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

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[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. *Pierotoxine* 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.

[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.