact has not been ascertained in a decisive manner. They undoubtedly combine in a red heat: it is, however, probable that the combination is not direct, but that a portion of the sulphur is first separated, and then enters into combustion.

All these gases suffer condensation when they combine. The following TABLE exhibits at one view the principal facts connected with their combinations.[2]

Constituent gases.	Proportions.	Specific gravity of each.	Compounds produced.	Calculated gravity of the compound.	Real specific gravity.	Bulk of the compound.	Condensation.
Oxygen - - - - Hydrogen - - -	59·8 10·	0.675* 0.065	Steam.	0·287	0·700	41·	59·
Oxygen - - - - Carb. oxide - - -	31· 69·	1·103 0·956	Carbonic acid.	0·997	1·500	66·4	33·6
Oxygen - - - - Azote - - - -	70·23 29·77	1·103 0·978	Nitric acid.	1·062	2·427	43·7	56·3
Oxygen - - - - Sulphurous acid -	24·3 147·0	1·103 2·265	Sulphuric acid.	1·970			
Oxygen - - - - Nitrous oxide - -	175· 158·	1·103 1·603	Nitric acid.	1·292	2·427	53·	47·†
Oxygen - - - - Nitrous acid - -	78· 158·	1·103 1·603	Nitric acid.	1·394	2·427	57·4	42·6†

* The temperature at which the gravity in this case is taken is 212°; all the rest are taken at 60°.

† The condensation stated in these two columns is hypothetical.

TABLE *of the principal gases which mutually decompose each other when mixed together.*

Oxygen with ....Phosphureted hydrogen.
Oxymuriatic acid with ....Ammonia.
———————— ....Phosphureted hydrogen.
———————— ....Carbureted hydrogen.
———————— ....Olefiant gas.
———————— ....Sulphureted hydrogen.

[1] I am the more induced to adhere to the old opinions, from the convincing proofs of their accuracy, which have been lately advanced by my friend Dr. Murray. Vide *Experiments on Muriatic Acid Gas, &c. Edinburgh Transactions*, 1818.

[2] This Table is copied from that drawn up by Dr. Thomson (*Syst. of Chemistry*, 4th edit. iii. 477.); but I have left out the columns relating to the combination of oxygen with the muriatic and oxymuriatic acids, for the reasons already stated.

Oxymuriatic acid with ....Nitrous gas.
Sulphureted hydrogen with ...Nitrous gas.
——————————— ...Sulphurous acid.

All these gases, except the oxygen and hydrogen, are compounds. The three first decompositions are attended with combustion.

a. Phosphureted hydrogen with *oxygen*. The first of these gases may be regarded as phosphorus dissolved in hydrogen; and consequently in that state which enables oxygen to act upon it at the ordinary temperature of the atmosphere. When the proportion of phosphorus is considerable, the combustion is extremely brilliant, and the caloric evolved is sufficient to set fire to the hydrogen. The products, when the combustion is incomplete, are water, phosphorous acid, and hypophosphorous acid; but when it is complete, they are water and phosphoric acid.

b. Oxymuriatic acid and *ammonia* when brought into contact, excite spontaneous combustion; but none of the azote, which forms one constituent of the ammonia, enters into combination with the oxygen.

c. Phosphureted hydrogen gas, when mixed with oxymuriatic gas, burns, and exhibits a lively combustion. Both the components of the first gas combine with the oxygen, affording as products water and phosphoric acid, while common muriatic acid is evolved.

d. Oxymuriatic acid gas, when mixed with the heavy inflammable gases, does not occasion combustion, but slow and imperceptible decomposition takes place; the constituents of each gas uniting with the oxygen, and forming products corresponding to those of combustion. With nitrous gas it is brought to the state of common muriatic acid; while the nitrous gas is converted into nitric acid. The requisite proportions, according to Humboldt[1], are equal bulks of each gas.

e. Sulphureted hydrogen gas and *nitrous gas* mixed together in a dry state suffer spontaneous decomposition, sulphur is deposited, and nitrous oxide, ammonia, and water, are produced.

TABLE *of gases which mix without spontaneous decomposition, but which may be made to decompose each other by peculiar treatment.*

Oxygen with sulphureted hydrogen.
——————— carbureted hydrogen.
——————— olefiant gas.

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[1] *Ann. de Chimie*, tome xxviii. p. 142.

Oxygen with vapour of ether.
——————— alcohol.
Nitrous oxide with hydrogen.
——————— phosphureted hydrogen.
——————— sulphureted hydrogen.
——————— carbonic oxide.
Nitrous oxide with carbureted hydrogen.
——————— olefiant gas.
——————— vapour of ether.
——————————— alcohol.
——————— sulphurous acid.
Nitric acid with hydrogen, and probably all the preceding combustible gases and vapours.
——————— sulphurous acid.
Nitrous gas with hydrogen.
——————— sulphurous acid.
Hydrogen with sulphurous acid.
——————— carbonic acid.
Vapour of water with carbureted hydrogen.
——————— olefiant gas.

Some of these decompositions are produced by combustion, and are instantaneous; others take place without combustion, and are consequently very slow.

Oxygen and *sulphureted hydrogen gases* when mixed together do not suffer any change; "but if the mixture be made to approach an ignited body, combustion immediately takes place, and the products vary according to the proportion of the gases mixed." In all cases a great proportion of the sulphur is deposited, and some sulphurous acid is formed, owing to the caloric evolved by the combustion of the hydrogen setting fire to a portion of the sulphur.

If *oxygen gas*, in a small proportion, and *carbureted hydrogen*, or *oxygen* and *olefiant gas*, be exploded together, charcoal is deposited, and water and carbonic acid produced; beside which an inflammable gas, named by Berthollet oxycarbureted hydrogen, remains, occupying more than double the space of the original gases. But if the proportion of oxygen be large, that is, twice the bulk of the carbureted hydrogen, and three times that of the olefiant gas, these two gases are completely consumed, and the products are water and carbonic acid.

The *vapours of ether* and of *alcohol*, detonate when certain proportions are mixed with common air, or rather with the oxygen it contains; and the products are carbonic acid and water: the quantity of the former being very considerable when the vapour fired is that of alcohol. If the proportion of the ethereal vapour be one cubic inch, which should weigh 0·7 grains, and that of the oxygen 6·8 inches weighing 2·3 grains, the products will be 4·6 inches of carbonic acid, and a portion of water, resulting from the union of the remaining 2·2 inches of oxygen with 0·10 of hydrogen.

The following TABLE *shows the quantity of oxygen necessary for decomposing* 100 *inches of each of the above gases.*

100 Measures of	Measures of oxygen.	100 Measures of	Measures of oxygen.
Sulphureted hydrogen	75	Vapour of ether	680
Carbureted hydrogen	200	——— alcohol	680[1]
Olefiant gas	200		

When 100 measures of *nitrous oxide* are mixed with 100 of *hydrogen,* and fired by the electric spark, a complete combustion of the hydrogen and decomposition of the nitrous oxide take place, and water and azote are produced. The superior affinity of the hydrogen over azote is in this case aided by the caloric evolved during the combustion of the former gas.

One measure of *phosphureted hydrogen,* and three measures of nitrous oxide, are completely decomposed when exploded by the electric spark, producing water and phosphoric acid, and leaving three measures of pure azote. In this case the proportion of nitrous oxide is sufficient to combine with both the components of the phosphureted hydrogen gas. In the same manner *sulphureted hydrogen gas* is acted on by *nitrous oxide;* and the products of the detonation are water, sulphuric acid, and azote.

When a mixture of *olefiant gas* and *nitrous oxide* is detonated, the products are modified by the quantity of the latter gas employed; when this is large, the constituents of the inflammable gas are both saturated with oxygen, and water, carbonic acid, and azote, are produced; but when a smaller proportion is used, an inflammable gas remains.

In all cases of the combustion of nitrous oxide with inflammable gases the phænomena are analogous to their combustion in oxygen; and the same is the case when mixtures of nitrous gas and the combustible gases are fired by being passed through a red-hot tube. Nitrous gas, however, does not detonate with, nor decompose any of the combustible gases which have been just considered; but when moist iron is placed in contact with nitrous gas, the hydrogen evolved by the decomposition of the water for the oxidizement of the iron, decomposes the nitrous gas, converting it into nitrous oxide, and forming ammonia.

1 *Thomson's Chemistry,* 4th edit. iii. 496.

The other cases of decomposition enumerated in the table are slowly produced by the continued action of elasticity, without any combustion taking place.

The combinations of gases with gases are not immediately effected for the purposes of Pharmacy, but several of them occur during many of the operations for the preparation of the saline and metallic compounds; and therefore require to be known and understood for comprehending the theory of these operations.

2. OF THE COMBINATION OF GASES WITH LIQUIDS.

Water is the only liquid the action of which upon the gases has been accurately examined. In its ordinary state it contains in solution a considerable portion of atmospheric air, which can be separated from it by boiling: and it is then capable of re-absorbing air, and any other gaseous fluid with which it may come in contact. All gases, however, are not equally absorbable; some being taken up in great quantity, and others only in a very small proportion.

TABLE *of gases which are but little absorbable by water, placed in the order of their absorption, beginning with the least absorbable.*

1. Azotic gas.	7. Oxygen gas.
2. Hydrogen gas.	8. Nitrous gas.
3. Arsenical hydrogen.	9. Olefiant gas.
4. Carbureted hydrogen.	10. Nitrous oxide.
5. Carbonic oxide.	11. Carbonic acid.
6. Phosphureted hydrogen.	12. Sulphureted hydrogen.

The quantity of any gas absorbed by water is very much increased by pressure; but by diminishing this pressure the gas again separates in its elastic form. Temperature also regulates the quantity, which diminishes as the temperature increases, owing to every additional increment of caloric augmenting the elasticity of the aëriform fluid. Thus Dr. Henry found that 100 inches of water at 55° absorbed 108 inches of carbonic acid, while at 85° it absorbed only 84 inches.

When water is pure, and the pressure and temperature the same, it then "absorbs a determinate quantity of every individual gas."

TABLE, *exhibiting the bulk of each of the foregoing gases absorbed by* 100 *cubic inches of water at* 60°, *according to the experiments of Mr. Dalton, Dr. Henry, and M. Saussure.*[1]

Names of Gases.	Bulk absorbed by 100 cubic inches of water.		
	DALTON.	HENRY.	SAUSSURE.
Carbonic acid - - - - -	100	108	106
Sulphureted hydrogen -	100	106	253
Nitrous oxide - - - - -	100	86	76
Olefiant gas - - - - - -	12·5	—	15·3
Nitrous gas - - - - - -	3·7	5·	—
Oxygen gas - - - - - -	3·7	3·7	6·5
Phosphureted hydrogen -	—	2·14	—
Carbureted hydrogen - -	3·7	1·4	5·1
Azotic gas - - - - - -	1·56	1·53	4·1
Hydrogen - - - - - -	1·56	1·61	4·6
Carbonic oxide - - - -	1·56	2·01	6·2

From this table, it appears that water absorbs its own bulk, or rather more, of the gases in the first compartment; one-eighth of its bulk of that in the second; one-twenty-seventh of those in the third, and one-sixty-fourth of those in the fourth; and the absorption is in the direct ratio of the densities of the gases.

With regard to pressure, water of the same temperature always takes up the *same bulk* of each gas, whatever be the density of the gas; and therefore, by increasing the pressure sufficiently, water may be made to absorb any quantity of gas. Thus, twice its bulk of carbonic acid will be absorbed under an additional pressure of 30 inches of mercury; three times its bulk under a pressure of 60 inches, and so on. A fact which has been applied to practice, in the manufacture of aërated soda-water, on a great scale. From this circumstance it would appear that the absorbed gas still retains its elasticity; yet it is probable that a chemical attraction is exerted between the particles of the water and those of the gas, and it is taken up until the repulsion between the particles of the absorbed gas just balances the affinity of the water for them. Owing, however, to the weak affinity exerted between the gas and the

[1] *Thomson's Chemistry*, 5th edit. iii. 58.

water, if a quantity of water fully impregnated with any gas, as carbonic acid, for example, be exposed to the atmosphere, or any other gaseous body, the greater part of the absorbed gas escapes from the water and mixes with the superincumbent air; and, therefore, to preserve the impregnation complete, the aërated water must be preserved in well-stopped bottles; or under an atmosphere of the same gas it contains.

Such are the principal circumstances connected with the absorption of the less absorbable gases: those which are more absorbable appear to belong to the class of *acids* and *alkalies.*

TABLE *of the very absorbable gases hitherto examined, placed in the inverse order of their absorbability, with the numbers of measures of each absorbed by one measure of pure water.*[1]

Names of gases.	*Measures absorbed.*
Oxymuriatic acid gas (chlorine) - - -	2
Cyanogen - - - - - - - - - - - -	4½
Sulphurous acid - - - - - - - - -	43·78
Fluosilic acid - - - - - - - - -	363+
Muriatic acid - - - - - - - - -	516
Fluoboric acid - - - - - - - - -	700
Ammoniacal - - - - - - - - - -	780

The water when saturated with these gases undergoes an increase of bulk. The following table exhibits this change, supposing the original bulk to have been 1.[2]

Saturated with	*Cubic inches.*
Oxymuriatic acid gas (chlorine) - -	1·002+
Sulphurous acid - - - - - - - -	1·040
Fluosilic acid - - - - - - - - -	——
Muriatic acid - - - - - - - - -	1·500
Ammoniacal - - - - - - - - -	1·666

The absorption of these gases is the consequence of the exertion of an affinity between them and water; but in every respect the circumstances attending it are exactly the same as those attending the absorption of the former class of gases; except that "most of the gases belonging to the first class experience an expansion when absorbed; while all those of the second undergo a condensation, their affinity for water being greater than their elasticity."

With regard to the absorption of gases by other liquids, scarcely any very decisive experiments have been made.

3. OF THE COMBINATION OF GASES WITH SOLIDS.

From the difference which exists between the constitutions of gases and solids, their combination appears to be opposed by

[1] *Thomson's Chemistry*, 5th edit. iii. 68. [2] Ibid. 68.

the elasticity of the former and the cohesion of the latter; but, nevertheless, under proper circumstances, both the simple and the compound gases combine with solids.

The simple gases are *oxygen*, *hydrogen*, *azote*. Of these oxygen combines with all the known simple solids; hydrogen requires that the solids be brought into a fluid state before it combines with them; and azote combines with one solid only, which is carbon.

a. Oxygen gas unites with carbon in two proportions, and forms *carbonic acid*, and *carbonic oxide*, which are gaseous fluids. Experiment has demonstrated that carbonic acid is composed of 27·27 parts of carbon and 72·73 of oxygen: hence, according to the theory of Dalton, an atom of it must consist of two atoms of oxygen and one of carbon. *Carbonic oxide* is composed of 41 parts by weight of oxygen and 28 of carbon; or of one atom of oxygen and one of carbon. Oxygen combines with boron in one proportion only, forming boracic acid, which is a compound of one atom of boron and two atoms of oxygen, or 100 parts of boron and 228·57 of oxygen.

With phosphorus, oxygen unites in three proportions, and forms *hypophosphorous acid*, *phosphorous acid*, and *phosphoric acid*, which are all solid substances. The proportions of the constituents of these three compounds are the following: hypophosphorous acid consists of 100 of phosphorus and 66·6 of oxygen, or one atom of phosphorus and one of oxygen: phosphorous acid of 100 of phosphorus and 133·3 of oxygen, or of one atom of phosphorus and two of oxygen; and phosphoric acid of 100 of phosphorus and 200 of oxygen, or one atom of phosphorus and three of oxygen.

Oxygen combines with sulphur in the same manner, and forms *hyposulphurous acid*, *sulphurous acid*, and *sulphuric acid*; the first of which is supposed to be a solid, the second and third are gases. According to Dalton's theory, the constituents of hyposulphurous acid are one atom of sulphur and one of oxygen; or of 100 parts of sulphur and 50 of oxygen; one of sulphurous acid, one of sulphur and two of oxygen, or 100 of sulphur and 100 of oxygen: while sulphuric acid, which is found by experiment to be composed of 150 parts by weight of oxygen and 100 of sulphur, is formed by the union of one atom of sulphur to three atoms of oxygen. The oxygen in these compounds is much more loosely combined than in the preceding; and hence the greater facility with which they are decomposed by combustibles.

Oxygen unites readily with the *metals*, forming solid compounds. In them the oxygen is condensed, while the cohesion of the metallic particles is merely weakened, but not overcome.

It has been supposed that the metals combine with determinate proportions only of oxygen, that there are no intermediate combinations, and that in general there are only two degrees of metallic oxidizement. There is reason, however, to believe with Berthollet, that the proportions are indefinite from the commencement to the highest degree of oxidizement of which any metal is susceptible, or to complete saturation; and in cases where determinate proportions are observed, these are owing to peculiar circumstances, which limit the combination, and "which in general being uniform, give rise to an invariable proportion." Thus, if the oxidizement of a metal takes place at its melting point, or at its vaporific point, these being uniform, the oxide will consequently be so, or the same determinate proportion will be observed in the combination. The compounds formed by the combination of oxygen with the metals have a powerful action on the animal œconomy, and are consequently very important objects of pharmacy. In this state metals become, also, capable of combining with acids, and acquire still greater activity; and as the degree of oxidizement varies, so the combination of the oxide in these different states with the same acid forms compounds differing from each other, and exerting various degrees of medicinal power.

b. Hydrogen has a considerable affinity for the simple combustibles; but they do not combine unless the cohesive force, which keeps together the particles of the solid, be overcome, or the hydrogen be exhibited in a nascent state; and, therefore, it is chiefly by the decomposition of water that these combinations are effected. Owing to the great elasticity of hydrogen gas, all the known combinations of it with the simple combustibles, except one, are gases.

Hydrogen unites with *carbon* in three proportions, constituting *olefiant gas*, which is composed of one atom of carbon and one of hydrogen; *carbureted hydrogen*, composed of two atoms of hydrogen and one of carbon; and *ether*, composed of 6 atoms of hydrogen, 5 of carbon, and 1 of oxygen. The first is the most intimate compound of the three, and carbureted hydrogen the next; for neither of these is affected by a red heat; whereas ether is decomposed, and converted into olefiant gas, carbureted hydrogen, and charcoal.

"Sulphureted hydrogen is the most intimate of the combinations of *sulphur* and hydrogen. A red heat does not decompose it." It is commonly formed by the "decomposition of water by the compound agency of an acid and a metal united to sulphur." In this case no obstacle is raised to the combination of the hydrogen, which is nascent, by the attraction of cohesion, the sulphur being just separated from the metal.

The combination of hydrogen with *phosphorus* is also obtained by the decomposition of water, by boiling the phosphorus in a liquid alkali, which retains the phosphorus in a temperature sufficient for enabling it to effect the decomposition. The oxygen of the water unites with one portion of the phosphorus, and forms phosphoric acid; while at the same time the hydrogen unites with the other portion, and forms phosphureted hydrogen.

c. The combinations of *azotic gas* with the simple solid combustibles are not yet sufficiently understood, except its combination with carbon to form *cyanogen*[1], which is a compound of one atom of azote and two atoms of carbon.

The compound gases do not enter into many combinations with solids, if the salts, which the acid gases form with alkalies, earths, and metallic oxides, be excepted; and those formed by ammonia with the solid acids. In general they are rather decomposed. Thus, carbon, phosphorus, sulphur, and many metals decompose nitrous gas, nitric acid, and oxymuriatic acid; and sulphurous acid is decomposed by the metals.

Such are the effects of the combinations of solids, liquids, and gases. The knowledge of the laws which regulate them, and the results of the combinations, are of the utmost importance; the greater number of the operations of pharmacy consisting of the combination of substances, with a view either of obtaining compounds by their direct chemical union, or the products of chemical action resulting from their mutual decomposition.

SECTION III.

PHARMACEUTICAL OPERATIONS AND APPARATUS.

THE operations of pharmacy may be arranged under two classes: —

I. *Operations which are purely mechanical.*

II. *Operations which are performed by chemical powers and agents.*

The first are intended for determining the weight and bulk of bodies, diminishing their cohesion, and separating their in-

[1] This name was imposed upon this gaseous compound by Guy Lussac, who discovered it in 1815; and who found that, in combination with hydrogen, it forms Prussic acid, which he therefore named *hydrocyanic acid*. It may be obtained from exposing dry prussiate of mercury in a small retort to a moderate heat. It is a colourless, transparent, elastic fluid, with a strong, disagreeable odour, soluble in water and alcohol; and highly inflammable.