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

II. COMPOUND GASES.

a. Simple gases combined.

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

b. Oxygen and a solid base.

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

c. Hydrogen and a solid base.

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

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

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

e. Triple or quadruple compound gases.

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

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.

[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.

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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.