THE

EDINBURGH

NEW DISPENSATORY.

PART I.

ELEMENTS OF PHARMACY.

1. THE object of Pharmacy is to provide those substances which may be employed for the prevention or cure of disease.

2. To obtain this object completely, an acquaintance with the physical and chemical properties of these bodies is necessary. This may be termed the *Science of Pharmacy.*

3. Few substances are found in nature in a state fit for their exhibition in medicine. The various preparations which they previously undergo constitute the *Art of Pharmacy.*

4. Pharmacy is so intimately connected with Chemistry, that the former can neither be understood as a science, nor practised with advantage as an art, without a constant reference to the principles of the latter. For this reason, it is proper to premise such a view of the general doctrines of chemistry, and of the most remarkable properties of chemical agents, as is necessary for the purposes of pharmacy.

SECT. I.

EPITOME OF CHEMISTRY.

5. THE most minute particles into which any substance can be divided, similar to each other, and to the substance of which they are parts, are termed its *Integrant particles.*

6. The most minute particles into which bodies can ultimately be divided are called their *Elementary particles.*

7. When the integrant particles admit of no further division, the body is a *Simple Substance.*

8. But the integrant particles of most bodies can be subdivided into other particles, differing in their nature from each other, and from the body of which they are parts. These are *Compound Bodies.*

9. If the particles, of which the integrant particles of any compound body are composed,

a. admit of no further division, the body is a *Primary Compound;*

b. but if they be also compound, and admit of still further subdivision, they are called *Intermediate particles*, and the body is a *Secondary Compound.*

10. Therefore the integrant particles

a. of simple substances are also their elementary particles;

b. of primary compounds are composed of elementary particles;

c. of secondary compounds are composed of intermediate particles.

11. The phenomena of matter are regulated by attraction and repulsion.

ATTRACTION.

12. *Attraction* comprehends those forces which cause bodies to approach towards each other.

13. It operates

a. at sensible distances, as in the attractions of *gravity, electricity*, and *magnetism;*

b. at insensible distances; *Contiguous Attraction.*

a. a. between particles of the *same* species, constituting the attraction of *cohesion* or *aggregation;*

b. b. between particles of *different* species, the attraction of *composition* or *affinity.*

REPULSION.

14. *Repulsion* tends to separate bodies from each other.

15. It also operates either

a. at sensible distances, as in the repulsion of *electricity* and *magnetism;* or,

b. at insensible distances, as in the repulsion of the matter of heat or *caloric.*

16. The phenomena resulting from the operation of attractions, and repulsions at insensible distances, constitute the proper objects of chemistry.

GRAVITY.

17. The most general species of attraction is that by which masses of bodies tend to approach each other.

Light, heat, electricity and magnetism alone, seem to be exempted from its influence. Hence those substances have been called, though not correctly, *Imponderable*. They are the *Inconfinable substances* of Dr T. Thomson, the *Etherial* of Sir H. Davy.

a. Gravity acts in the direct ratio of the quantity of matter, and in the inverse ratio of the square of the distance.
b. It is indestructible and uniform.
c. It has no antagonist repulsion.
d. In free space it acts equally on all kinds of matter.
e. In gravitating media, it is different with respect to different kinds of matter; and the relative weights of equal masses of bodies constitute their *Specific Gravity*; water being commonly assumed as unity for solids and fluids, and hydrogen gas sometimes for airs and vapours.
f. The proportions in which bodies unite, seem to be multiples of the specific gravity of their elementary particles.

AGGREGATION.

18. Gravitating bodies exist under different forms of aggregation:
a. Solid, in which the attraction of cohesion resists relative motion among the particles, more or less perfectly, and the fragments are angular, and do not reunite on being placed in contact.
b. Fluid, in which it admits of relative motion among the particles, with greater or less facility, and small portions have a tendency to assume a globular form, and readily reunite on coming into contact.
c. Gaseous, in which the particles repel each other.

AFFINITY.

19. Affinity is regulated by the following laws:

a. It does not act at sensible distances.

b. It is exerted only between particles of different species.

c. It is exerted by different bodies, with different degrees of force; and hence it was called *Elective Attraction*.

d. It unites bodies in definite proportions; and when bodies combine in more proportions than one, these are multiples of each other. Also when more than two bodies unite, they exist in the same proportions, or multiples of the same proportions in which they form binary compounds. Lastly, when oxygenized bodies are combined, each of them contains the same quantity of oxygen, or multiples of the same quantity; and oxygenizable bodies combine in such proportions as will require equal or multiple quantities of oxygen for their oxygenizement.

e. It unites a first proportion of one body with another, more strongly than a second; a second than a third, and so on; and hence it is in the inverse ratio of saturation, and seems to increase with the mass.

f. It is influenced by cohesion, specific gravity, elasticity and temperature.

g. It is often accompanied by a change of temperature.

h. Substances, chemically combined, acquire new properties;

i. and cannot be separated by mechanical means.

k. The action produced by different affinities, existing in one substance, is called *Resulting Affinity*.

20. Affinity is

a. *simple*, when two bodies unite, in consequence of their mutual attraction, whether these bodies be themselves simple or compound, and even although, in the latter case, it be attended with decomposition.

b. *compound*, when there is more than one new combination, and when the new arrangement would not have taken place, in consequence of the attractions tending to produce either combination singly.

21. The attractions which tend to preserve the original arrangement of bodies presented to each other, are denominated *Quiescent attractions*; those which tend to destroy the original, and to form a new arrangement, are termed *Divellent attractions*.

It is evident, that no new arrangement can take place, unless the divellent be more powerful than the quiescent attractions.

SIR H. DAVY'S CLASSIFICATION OF SIMPLE BODIES, WITH THEIR NUMBERS *.

22. A. Etherial substances:
Light.
Caloric.
Electricity.
Magnetism.

B. Empyreal undecomposed substances:
15 Oxygen gas.
33.5 Chlorine. Oxymuriatic gas.

C. Inflammable, or acidiferous substances not metallic:

1	Hydrogen gas.	20	Phosphorus.
26	Nitrogen gas.	11.4	Carbon
30	Sulphur.		Boron.

D. Metals:

75	Potassium.	166	Cobaltum.
88	Sodium.	120	Cuprum.
130	Barium.	111	Nicolum.
90	Strontium.	76.8	Uranium.
40	Calcium.		Osmium.
53	Magnesium.	125	Tungstenum.
33	Aluminum.		Titanium.
39	Glucinum.		Columbium.
70	Zirconum.	86	Cerium
61	Silicum.	134	Palladium.
111	Ittrium.		Iridium.
113	Manganesum.		Rhodium.
66	Zincum.	380	Mercurium.
110	Stannum.	205	Argentum.
103	Ferrum.	372	Aurum.
398	Plumbum.	181	Platinum.
170	Antimonium.	90	Arsenicum.
135	Bismuthum.	88.2	Molybdenum.
74	Tellurium.		Cromium.

Substances not ascertained:
Fluoric principle.
Ammoniacal amalgam.

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* These numbers are the results of experiments, and indicate merely the relative weights in which bodies combine, and are independent of the speculations on the atouic doctrines. In the Appendix will be given more extensive tables of these numbers by Drs Wollaston and T. Thomson, in which oxygen is assumed as 10.

COMPOUND BODIES.

23. Compound bodies may be divided into

a. Primary compounds (9. *a*), consisting of simple substances combined with each other. These may be subdivided into binary, ternary, quaternary, &c. according to the number of their constituents.

b. Secondary compounds, (9. *b*), consisting of compound bodies combined with simple bodies, or with each other.

This division is convenient, but arbitrary, as we are in fact ignorant of what are really simple bodies, and cannot ascertain the manner of combination in bodies compounded of three or more elements.

LIGHT.

24. Light emanates in every direction from visible bodies.

25. It moves in straight lines, with a velocity equal to 164,000 miles in a second.

26. Its gravity is not appretiable.

27. When a ray of light passes very near a solid body, it is *inflected* towards it.

28. When it passes at a distance somewhat greater, it is *deflected* from it.

29. When a ray of light falls upon a polished surface, it is *reflected* from it, and the angle of reflection is equal to the angle of incidence.

30. Some bodies have the property of polarizing and others of depolarizing light.

31. Bodies which do not allow light to pass through them are termed *Opaque*.

32. Those which allow it to pass freely through them are termed *Transparent*.

33. When a ray of light passes obliquely from one medium into another of greater density, it is bent towards the perpendicular; but if the second medium be of less density, it is bent from the perpendicular. The light, in both cases, is said to be *Refracted*.

34. The refracting power of bodies is proportional to their densities, except with regard to inflammable bodies, of which the refracting power is greater than in proportion to their densities.

35. By means of a triangular prism, light is separated by refraction into seven coloured rays; red, orange, yellow, green, blue, indigo, and violet.

36. These rays are permanent, and suffer no further change by reflection or refraction.

37. They differ in flexibility and refrangibility; the red possessing these properties in a less degree than the orange, the orange than the yellow, and so on in the order of their enumeration.

38. The *illuminating power* of the different rays is greatest between the yellow and green, and gradually declines towards both ends of the spectrum.

39. The different colours of bodies depend on their transmitting or reflecting those rays only which constitute their particular colours.

40. White consists of the whole prismatic rays united.

41. Black is the total absence of light, or complete suffocation of all the rays.

42. The sun's rays possess the power of heating bodies.

43. The *heating power* of the different rays is inversely as their refrangibility. But as this power is greatest at some distance beyond the red end of the visible spectrum, it is probable that it is totally independent of the calorific rays.

44. Bodies are heated by light inversely as their transparency, and directly as the number of rays suffocated by them.

45. The sun's rays possess the chemical property of separating oxygen from many of its combinations.

46. The *disoxygenizing power* of the different rays is in proportion to their refrangibility. But as this power is greatest at a small distance beyond the violet end of the visible spectrum, it is probable that it is totally independent of the colorific or calorific rays.

47. Light is absorbed by many bodies, and again emitted by them in the dark.

48. The sources of light are the sun's rays, phosphori, combustion, combination, heat, and percussion.

49. Light is supposed by some to exist in a latent state in all combustible bodies.

CALORIC.

50. Heat, in common language, is a term employed to express both a certain sensation, and the cause producing that sensation. In philosophical language, it is now confined to the sensation, and the term *Caloric* has been adopted to express the cause.

51. The particles of caloric repel each other: it is therefore disposed to fly off in every direction from a body in which it is accumulated, or to pass off by radiation.

52. Caloric is attracted by all other bodies. It has therefore an irresistible tendency so to distribute itself as to produce an universal equilibrium of temperature, or to pass from bodies in which it is accumulated, into bodies in which it is deficient, until the attraction of each for caloric, and the repulsive force of the caloric contained in each become equal to each other.

53. Caloric is radiated most slowly by polished metallic surfaces, and most quickly by rough blackened surfaces.

54. Radiated caloric is admitted most readily by rough blackened surfaces, and most difficultly by polished metallic surfaces.

55. Radiated caloric is transmitted with the velocity of light; and is, in like manner, reflected and refracted.

56. But the passage of caloric through most bodies is immensely slower than radiated caloric.

57. When caloric moves through bodies with this diminished velocity, it is said to be conducted by them. Metals are the best conductors; then stones, glass, dried wood. Spongy bodies, in general, are bad conductors. Fluids also conduct caloric; but as they admit of intestine motion among their particles, they carry it more frequently than they conduct it.

58. *Temperature* is that state of any body, by which it excites the sensation of heat or of cold, and produces the other effects which depend on the excess or deficiency of caloric.

59. The most general effect of caloric is *expansion;* the only real exception to this law being the contraction of water, from the lowest temperature at which it can remain fluid, to 42° 5′ F. This expansion either consists,

a. in a simple increase of volume; or

b. it produces a change of form in the substance heated.

a. a. from solid to fluid; *fusion*, *liquefaction*.

b. b. from solid or fluid to vapour; *vaporization*.

60. Bodies expand gradually, and at all temperatures, so long as they undergo no other change.

61. Bodies differ very much in the degree of gradual expansion, (58. *a*) which equal increments of temperature produce in them. Gases are more expansible than fluids, fluids than solids. The individuals of the latter forms of aggregation also exhibit considerable differences.

62. The change of form (58. *b*) occurs suddenly, and always at certain degrees of temperature.

63. *Vaporization* is much retarded by increase of pressure and facilitated by its diminution, insomuch, that those sub-

stances which, under the ordinary pressure of the atmosphere, seem to pass at once from the state of solid to that of vapour, may, by the application of sufficient pressure, be made to assume the intermediate state of fluidity; while, on the contrary, *all* fluids which have been hitherto tried, begin in a vacuum to boil and to emit vapour, when their temperature is lower, by 120° at least, than their vaporific point, at the ordinary pressure of the atmosphere.

64. From analogy, all bodies are considered as solid when totally deprived of caloric; but they are termed solid, fluid, or gaseous, according to the state in which they exist at the ordinary temperature of the atmosphere. They are also termed fusible or infusible, volatile or fixed, condensible or permanently elastic, according to the effects of caloric upon them.

65. Another very general effect of caloric is *increased temperature.*

a. This effect is constant when bodies retain their form of aggregation, or undergo the gradual species of expansion (58. *a*);

b. but while they undergo the sudden species, (58. *b*) they remain at one determinate temperature, that necessary for their fusion or vaporization, until the change be completed throughout the whole mass.

66. During the time necessary to effect this, the influx of caloric continues as before; and as it does not increase the temperature, it is said to become latent or combined.

67. The caloric necessary for these changes (64.*b*) is best denominated the caloric of fluidity, and the caloric of vaporization; and its quantity is determinate with regard to each substance.

68. The absolute caloric, or total quantity of caloric contained in any body, is perfectly unknown; but the quantity which increases the temperature of any body a certain number of degrees, is termed its Specific caloric, (Capacity for caloric, of Black, Crawford, and others), when its weight is the object of comparison; and by Dr Thomson, its capacity for caloric, when its volume is considered. The specific, and therefore the absolute, caloric of bodies, varies very much.

69. *Incandescence* is the least general effect of caloric, as it is confined to those substances which are capable of supporting the very high temperature necessary for its production, without being converted into vapour or gas.

70. On the living body caloric produces the sensation of heat, and its general action is stimulant. Vegetation and ani-

mal life are intimately connected with temperature, each climate supporting animals and vegetables peculiar to itself.

71. Caloric influences affinity, both on account of the operation of its own affinities, and of its facilitating the action of bodies, by counteracting cohesion. For the latter reason, it also promotes solution, and increases the power of solvents.

72. The general effects of the abstraction of caloric, are *diminution of volume*, *condensation*, *diminution of temperature*, and *sensation of cold*. It also influences affinity, and, in general, retards solution. The abstraction of caloric never can be total; and the attempts to calculate the thermometrical point at which it would take place, although ingenious, are not satisfactory. Those most worthy of attention place it about —1500° F.

73. The means employed to increase temperature are, the rays of the sun, collected by means of a concave mirror, or double convex lens, electricity, friction, percussion, collision, condensation, and combustion. Temperature is diminished by rarefaction, evaporation, and liquefaction.

74. Temperature is estimated relatively by our sensations, and absolutely by means of various instruments. The thermometer indicates temperature by the expansion which a certain bulk of fluid undergoes from the addition of caloric, and by the condensation produced by its abstraction. Mercury, from the uniformity of its expansion, forms the most accurate thermometer; but for temperatures in which mercury would freeze, alcohol must be employed. Air is sometimes used to shew very small variations of temperature. The action of the pyrometer of Wedgwood, which is employed for measuring very high temperatures, depends upon the permanent and uniform contraction of pure clay at these temperatures.

ELECTRICITY.

75. The particles of the electric fluid repel each other, with a force decreasing as the distances increase.

76. They attract the particles of other bodies, with a force decreasing as the distances increase; and this attraction is mutual.

77. They are dispersed in the pores of other bodies, and move with various degrees of facility through different kinds of matter.

a. Bodies, through which they move without any perceivable obstruction, are called *Non-electrics*, or *Conduc-*

tors. Of these the chief are the metals, charcoal, and inflammable metallic compounds.

b. Bodies, through which they move with very great difficulty, are called *Electrics*, or *Non-conductors*. Of these the chief are glass, sulphur, oils, resins and compounds of the metals with oxygen or chlorine, (oxymuriatic acid).

c. Bodies through which they move, but with difficulty, are called *Imperfect Conductors*. Of these we have examples in alcohol and ether.

78. The phenomena of electricity arise

a. from the actual motion of the fluid from a body containing more, into another body containing less of it;

b. from its attraction or repulsion, independently of any transference of fluid.

79. By rubbing electrics on each other, the distribution of the electric fluid in them is altered. On separating them, the one contains more, and the other less, than the natural quantity; or, the one becomes positively, and the other negatively electrified. Positive electricity is also called *vitreous*, and negative also *resinous*.

80. Electrics may also be excited by rubbing them with non-electrics.

81. If a body B be brought into the neighbourhood of an electrified body A, B becomes electrified by position.

82. If a body B be insulated, that is, in contact with electrics only, when brought into the neighbourhood of an electrified body A, B becomes permanently electrified, and the electricity of A is diminished, while a spark passes between them accompanied by sound. If a metallic point be presented to a body negatively electrified, it emits rays of light; if to a body positively electrified, it becomes simply luminous.

83. When a body A has imparted electricity to another body B, they repel each other, unless B shall have afterwards imparted all its electricity to other bodies.

84. Bodies repel each other, when both are positively or both negatively electrified.

85. Bodies attract each other, when the one is positively and the other negatively electrified.

86. If either of the bodies be in the natural state, they will neither attract nor repel each other.

87. The electric spark is accompanied by intense increase of temperature, and will kindle inflammable bodies.

88. Electricity is disengaged during many chemical actions, and it produces very remarkable chemical effects, depending

chiefly on sudden and momentary increase of temperature, and on the light produced.

89. Electricity acts on the living system as a stimulus.

GALVANISM.

90. The phenomena of galvanism seem to depend solely on the agency of electricity, excited during certain chemical actions.

91. It is excited by arranging at least three heterogeneous bodies, two conductors and one imperfect conductor, or two imperfect conductors and one conductor, in such a manner, that they form a connected arc or chain, in which each is interposed between the other two.

92. The pile of Volta, by which it is rendered most manifest, is constructed, by combining a series of simple galvanic arcs into one continuous circle, in one uniform order of arrangement.

93. The solid conductors most capable of exciting galvanism, are the metals and charcoal; and the most efficient imperfect conductors are certain saline solutions.

94. The effects of the simple galvanic circle on the animal body, are the production of a sensation of light when applied to the eye; of an acid taste on the tongue; and the excitement of the muscles through the medium of the nerves.

95. The pile, when well constructed, besides these effects, also gives a shock and spark resembling those of electricity, and is the most powerful instrument of analysis with which we are acquainted.

MAGNETISM.

96. If an oblong piece of iron be suspended freely, it will assume a determinate position with regard to the axis of the earth.

97. When the same end always points in the same direction, it is said to possess polarity, or to be a magnet.

98. The similar poles of two magnets repel each other, and the dissimilar poles attract each other, with a force decreasing as the distances increase.

99. Any piece of iron, when in the neighbourhood of a magnet, is a magnet; and its polarity is so disposed, that the magnet and iron mutually attract each other.

100. Magnetism does not seem to affect sensibility or irritability, or to influence chemical action.

OXYGEN.

101. *Oxygen* is the principle on which most of the chemical qualities of atmospheric air depend. Its tendency to combination is so strong, that it has never been procured in a separate state. Oxygen gas, or the combination of oxygen with caloric, is its most simple form. This is permanently elastic, compressible, transparent, inodorous, and insipid. 100 cubical inches at 60° Fahrenheit, and 30 inches mercurial pressure, weigh about 34 grains. Its specific gravity in relation to water is 0.00135; and in relation to hydrogen, its specific gravity is 15 to 1; its power of refracting light 1958, hydrogen being 1000; and its capacity for heat 4.7, water being assumed as unity. It supports inflammation, is necessary for respiration and vegetation, and is decomposed in all these processes; it constitutes 0.21 of the bulk of atmospheric air. Water at 60° takes up $\frac{1}{27}$ of its bulk of the gas. Oxygen is also a constituent in water, in all acids and metallic oxides, and in almost all animal and vegetable substances. It is separated from many of its combinations by the sun's rays.

102. *Oxygenizement* is an example of chemical union, and is subjected to all the laws of affinity. It requires the presence and contact of oxygen, and of another substance possessing affinity for it.

103. The term *Combustion* has been, by the French chemists, incorrectly extended to all these combinations; for, in common language, that word is applied to cases in which oxygen is not an agent, and always supposes the production of heat and light, although in numberless instances of oxygenizement these phenomena do not appear.

104. Oxygenizable bases attract oxygen with very different degrees of force. This attraction is much influenced by temperature. Thus charcoal, which at ordinary temperatures seems to possess no attraction for oxygen, unites with it rapidly and almost inseparably, when heated to ignition.

105. In many instances, oxygenizement is so strongly opposed by cohesion, that it does not take place unless assisted by a degree of heat sufficient to melt or vaporize the oxygenizable base.

106. It is also often accompanied by the extrication of ca-

loric and light in a very conspicuous degree. To these the term combustion should be confined; and only such oxygenizable bases as are capable of exhibiting these phenomena are combustible. These phenomena depend upon the new compound having a weaker affinity or less capacity than its constituents for light and caloric, which are therefore extricated.

107. If the combustible body be vaporized, flame is produced, and the process is then denominated *inflammation*.

108. By its union with oxygenizable substances, oxygen undergoes various changes in its properties. In many instances the compounds of oxygen are fluid or solid, opaque, coloured, incapable of supporting inflammation, and deleterious to animal or vegetable life. The changes which the oxygenizable bases undergo, are no less conspicuous. Their form, colour, taste, odour, density, permeability to light and electricity, specific caloric, and, finally, their affinities, are often totally altered.

109. When, in consequence of oxygenizement, any substance acquires a sour taste, and the properties of converting vegetable blues to red, and of saturating or destroying the characteristic properties of alkalies and earths, it is said to be acidified, and such compounds are termed *Acids*. In general, they combine with water, in almost any proportion, without suffering any change in their properties, except what depends on dilution.

110. When, on the contrary, a base by oxygenation acquires a harsh, austere, and urinous taste, and the properties of converting vegetable blues to green, and of saturating or destroying the characteristic properties of acids, it may be said to be alkalized, and the compounds are termed *Earths* or *Alkalies*.

111. Earths, in general, are characterized by total want of inflammability, infusibility, fixedness, a specific gravity less than five, inalterability, whiteness, dryness, brittleness, sparing solubility in water, and, in general, insipidity and want of smell, capability of forming chemical compounds with acids, alkalies, sulphur, phosphorus, and oils, and fusibility when mixed with each other, or with alkalies, into colourless glasses, enamels, or porcelains.

112. Alkalies are a class of bodies which are commonly defined to be incombustible, soluble in water, caustic, and capable of neutralizing the acids, of combining with alcohol, oils, earths, sulphur and phosphorus, and of changing vegetable blues and reds to green: but as many of these properties are

possessed in a greater or less degree by substances usually classed with the earths, and as there is a continual gradation from the insipidity, insolubility, and infusibility, of silica, to the causticity, solubility, fusibility, and comparative volatility of potass, they may be both included under the name of Salifiable Bases.

113. When the oxygenized substance does not acquire these properties it is termed an *Oxide;* but many oxides have some of the properties of acids or earths.

114. Many oxides are capable of combining with additional doses of oxygen; those which have only one portion are called *Protoxides,* with two *Deutoxides,* with three *Tritoxides,* and when fully saturated they get the name of *Peroxides.*

115. Oxygen is capable of combining at the same time with two or more substances; and the oxides or acids which result from such combinations are termed Oxides or Acids with a double or triple base.

116. In general, the bases which are least simple, unite with oxygen in the greatest variety of proportion.

CHLORINE.

117. *Chlorine,* Sir H. Davy, (oxymuriatic acid gas of other chemists), is of a yellowish-green colour, has an extremely disagreeable smell, 100 cubical inches weigh 76 or 77 grains, its specific gravity to hydrogen being 33.5 to 1; is irrespirable, and does not support the combustion of charcoal: but phosphorus, and many metals burn spontaneously in it, and it maintains the flame of a taper. It is not changed by heat or cold, or electricity, and when perfectly dry does not act on vegetable colours; but they are quickly destroyed by it when vapour or moisture is present. Water at 60 absorbs about double its volume, weighs 1.003, freezes at 40°, and acquires a strong acrid taste, and disagreeable smell.

118. *Chloride of oxygen (Euchlorine)* was first obtained in a separate state by Sir H. Davy. It is a gas of a bright yellow green colour, having somewhat the smell of burnt sugar. It is not respirable. 100 inches weigh 74 or 75 grains. Even the heat of the hand causes it to explode, 50 parts expanding to 60, consisting of 40 chlorine and 20 oxygene. Metals do not burn in it, but phosphorus and sulphur decompose it. It gradually destroys vegetable colours. Water takes up eight or ten times its volume, and acquires a lemon colour, and a strongly acrid taste, approaching to sour.

119. *Muriatic acid gas* is transparent and colourless. It destroys life, and extinguishes flame. 100 cubic inches weigh between 39 and 40 grains; or its sp. gr. is 0.002315, water being unity; or 17, hydrogen gas being 1. According to Sir H. Davy, it consists of equal volumes of chlorine and hydrogen gas. It decomposes alcohol and oil, and destroys putrid exhalations. Water is capable of absorbing about an equal weight of the gas. Its specific gravity is then 1.500; it is generally of a pale yellow colour, is very volatile, and emits white fumes of a peculiar unpleasant odour. It is further oxygenized by the nitric acid, or, according to Sir H. Davy, de-hydrogenated. *Officinal:* Muriatic acid.

NITROGEN, (AZOTE).

120. *Nitrogen*, or *azotic gas*, constitutes 0.79 parts by bulk of the atmosphere; but as it has few attractions at ordinary temperatures, its principal effect on the chemical properties of the atmosphere seems to be the dilution of the oxygen gas, which in its pure state would be more active than is consistent with the economy of nature. It is permanently elastic, compressible, inodorous, and insipid; it converts very delicate vegetable blues to green; 100 cubic inches weigh between 29 and 30 grains; its specific gravity is 0.0012, water being 1; or 13, hydrogen gas being 1; it is unable to support respiration, vegetation or combustion; it is acidifiable; it dissolves phosphorus and carbon in small quantities, and water absorbs $\frac{1}{75}$ of its volume. Its number is 13 or 26.

121. *Atmospheric air* consists of 21 parts of oxygen gas, and of 79 of azotic gas by measure, or 23.47, and 76.53 by weight; it is transparent, compressible, and permanently elastic; its specific gravity is 0.00123; water being unity, or 13.8, hydrogen being unity; 100 cubic inches weighing 31 grains: it is inodorous and insipid, respirable, and capable of supporting inflammation. The atmosphere also contains other gases, vapour, &c.

122. *Nitrous oxide gas* is composed of 15 in weight of oxygen, and 26 of nitrogen, or of equal volumes of their gases. It does not change vegetable colours; 100 cubic inches weigh between 48 and 49 grains; its specific gravity, hydrogen being 1, is 21; it suffers no diminution when mixed with oxygen gas. Water absorbs nine-tenths of its bulk, at a mean temperature. It does not combine directly with alkalies; it sup-

ports combustion; and its respiration, when perfectly pure, or mixed with atmospheric air, produces the highest excitement of which the animal frame seems capable.

123. *Nitric oxide gas* (nitrous gas) consists, according to Sir H. Davy, of 26 nitrogen and 30 oxygen, or of one volume of nitrogen and two of oxygen gas. It does not change vegetable colours; 100 inches weigh about 32 grains; its specific gravity to hydrogen is 14. When mixed with half its bulk of oxygen gas, the compound condenses into red fumes (nitrous acid), which are entirely absorbed by water. The quantity of oxygen gas which any air contains is sometimes estimated by the diminution of volume which occurs, after a due proportion of nitrous gas has been added. Water absorbs about one-twentieth of its bulk of this gas. It is not inflammable, and only in very few instances supports combustion. It is noxious to vegetation, and its respiration is fatal to animals.

124. *Nitrous acid gas* consists, according to Davy, of 2 measures of nitric oxide gas, and one of dry oxygen gas, condensed to half their volume. It has a deep orange colour, disagreeable smell and sour taste. It reddens litmus paper, and gives a yellow colour to animal substances. 100 cubic inches weigh 65.3 grains, and its specific gravity to hydrogen is 28. It is rapidly absorbed by water, which acquires a tint of green, by ether, oil and sulphuric acid. Its compounds are nitrites.

125. *Hydro-Nitrous acid* is of a brown or red colour, exceedingly volatile, and emitting an intolerable and suffocating odour. By the addition of water, its colour is successively changed to blue, green and yellow.

126. *Hydro-Nitric acid* (aqua fortis) consists of nitric acid combined with water. It is liquid, colourless, and transparent. It is very corrosive, and tinges the skin of a yellow colour. When most concentrated, its specific gravity is 1.5543, and it contains 15 *per cent.* water. It produces heat when mixed with water, and absorbs water from the atmosphere. Acid of 1.42 rises unaltered at 248° Fahrenheit. Below 1.4 it strengthens by being boiled, and above 1.45 it becomes weaker. It is decomposed by many substances. Light converts it in part into nitrous acid gas. When highly concentrated, it sets fire to oils, to sulphuretted hydrogen gas, to iron-filings, and to zinc, bismuth and tin, when poured on them in a state of fusion. It oxygenizes all the metals, except gold, platinum, and titanium. It consists of five parts,

by bulk, of oxygen, and one of nitrogen, combined in the strongest acid with one, and in that of 1.42 with two of water. Its saline compounds are called nitrates.

127. *Chloride of azote.* Nitrogen forms a very singular compound with chlorine. It is obtained by confining chlorine over a saturated solution of nitrate of ammonia, at a very low temperature. The gas is absorbed, and a heavy oil falls, which explodes violently when put in contact with olive oil.

HYDROGEN.

128. *Hydrogen gas* is often found collected in mines and caverns. It is permanently elastic and compressible. 100 cubic inches weigh $2\frac{1}{4}$ grains. Its specific gravity, in relation to water, is 0.000094, being the lightest body with which we are acquainted. It is highly inflammable, burning with a blue flame, when kindled in contact with oxygen gas or atmospheric air, and detonating when mixed with them. It extinguishes flame, and is deleterious to animal life. It dissolves sulphur, phosphorus, carbon, and some of the metals, forming with them peculiar fetid gases. In estimating the specific gravity of the gases, being the lightest of them, it is assumed as unity.

129. *Water* consists of hydrogen combined with oxygen, in the proportion of 14.42 to 85.58 by weight, or two of hydrogen to one of oxygen by volume. Water is transparent, colourless, inodorous, and insipid. As water is assumed as the standard, or unity, in all tables of specific gravity of fluids and solids, it is necessary to know that a cubic inch of it weighs, at 30 inches barometer, and 60° thermometer, 252.422 grains. At 32° it exists in a solid form, and is crystallized. At 212° it expands to 2000 times its bulk, and is converted into a very elastic vapour. It absorbs small quantities of the simple gases, especially oxygen. It dissolves several of the salifiable bases, and in some degree all saline bodies, and is essential to their crystallization. It is composed and decomposed in many instances, and its chemical agency is almost universal.

130. *Ammonia* consists of 1 part of nitrogen and 3 of hydrogen by bulk, or 3 of hydrogen and 13 of nitrogen by weight. It exists in its purest form combined with caloric as a gas, which is perfectly transparent and colourless, elastic and compressible: specific gravity 8 to hydrogen, or 100 inches weigh 18 grains; has a urinous and acrid odour, irritating the nostrils and eyes, and an acrid and caustic taste; does

not dissolve animal substances; is irrespirable; extinguishes flame; colours vegetable blues green; and is decomposed by being transmitted through a red-hot tube, and by the electric spark, into its constituent gases; and by oxygen and atmospheric air at a red heat; and by oxymuriatic acid (chlorine), it is converted into water and nitrogen gas. It is absorbed without change by porous bodies; it dissolves sulphur and phosphorus, and combines readily with water in all its states. Water, at a mean temperature and pressure, is saturated by 670 times its volume of gaseous ammonia, is thereby increased in bulk, and acquires the specific gravity of 0.875. Ammonia combines with all the acids, forming neutral salts. It is formed during the putrefactive fermentation, and is commonly classed with the alkalies. *Officinal.*

CARBON.

131. *Carbon*, in a state of great purity and extreme aggregation, is well known by the name of *diamond*. It possesses a very high degree of lustre, transparency, hardness, and refractive power. It is crystallized, and generally colourless. Its specific gravity is about 3.5. It is insoluble in water, and can neither be melted nor vaporized by caloric. It is a non-conductor of electricity. It is not acted upon by any chemical agent, except oxygen, at very high temperatures. When exposed in oxygen gas to the rays of the sun, concentrated by a very powerful lens, its surface becomes sensibly blackened; it is ignited, and at last consumed. The result of this combustion is carbonic acid gas, which is exactly equal in volume to the oxygen gas consumed; and 100 parts of it consist, according to Messrs Allen and Pepys, of 28.6 of carbon, and 71.4 of oxygen by weight. It combines with iron, forming steel. It is a constituent of almost all animal and vegetable substances; and is obtained from them by exposing them to heat in close vessels.

132. *Plumbago* and *incombustible coal* are carbon in a state of less aggregation and somewhat impure. In the former, it is combined with about $\frac{1}{25}$ of iron; in the latter with earthy matter. The most remarkable known property of these substances is the very high temperature necessary for their combustion.

133. Common *Charcoal* of wood, is another, and the commonest form of carbon. It is obtained in the form of solid masses, of a black colour, and more than twice as heavy as

water. It has neither smell nor taste. It is brittle, and never crystallized; it rapidly attracts moisture, so as to acquire from 12 to 14 *per cent.* of weight. When dry, it also absorbs several times its bulk of any gas in which it is placed. It absorbs light strongly, is refractory in the fire, insoluble in water, and a bad conductor of caloric, but an excellent one of electricity. At a red heat, it burns rapidly in oxygen gas; 28.6 of charcoal, and 71.4 of oxygen, forming 100 of carbonic acid gas. It also burns in atmospheric air, but less vividly. In vacuo, and in gases on which it has no action, it is slowly volatilized by the highest power of galvanism. Common charcoal always furnishes a little water on its combustion; but charcoal from the decomposition of oil gives carbonic acid alone. *Officinal.*

134. *Gaseous oxide of carbon* (carbonic oxide gas) is carbon in its first degree of oxidation. It is invisible and elastic; 100 cubic inches weigh about 30 grains, or its specific gravity to hydrogen is 13.2. It does not support combustion or respiration. With oxygen gas it burns with a lambent blue flame, and is converted entirely into carbonic acid, without producing any moisture. It has no affinity for lime. It consists of about 4 carbon, and 56 oxygen. When mixed with an equal bulk of chlorine, and exposed to the direct rays of the sun, they unite, are condensed to one half, and form a peculiar gas discovered by Dr John Davy.

135. *Carbonic acid gas* is transparent, colourless, without smell, irrespirable, and incapable of supporting combustion. 100 cubic inches weigh 47 grains, or its specific gravity to hydrogen is 20.7. Water at 41° absorbs an equal bulk of it, and acquires a specific gravity of 1.0015, an agreeable viscidity, and a sparkling appearance, especially if heated to 88°. It is separated from water by freezing or boiling. It is also absorbed by alcohol, volatile and fixed oils. It contains 28.6 carbon, and 71.4 oxygen. Its compounds are called carbonates.

136. *Carburetted hydrogen gas* is the gas evolved in stagnant waters. It has no taste, but a disagreeable empyreumatic smell. 100 cubic inches weigh about 17 grains, and its specific gravity is rather less than 8. It is incapable of supporting respiration or combustion. It burns with a bright yellowish flame, consuming two parts of oxygen gas. It detonates with two of chlorine by the electric spark, forming four of muriatic acid gas.

137. *Supercarburetted hydrogen* or *Olefiant gas.* 100 cubic inches weigh between 29 and 30 grains, or its specific gravity is 13. It does not support respiration or combustion. It burns with a splendid white flame, and detonates by the electric spark with great violence, with three volumes of oxygen. With an equal volume of chlorine, it forms a fluid resembling an oil.

138. *Chloride of carbonic oxide* was discovered by Dr John Davy, who called it phosgene gas. It consists of equal volumes of chlorine and carbonic oxide gases; is colourless, has a suffocating smell like chlorine, affects the eyes. It reddens turnsole. 100 cubic inches weigh 111.91 grains. It does not support combustion, and is not decomposed by any of the simple combustibles, but is acted upon by zinc, antimony, arsenic, and other metals, which absorb the chlorine, and disengage the carbonic oxide, while the oxide disengages carbonic acid. It is decomposed by water, and alcohol dissolves twelve times its volume.

139. *Carbo-chloride of ammonia.* The preceding gas unites with four times its bulk of ammoniacal gas, forming a neutral salt, solid, white, volatile, pungent, deliquescent, and very soluble in water, which is decomposed by the sulphuric, nitric, muriatic and phosphoric acids.

BORON.

140. *Boron,* the recently discovered base of boracic acid, is a friable, dark, olive, opaque powder, without taste or smell. It is insoluble in water, and a non-conductor of electricity.— An intense heat has no action on it, unless atmospheric air or oxygen be present. But heated strongly in contact with air it burns and forms dry boracic acid. In oxygen it burns with scintillation. It combines with about an equal weight of oxygen. It emits white fumes when gently heated in chlorine.

141. *Boracic acid* crystallizes in small shining flakes, with little taste, and slightly affecting turnsole; sp. gr. 1.479; fixed and vitrifiable in the fire; soluble in 50 parts of boiling water, and in alcohol, to which it imparts the property of burning, with a yellow flame.

SULPHUR.

142. *Sulphur* is a crystallizable solid, of a yellow colour; little sensible taste; peculiar smell when rubbed or heated;

specific gravity 1.99; brittle; electric; fusible at 226°; burning with a pale blue flame at 302°; and with a bright white flame at 570°; and capable of combining with different proportions of oxygen. It is found pure in the vicinity of volcanoes, and exists in many minerals, and in animal substances. *Officinal.*

143. *Oxide of sulphur* is said by Dr Thomson to be of a dark violet colour, and an austere taste, fracture fibrous, specific gravity 2.325; consistence tough. It contains nearly 7 *per cent.* of oxygen. It is formed on the surface of melted sulphur. Dr Irvine and Sir H. Davy think this substance contains no oxygen, and differs only in arrangement of particles.

144. *Sulphurous acid gas* is colourless, incapable of maintaining combustion, and deleterious when respired. It has a strong suffocating odour; 100 cubic inches weigh about 68 grains; its specific gravity to hydrogen is 30 to 1. It whitens many animal and vegetable substances. Water at 54° rapidly absorbs 30 times its bulk of this gas, and when saturated, acquires the specific gravity of 1.0513. It is again expelled from the water by heat, but not by freezing. When water is present it is converted by oxygen gas into sulphuric acid. It is decomposed by hydrogen, carbon, and sulphuretted hydrogen gas, when assisted by heat. It oxidizes iron, zinc, and manganese. It consists of equal weights of sulphur and oxygen.

145. *Hydrosulphuric acid* is also composed of sulphur and oxygen. It is a dense liquid; specific gravity 1.85; slightly viscid; transparent and colourless; without smell; of a strong acid taste. It freezes at —36°, and boils at 590°. It has a strong attraction for water, absorbing it rapidly from the atmosphere, and producing considerable heat when mixed with it. It is decomposed by most inflammable substances. It does not oxidize gold, platinum, tungsten, or titanium. It decomposes the alkaline and earthy sulphurets, and reduces all organic substances to charcoal. In medicine it is a powerful refrigerant and antiseptic. It consists of 30 sulphur, 45 oxygen, and 17 of water. What was called Glacial sulphuric acid, consists, according to Sir H. Davy, of 4 volumes of sulphurous acid gas, and 3 of nitrous acid gas, probably in two or three proportions, with a single proportion of water. *Officinal.*

146. *Chloride of sulphur* was first formed by Dr Thomson, who called it *Sulphuretted muriatic acid.* It is a fluid, appearing red by reflected, and yellowish-green by transmitted light. Sp. 1, 6. It smokes in the air, has the smell of sea-weed, and

affects the eyes like peat smoke. It does not redden perfectly dry litmus paper, but is decomposed by water. It consists, according to Davy, of one proportion of sulphur, and two of chlorine.

147. *Sulphuretted hydrogen gas* consists of one sulphur and two hydrogen; 100 inches weigh 36 or 37 grains, or its specific gravity to hydrogen is 16. It has the odour of rotten eggs; is not respirable; burns with oxygen gas without exploding, and deposites sulphur; an equal volume is absorbed by water, and is the mode in which sulphur exists in mineral waters; reddens vegetable blues; and in its affinities, and the crystallizability of its compounds, it resembles the acids. *Officinal.* Hydrosulphuret of ammonia.

148. *Sulphurets* are solid opaque bodies, of considerable specific gravity; decomposable by heat, water, and the acids.

a. The alkaline and earthy sulphurets have a red or brownish-red colour, and by solution in water are immediately converted into hydrosulphurets. *Officinal.* Sulphuret of potass.

b. The metallic sulphurets have neither taste nor smell, are often possessed of metallic brilliancy, and are conductors of electricity. *Officinal.* The sulphurets of antimony, of mercury, of iron.

Hydro-sulphurets are soluble in water, and crystallizable, decomposed by the atmosphere and acids.

149. *Procarburet of sulphur* is a reddish or greenish-brown lamellated solid, having many of the properties of sulphur.

150. *Percarburet of sulphur* is a transparent colourless liquid, of a fetid smell and acrid taste; sp. gr. 1.263. It boils at 115 F, but evaporates rapidly at 60, when in contact with the air producing intense cold. It is exceedingly inflammable.

PHOSPHORUS.

151. *Phosphorus* is a semi-transparent solid, slightly brilliant, and of a waxy consistence; specific gravity 1.79; taste in some degree acrid and disagreeable; smell alliaceous. It is brittle under 32°; its fracture is vitreous, brilliant, and sometimes lamellated; above 32° it softens a little, becomes ductile about 90°, melts at 99°, becoming transparent like a white oil; at 180° begins to be vaporized, and at 554° boils. It is highly inflammable, and burns at 148°. It is crystallizable into prismatic needles or long octohedrons. It exists in many minerals, and is obtained from bones and other animal substances.

In its solid state, phosphorus is not acted upon by pure oxygen gas; but when melted, burns in it at 80° with a dazzling splendour, absorbing about half its weight of oxygen, and forming phosphoric acid. In atmospheric air it undergoes a slow combustion at 43°, emitting light in the dark, but without the production of sensible heat, absorbing a portion of oxygen, and forming phosphorous acid; at 148° it burns rapidly, but less brilliantly than in oxygen gas, forming phosphoric acid. It is therefore always kept immersed in boiled water; but even there its surface is oxidized, becoming white and opaque.

152. *Oxide of phosphorus* is a solid of a red colour, not volatile, and requiring a heat above 212° for its fusion. Sir H. Davy thinks it may consist of two parts of phosphorus and one of oxygen.

153. *Hydro-phosphorous acid* is a white crystalline solid, but water is essential to its composition. It contains four of phosphorous acid and two of water. It is readily soluble in water. The solution has a fetid odour, and disagreeable taste; and gives out a thick white smoke and vivid flame when strongly heated. It is decomposed by ignited charcoal, and by heating it in contact with ammonia.

154. *Phosphoric acid* is also composed of phosphorus and oxygen. It is crystallizable, fusible, and vitrescent. Its specific gravity is 2.687. It dissolves in water, producing great heat. It readily attracts moisture from the atmosphere, and then its specific gravity becomes 1.417. It is decomposed at a high temperature by hydrogen and carbon, and by several of the metals. It consists of 40 phosphorus and 60 oxygen.

155. Phosphorus burns in chlorine with a pale flame, throwing off sparks, and forms two compounds according to their proportions. *Prochloride of phosphorus* is a fluid as clear as water, to which its sp. gr. is 1.45. It emits acid fumes when exposed to the air by decomposing the air. It does not redden dry litmus paper. Its vapour burns in the flame of a candle. It dissolves phosphorus when heated. It is decomposed by water, forming phosphorous and muriatic acids, and by ammonia, depositing a part of its phosphorus. It is converted by chlorine into the perchloride. It consists of one proportion of phosphorus, and two of chlorine.

156. *Perchloride of phosphorus* is a snow-white substance, crystallizable, very volatile, but fusible under pressure. It produces flame when exposed to a lighted taper. Its vapour reddens litmus paper. It forms an insoluble compound with

ammonia, having characters analogous to an earth. It is decomposed in a red-hot tube by oxygen, and it acts violently on water, forming phosphoric and muriatic acids. It consists of one of phosphorus and four of chlorine.

157. *Phosphuretted hydrogen gas* varies in specific gravity from 4 to 7, hydrogen being 1. It has a disagreeable alliaceous smell. It explodes with a most intense white light in oyygen gas. It detonates with a brilliant green light in chlorine. Water absorbs about $\frac{1}{40}$ of its volume; and it is decomposed by electricity, heated metals, &c.

158. *Hydrophosphoric gas*, disagreeable smell, specific gravity 12. to hydrogen. Water absorbs $\frac{1}{8}$ of its volume. It explodes with a white flame in chlorine, one volume absorbing four of the latter. It does not explode spontaneously with oxygen, but detonates violently when heated to 300 Fahrenheit, three volumes absorbing more than five.

159. *Sulphuretted phosphorus* contains various proportions of its elements. It is exceedingly inflammable and more fusible than either of its constituents. 1 of phosphorus and 3 of sulphur congeal at 100 Fahrenheit. 2 of phosphorus and 1.5 of sulphur remain liquid at 40°, and 8 of phosphorus and 1 of sulphur at 68°.

160. Nitrogen gas dissolves phosphorus, forming a fetid gas, which inflames at a low temperature.

161. *Phosphuret of lime* is insoluble in water, but they decompose each other, producing phosphuretted hydrogen gas, which arises in bubbles to the surface of the water, where they explode with a clear flame. Phosphuret of baryta is a brown mass; of a metallic appearance; very fusible; luminous in the dark; decomposed by exposure to air; emitting an alliaceous smell when moistened; and decomposed by water, furnishing phosphuretted hydrogen gas. The phosphuret of strontia is very similar.

IODINE.

162. *Iodine* is of a black-grey colour, and crystallized either in micaceous plates, or broad and brilliant rhomboidal plates, or long octohedrons. Its fracture is lamellated and greasy. It is very friable, and may be reduced to impalpable powder. It destroys vegetable colours, and stains the skin a deep-orange. Its sp. gr. is 4.948. It does not conduct electricity. It melts at 225 F. and boils between 335° and 355°. Its vapour is of a beautiful violet colour, and smells like chlo-

rine, but weaker. It is not inflammable, and does not combine with oxygen. Water dissolves a seven-millioneth part of its weight, and acquires an orange-yellow colour, and when combined with water, it is vaporized along with it at 212°.

163. *Iodic acid* has not been obtained in a pure state, but only mixed with sulphuric acid. It consists of iodine and hydrogen, and is decomposed even by sulphureous acid, which becomes sulphuric, while iodine is precipitated and then dissolved.

164. *Hydro-iodic acid gas* is colourless, but has a strong smell and taste. It consists of iodine and hydrogen. It extinguishes combustion, and reddens turnsole. It has a strong affinity for water, forming fumes with that of the atmosphere, and being rapidly absorbed by it. Chlorine decomposes it, becoming muriatic acid, while the iodine is disengaged in violet vapour. Potassium, zinc, and other metals absorb its iodine, and disengage the hydrogen.

165. *Iodure of azote* is a blackish powder, which detonates with great force spontaneously, when dry, and by a slight pressure under water.

166. *Iodure of ammonia.* Dry ammoniacal gas is absorbed rapidly by iodine, and with great production of heat. It is a very viscid liquid, of a metallic appearance; by excess of ammonia it loses its lustre, part of its viscidity, and becomes of a very dark red-brown colour. It is not detonating, but becomes so when moistened.

167. *Iodure of sulphur* is formed by exposing them to a gentle heat. It resembles in appearance sulphuret of antimony, and is easily decomposed by heat, the iodine being sublimed.

168. *Prot-iodure of phosphorus.* Iodine unites with phosphorus in various proportions, disengaging heat but no light. 1 of phosphorus with 4 iodine gives a compound of a red-brown colour, not fusible at a heat considerably above 212°, scarcely acted on by water, but soluble in potass, with disengagement of phosphuretted hydrogen gas; burning at an elevated temperature in the air like phosphorus, and only shewing traces of iodine by the action of chlorine.

169. *Per-iodure of phosphorus.* 1 of phosphorus with 8 of iodine is of a red orange-brown colour, fusible at about 212, and volatilized at a higher temperature. It is decomposed by water, disengaging phosphuretted hydrogen gas, while flakes of phosphorus are precipitated, and the water contains phosphorous acid and hydro-iodic acid. 1 of phosphorus with 16 of iodine is a crystallized substance of a grey-black co-

lour, fusible at 86°, decomposing water without disengagement of phosphuretted hydrogen gas. In whatever proportions phosphorus and iodine are mixed, they exhale, on being moistened, vapours of hydro-iodic gas.

FLUORINE.

170. *Fluoric acid* does not congeal at —4° Fahr. and boils at a moderate heat, but evaporates very quickly when in contact with the air. Its vapour is very pungent and deleterious. It produces great heat when dropt into water. It acts with great violence on the skin, occasioning great pain and general irritation. It is converted, by its union with a small proportion of silica, into a permanent gas, which till lately was considered to be pure fluoric acid.

171. *Siliceo-fluoric acid gas* is invisible, irrespirable, extinguishes flame. It has a pungent smell, like that of muriatic acid, is heavier than atmospheric air, is absorbed by water, and corrodes the skin. It does not contain combined water.

172. *Fluo-boric acid gas* is invisible, extinguishes combustion, reddens vegetable blues strongly, is rapidly absorbed by water, and detects, by the formation of dense vapour, hygrometric water in air. It rapidly decomposes animal and vegetable substances. Liquid fluo-boric acid resembles sulphuric acid in causticity and appearance, and in its relations to heat.

METALS, AND METALLIC OXIDES.

173. Metals are crystallizable; their form depends on the regular tetrahedron or cube; their surface is specular; they are perfectly opaque, even when melted; their colour is various; their lustre peculiar and shining, or splendent; their hardness various, but at least considerable; many of them are brittle, others possess malleability and ductility in a very great degree, and some are scissile, flexile, or elastic; their fracture in general is hackly; their texture compact, fibrous or foliated; many of them are remarkably sonorous; their specific gravity greater than 5, or remarkably light; they possess no smell or taste, unless when heated or rubbed; they are the best conductors of caloric and electricity, are powerful agents in producing the galvanic phenomena, and a few of them are the only substances which exhibit the phenomena of magnetism. By the action of caloric they are melted, but with different degrees of facility, and some of them may be

vaporized. Except iron and platinum, they melt suddenly, without undergoing any intermediate state of softness; and when melted, their surface is convex and globular. They are insoluble in water; but some of them decompose it, and are oxidized by it.

174. They are oxidized with different degrees of facility, some by mere exposure to air, and others seem almost to resist the action of heat and air. Their oxidizability is always increased by increase of temperature. Their oxides are in the form of powder, laminæ, or friable fragments; sometimes crystalline; of various colours, determinate with regard to each metal; possess greater absolute weight; are refractory, or fusible into glass; insipid, or acrid and styptic; in general insoluble in water; and combine either with acids and alkalies, or only with one of these. Some of them are disoxygenized by light alone, others by caloric, and others require hydrogen, carbon, &c.

Most of the metals are capable of combining with different proportions of oxygen. Dr Thomson proposes to call the oxides with a minimum of oxygen, Protoxides; and with additional proportions, Deutoxides, Tritoxides, &c. in succession; and the oxides with a maximum of oxygen, Peroxides.

175. Chlorine combines with many of the metals, constituting the substances formerly called *muriates* and metallic butters. With the metal it unites without decomposition, but when an oxide is exposed to the action of muriatic acid, the hydrogen of the acid and oxygen of the oxide combine to form water, while the metal and chlorine unite. Some metals combine with chlorine in more proportions than one. Sir H. Davy distinguishes them by adding to the name of the metal the termination *ane* when it is combined with a smaller proportion of chlorine, and *ana* or *anea* when with a greater, as phosphorane, phosphorana, stanane, stananea, ferrane, ferranea, &c. but the terms of *Prochloride* and *Perchloride*, used by other chemists, are preferable.

176. Hydrogen gas is capable of holding arsenic, zinc, iron, tellurium, potassium, and boron, in solution; and all these gases contain their own bulk of hydrogen gas.

177. Carbon unites only with iron.

178. The metallic phosphurets are fusible, brilliant, brittle, granulated, lamellated, scarcely combustible, and permanent.

179. The sulphurets are brittle; crystallizable in large brilliant and metallic laminæ, more easily fusible that the refractory metals, but less easily than the very fusible metals; decomposible by heat, humidity, and the acids.

180. The metallic iodurets have considerable analogy with the sulphurets. Those of the easily oxidizable metals, as zinc, iron, tin, antimony, decompose water; those of lead, silver and mercury do not. The ioduret of mercury has a fine red colour, or yellowish-green, according as the iodine or mercury predominates. The former melts, and is sublimed in rhomboidal plates of a golden yellow, which on cooling become of a brilliant scarlet.

181. The mixtures of the metals with each other are termed *Alloys*: those in which mercury is contained are *Amalgams*. They acquire by mixture new properties, and are in general more fusible than their components. The reguline metals are not soluble in the acids; but when acted upon by them, are first oxidized, and then dissolved. The metallic oxides, by fusion, colour glasses and enamels.

ALKALIZABLE METALS.

The heavier earths, and even the alkalies, have long been supposed by different chemists to be metallic oxides, and were even stated to have been reduced to their metallic form. But their supposition rested only on the vaguest analogies, and their experiments were completely fallacious. The merit of discovering the metallic bases of the earths and alkalies belongs to Sir H. Davy, to whose ingenuity and skill, in applying the powerful agency of galvanism, we are indebted for the most unexpected conclusions ever obtained in experimental chemistry.

182. *Potassium*, the base of potass, is a white metal, brittle and crystallized; in its section resembling polished silver; and at 150° perfectly fluid, very much resembling quicksilver. At a red heat it is converted into vapour. Its specific gravity is between 8 and 9, water being 10. Exposed to the air, it attracts oxygen, and becomes covered with a crust of potass; when gently heated, it burns with an intense heat, and a red light. It explodes and inflames with water, and even with ice. It acts upon all bodies containing water or much oxygene. It burns vividly in chlorine. It is soluble in hydrogen gas, forming a compound which inflames with atmospheric air. It combines with sulphur and phosphorus, and the metals, forming readily oxidizable compounds.

183. *Protoxide of potassium* scarcely known; of a greyish colour, effervesces with water without inflaming.

184. *Potassa*, (Sir H. Davy), a difficultly fusible substance of a grey colour, vitreous in its fracture, dissolving in water,

without effervescence, but with much heat, forming an alkaline solution.

185. *Potass* (hydrat of potassa) is a solid white substance, containing 90 potassa and 17 water, which cannot be separated by heat; extremely acrid to the taste; unctuous to the feel, but highly caustic; destroying the skin, and dissolving all soft animal substances. It is deliquescent, and soluble in half its weight of water at 58° Fahrenheit; it is fusible, and may be vaporized, but is perfectly incombustible; it is capable of crystallizing into very long quadrangular, compressed prisms, terminated by sharp pyramids; it changes vegetable blues to green, and combines with all the acids, oils, sulphur, sulphuretted hydrogen, and the earths. It is obtained from the ashes of vegetables, and exists in some minerals. *Officinal.*

186. *Orange oxide of potassium*, fusible, the result of the slow combustion of potassium in oxygen or air. It supports the combustion of inflammable bodies, supplying the oxygen. It is decomposed by water and carbonic acid, oxygen being evolved.

187. *Chloride of potassium* (muriate of potass). When muriatic acid and solution of potass are mixed and heated to redness, the hydrogen of the acid and the oxygen of the alkali are set free as water, while the metal and the chlorine combine to form the substance known by the name of muriate of potass. Chlorine also decomposes potassa and the orange oxide, expelling its oxygen, and potassium attracts chlorine from hydrogen and phosphorus. *Officinal.*

188. *Sodium*, the base of soda, resembles in its appearance silver, has great lustre, and is a conductor of electricity. It fuses at 200° Fahrenheit. It is not volatilized by the heat which melts plate glass. Its specific gravity is 0.9348, water being 1. It absorbs oxygen slowly from the atmosphere, and at a high temperature burns with bright sparks. It decomposes water with effervescence, and is inflamed by nitrous acid.

189. Protoxide of sodium, scarcely known; of a dark grey colour.

190. *Soda*, of a grey colour, and vitreous fracture, a non-conductor of electricity.

191. *Hydrat of soda*, formerly considered as pure soda, contains 22 *per cent.* of water, which cannot be separated by heat, of a greyish white colour, urinous taste, and burning causticity, acting with considerable violence on animal matter. Water, in a certain proportion, when thrown up-

on it, is absorbed and solidified, with the disengagement of caloric, and a lixivial smell. A larger quantity dissolves it. From the atmosphere it absorbs moisture and carbonic acid, becoming less caustic. In the fire it melts like an oily substance; boils, and is converted into vapour, but is incombustible. It is crystallizable into transparent prismatic crystals. It changes vegetable blues to green; unites with all the acids, oils, sulphur, sulphuretted hydrogen, phosphorus, many metallic oxides, and the earths. It forms the basis of rock-salt, and sea-salt; is obtained from the ashes of marine plants, and exists in some minerals.

192. *Chloride of sodium* (muriate of soda) consists of one proportion of sodium and two of chlorine. It is a non-conductor of electricity. It fuses in a strong red heat, and volatilizes in a white heat. It crystallizes in cubes. It is decomposed by potassium, which attracts its chlorine.

193. Sodium readily forms sulphurets and phosphurets which are less inflammable than those of potassium.

194. Potassium and sodium combine readily in various proportions. A small quantity of potassium renders sodium brittle and very soft. A small quantity of sodium renders potassium fluid at a common temperature, and reduces its specific gravity considerably.

195. *Barium*, the base of barytes, a dark grey-coloured solid; lustre less than cast-iron, heavier than sulphuric acid, decomposes water, and is oxygenized by exposure to the air.

196. *Barytes* is obtained in small, grey, porous masses of tolerable solidity; its taste is acrid, urinous and pungent; applied to the skin, it proves caustic, and it is deleterious when swallowed; its specific gravity is 4; it is soluble in twenty times its weight of cold water, and in twice its weight of boiling water; depositing, on cooling, transparent, white, prismatic crystals; when slaked, it boils up with violence, becomes very hot, increases in bulk, and is changed into a spongy white mass. It changes vegetable blues to green; it is fusible; and combines with all the acids, sulphur, sulphuretted hydrogen, and phosphorus. It is the basis of some of the heavy spars.

197. *Strontites* is obtained in small, whitish grey, and often porous masses; its taste is warm, acrid, and urinous; it is slightly caustic, acting feebly on animal matters. Taken into the stomach, it is not poisonous; its specific gravity is nearly 4; it is soluble in 200 times its weight of water at 50°, but in little more than six times its weight of boiling water, which, on cooling, deposites flat rhomboidal crystals; it is slaked

more rapidly than lime, and it is infusible; it changes vegetable blues to green; it combines with all the acids, sulphur, sulphuretted hydrogen, and phosphorus, alumina, and silex. It is the basis of some of the heavy spars.

198. *Calcium*, the base of lime, is brighter and whiter than barium or strontium.

199. Lime is of a grey-white colour, warm, acrid and urinous to the taste; sp. gr. 2.33, soluble in 450 times its weight of water. It is apyrous; it changes vegetable blues to green; it combines with all the acids, sulphur, sulphuretted hydrogen, and phosphorus; it is very abundant in the mineral kingdom, and forms the basis of animal bones and shells. The calcareous spars, marble, limestone, chalk and marl, consist chiefly of lime. *Officinal.*

200. Hydrat of lime. When a small quantity of water is thrown upon fresh burnt lime, it is absorbed rapidly, with the extrication of considerable heat, and some phosphorescent light; at the same time the lime crumbles down into a very fine, white, dry powder, augmented much in bulk, but less caustic than before. Lime, thus slaked, does not renew these phenomena, on a farther addition of water, but may be diffused or dissolved in it.

201. *Magnesium*, the base of magnesia, only obtained as a dark grey metallic film; less fusible than plate glass, burning with a red light when strongly heated, and decomposing water slowly.

202. *Magnesia* is obtained in light, white, friable masses, or very fine powder; to the touch it is very fine; its taste is not very sensible, but peculiar and pleasant; its specific gravity is 2.33. It is insoluble in water, but forms with it a paste without ductility. It is apyrous; slightly alters vegetable blues to green; forms soluble compounds with most acids, and unites with sulphur. The fossils in which it predominates are generally soft, and have an unctuous feel. The principal are talc, steatites, arbutus, &c.

203. Hydrat of magnesia is the state in which it is obtained by precipitation, from its solution in an acid, by potass or soda.

204. *Alumina* is obtained in friable fragments, or in a very fine white powder; soft and unctuous to the touch; adhering strongly to the tongue, absorbing its moisture, and producing a slightly styptic effect upon it; specific gravity 2; insoluble in water, but very diffusible through it; absorbing a certain quantity of it rapidly, and forming with it a very ductile adhesive paste, which contracts and hardens remarkably in the

fire, but is perfectly infusible. Its ultimate particles seem to be opaque. It combines with most of the acids, and these compounds have a sweetish styptic taste; it unites with charcoal, the alkalies, baryta, strontia, lime and silica; it is manufactured into porcelain and glass. Fossils, containing much alumina, have generally a laminated structure; it exists crystallized in sapphire; and it forms the basis of all clays, boles, mica, trap, basalts, slate, and corundum.

205. Glucinum; scarcely known.

206. *Glucina* is obtained in white light masses or powder, of a soft feel, insipid, but adhering strongly to the tongue; apyrous; and soluble in water, but forming with it a paste, slightly ductile and adhesive; it is soluble in potass, soda, and carbonate of ammonia; it combines with most of the acids, forming soluble salts, difficultly crystallizable, of a sweet and somewhat astringent taste, and with sulphuretted hydrogen. It has hitherto been found very sparingly only in the beryl and emerald.

207. *Zirconum*, the basis of zircona; properties little known.

208. *Zircona* is obtained in the form of a harsh whitish powder; without taste or smell; having a specific gravity of 4.3; insoluble in water; softened by the heat of a smith's forge; but when surrounded by charcoal, its particles become agglutinated, and so hard as to strike fire with steel; soluble in all the acids; fusible with silex and alumina; insoluble in the alkalies, but soluble in their carbonates. It is only found in the zircon or jargon of Ceylon, and in different varieties of hyacinth.

209. *Hydrat of zircona* has the appearance of a resin or glue. It contains more than 20 *per cent.* water, which may be expelled by heat.

210. *Silicum*, the basis of silica; properties not ascertained.

211. *Silica*, when obtained perfectly pure by art, is in the form of a very fine white powder, hard, rough, and gritty, to the touch; when applied to the tongue, giving a rough and dry sensation, but without taste or smell, having a specific gravity of 2.66; in the state of hydrat, soluble in 1000 times its weight of water; soluble in the fixed alkalies and fluoric acid; fusible with the fixed alkalies and other earths; and combining, by fusion, with the metallic oxides, and the phosphoric and boracic acids. It has a tendency to crystallization, and its ultimate particles seem to be transparent. It in general imparts to the fossils, of which it is a principal constituent, transparency, lustre, a tendency to crystallization,

and a degree of hardness, enabling them to strike fire with steel. Rock crystal, quartz, agate, flint, chalcedony, jasper, shorl, are examples of siliceous stones.

212. *Ittrium*, the basis of ittria, not ascertained.

213. *Ittria* is obtained in the form of a fine white powder, without taste or smell; insoluble in water; it does not alter vegetable blues; is infusible; insoluble in the alkalies, but readily soluble in the carbonate of ammonia. With the acids it forms salts, which have a sweet and somewhat austere taste. It has been found only in the Gadolinite.

OXIDIZABLE METALS.

214. *Manganesum*. Small whitish grey globules; specific gravity 6.850; very hard and very brittle; very difficult of fusion; very oxidizable by exposure to air; decomposes water rapidly; is oxidized by the sulphuric and nitric acids; burns when strongly heated in oxygen or chlorine; combines with many metals. According to Berzelius, it forms five oxides, containing 1, 2, 4, 6, and 8 proportions of oxygen, to one of metal. These oxides colour glass brown, violet, or red, and destroy the colour of glass coloured by iron.

215. *Zinc* is bluish-white, lamellated, sapid, and odorous; specific gravity 7.190; soft, clogging the file; above 212° malleable and ductile; fusible at 700°; vaporizable; a powerful agent in the phenomena of galvanism; oxidized by fusion; at a red heat it catches fire, and emits white films of oxide; it easily decomposes water; it is oxidized and dissolved by almost all the acids. *Officinal*.

216. *Tin* is pure brilliant white, sapid and odorous; specific gravity 7.291 to 7.500; soft, flexible, and emitting a crackling noise when bent; very malleable; fusing at 442° Fahrenheit; oxidizes slowly in the air; is converted, when fused, into a grey oxide; when red hot it burns vividly. Sulphuret and phosphuret are lamellated and brittle; it forms alloys with arsenic, bismuth, antimony, mercury, and zinc; it is oxidized by many acids, and combines with the fluoric, boracic, and carbonic acids. *Officinal*.

217. *Iron* is of a bluish-grey colour; texture either fine grained, fibrous, or dense plates; sapid and odorous; specific gravity 7.600; the hardest, most elastic, and most tenacious metal; very ductile; fusing at 158° Wedgwood, fusion at first clammy, afterwards very fluid; igniting by strong percussion, and inflaming by the collision of flint; magnetic. It is oxidized slowly in the air, especially when moist; when

heated in contact with air, it is oxidized; deutoxide, black, fusible, hard, brittle, lamellated, still attracted by the magnetic; tritoxide, fine, pulverulent, not attracted by the magnet, containing 0.40 to 0.49 of oxygen. It burns with splendour and deflagration in oxygen gas, and is converted into a fused, black oxide; it decomposes water slowly, and when ignited, very rapidly. Iron is oxidized and dissolved by almost all the acids. It gives glasses a brown, smoky, deep green, or black colour. Carbon united to iron converts it into steel. *Officinal.*

218. *Steel* is of a grey colour, brilliant and granular in its fracture; specific gravity 7.795; harder than any of the metals, and more elastic, ductile, malleable, and fusible at a lower temperature than pure iron. Its characteristic property is, that after being heated, if suddenly plunged into cold water, it becomes harder, more elastic, less pliable, and brittle; but by being again heated and cooled slowly, it acquires its former softness, pliability, and ductility. Steel contains only some hundredth parts of carbon, and is known chemically by letting a drop of acid fall upon it, which produces a grey or black spot. *Plumbago* consists of about 0.1 of iron, combined with carbon.

219. *Lead* is of a grey blue livid colour, streak grey, disagreeable taste and odour; specific gravity 11.352; soft; very laminable; hardens little under the hammer; very flexible; not very ductile; slightly tenacious; fusible at 612° Fahrenheit; volatile at a red heat; tarnished in the air; slightly oxidized by air and water; burns when strongly ignited, and in oxygen with a brilliant white flame. When heated in chlorine it unites with it, but it does not inflame. Its phosphuret and sulphuret are brittle; and it is oxidized by, and combines with, the sulphuric, nitric, phosphoric, and other acids. Its oxide imparts to glass a uniform density, and strong refracting power. *Officinal.*

220. *Antimony.* White, very brilliant, lamellated; specific gravity 6.702; moderately hard; pulverizable; fusible at 809; volatile when highly ignited; sensible taste and smell; unalterable in cold air; oxidizible by air and heat; oxide fusible into a yellow-brown glass; decomposes water when ignited; oxidized by the sulphuric and nitric acids; combines with phosphorus and sulphur. Oxides colour glass yellow and hyacinthine. *Officinal.*

221. *Bismuth.* White, slightly yellow, in large specular plates; pulverizable; specific gravity 9.822; moderately hard;

sensible odour and taste, fusible at 460°, and volatile at a high temperature; oxidizable by heat and air; oxide vitrifiable into a greenish-yellow glass; oxidizable by boiling sulphuric, nitric, and muriatic acids; unites with sulphur. Oxide yellow, and colours glass of a greenish-yellow.

222. *Tellurium.* White, lead-grey, very bright, harsh and brittle; lamellated; crystallizable; specific gravity 6.115; very fusible and volatile; burns with a blue and greenish flame, and a white smoke, having the odour of radishes; oxide very fusible into a straw-coloured radiated glass; soluble in sulphuric, nitric, and nitro-muriatic acids; unites with sulphur. Oxides black, white.

223. *Cobalt.* Reddish-grey, fine grained, pulverizable; specific gravity between 7.770 and 7.800; very difficult of fusion; oxidizable before fusion; unalterable by water; acted on by all the acids; combines with phosphorus and sulphur; its alloys are granulated, rigid, and brittle. Oxides deep blue and black, and colour glasses of a fine blue.

224. *Copper.* Bright red; disagreeable taste and smell when rubbed or heated; specific gravity 7.79; ductile; of great tenacity; sonorous; fusible at 27° Wedgwood; granulated texture, and subject to blisters; a good conductor of caloric, electricity, and galvanism; becomes brown, and at last green in the air; when heated turns blue, yellow, violet, deep brown; when ignited and plunged into water, forms brown, brittle scales of oxide. Its phosphuret is brilliant, brittle, hard, and fusible; its sulphuret brown, fusible, and very phosphoric; its alloy with arsenic is white, with bismuth reddish, with antimony violet, with mercury deep red, with zinc forms brass, and with tin is orange; it is oxidized and dissolved by the sulphuric, nitric, and muriatic acids; its oxide is brown, brittle, and soluble in ammonia, acquiring a beautiful blue colour. *Officinal.*

225. *Nickel.* Colour between those of platinum and steel; undergoing changes of colour by the action of fire similar to those of steel; specific gravity nearly 9; malleable and ductile; magnetic: very difficult of fusion, and of oxidization in the air; oxidizable by most of the acids, which it colours of a brilliant green; combines with phosphorus, sulphur, and the metals. Oxide grey, colouring glass brown, orange, red.

226. *Uranium.* An incoherent mass of small agglutinated globules, of a deep grey and pale brown; specific gravity 8.1; very hard; very difficult of fusion, even by long con-

tinued heat; is acted upon by several of the acids; combines with phosphorus. Oxide soluble in the alkalies: and very soluble in their carbonates. Oxides black, yellow, colouring glass of a greenish-yellow, emerald green, or brown.

227. *Osmium.* Dark grey or blue; infusible when excluded from the air; insoluble in all acids; oxide forms a yellow solution with potass, and is extremely volatile, smelling like oxymuriatic acid.

228. *Titanium.* Agglutinated, hard, friable masses, crystallized internally of a brilliant red; infusible; unalterable by water; oxidizable by boiling sulphuric, nitric, and muriatic acids. Oxides blue, deep red, white.

229. *Cerium.* Oxides white and brown; the former most readily soluble in nitric, and the latter in muriatic and sulphuric acids.

230. *Palladium.* Dull white, malleable, ductile, fusible, specific gravity 11.5; hard; forms a red solution with nitro-muriatic acid; affording an orange precipitate with alkalies and earths; and olive-coloured with prussiate of potass.

231. *Iridium.* White; very heavy; infusible; insoluble in acids, unless when previously combined with an alkali; muriatic and sulphuric solutions, green and blue; nitric, red. The former give a green precipitate, soluble in excess of alkali: the latter a red, insoluble.

232. *Rhodium.* White, infusible; specific gravity 11; unites with other metals readily, except mercury. Soluble in all acids. Muriate of rhodium rose-coloured; soluble in alcohol; not precipitated by prussiate of potass, muriate, or hydrosulphuret, or alkaline carbonates of ammonia; but by alkalies in the form of a yellow oxide.

233. *Mercury.* Very bright white; specific gravity 13.568; freezing at —39°; boiling at 660°; when frozen, ductile and malleable; oxidizable by trituration in the air, and in a farther degree by the action of the air and heat; does not decompose water; forms amalgams with many metals; and is oxidized and dissolved by the sulphuric, nitric and oxymuriatic acids. Oxides black, red. *Officinal.*

234. *Silver.* Very brilliant white, insipid, inodorous; specific gravity 10.474 to 11.091; hardness between iron and gold; elasticity between gold and copper; strong acute sound; considerable ductility and tenacity; hardening much under the hammer; a good conductor of electricity, caloric, and galvanism; fusible at 28° Wedgwood; crystallizable by cooling; unalterable in the air; changed into a greenish oxide by

long and violent heat, burning with a greenish flame; and instantly by the electric shock. Its phosphuret is granulated, brittle, and fusible; its sulphuret grey, black, lamellated, or striated, and fusible; it unites but slightly with the acidifiable metals and iron; is hardened by gold, bismuth, antimony, tin, lead, and copper, and amalgamates with mercury. It is oxidized and dissolved by the sulphuric, sulphurous, and nitric acids, and combines with chlorine. Its oxide is olive; reducible by the other metals, hydrogen, and light and heat; colours some glasses of an olive green, and is very soluble in ammonia. *Officinal.*

235. *Gold* is of a brilliant yellow colour, insipid, and inodorous; specific gravity between 19.258 and 19.300; soft and flexible; little elasticity or sonorousness; so ductile, that its surface may be extended more than 650,000 times; of very great tenacity; easily hammer hardened; a good conductor of caloric, electricity, and galvanism; fusing at 32° of Wedgwood; brittle when cooled too quickly; crystallizing in octohedrons; unalterable in the air; converted by a long and violent heat into a vitrified violet oxide; oxidized and dispersed by electricity; soluble in alkaline sulphurets; rendered brittle by phosphorus, arsenic, bismuth, tin, and antimony; less brittle by lead; soluble in mercury; hardened by zinc, copper, iron, steel, and silver; oxidizable, of a purple colour, and slightly soluble in nitrous acid; readily oxidized and dissolved by nitro-muriatic acid. Its oxide is easily reduced by light and heat, colours glasses purple or topaz yellow, and forms a fulminating compound with ammonia.

236. *Platinum.* Of a grey white colour, almost black when polished, insipid, inodorous; specific gravity 20.850 to 21.061; softer only than iron, and less ductile only than gold; most difficult of fusion, above 160° of Wedgwood; a good conductor of electricity and galvanism; unalterable by air and heat; converted into a grey powder, its first degree of oxidation, by electricity; unites with phosphorus; forms alloys with arsenic, bismuth, antimony, mercury, zinc, tin, lead, cast iron, copper, silver and gold. It is oxidixed and dissolved by the oxymuriatic acid, and more readily by the nitromuriatic. Oxide grey.

ACIDIFIABLE METALS.

237. *Tungsten.* Small slightly adherent globules of a slate-grey; specific gravity 17.5; very infusible; oxidizable in the

air by heat, and afterwards acidifiable. Oxide yellow, pulverulent, colouring glass of a blue or brown colour; and a white harsh powder; specific gravity 6.12.

238. *Columbium* or *Tantalium* has hitherto been examined only in the state of oxide or acid, which is a white powder insoluble in water, nearly insoluble in sulphuric, nitric, or muriatic acids, but soluble in citric, tartaric, and oxalic acid; soluble in water when fused with potass or soda; solution not precipitated by prussiate or hydrosulphuret of potass, but precipitated orange by infusion of galls.

239. *Arsenic.* Grey plates of a lively brightness; friable; specific gravity between 8.310 and 5.073; vaporizable at 540°; emitting a smell like garlic; crystallizable: oxidizable in the cold air; inflammable at a red heat, and sublimed in the form of the white oxide or acid; farther oxidizable by the nitric and nitrous acids; combines with phosphorus, sulphur, and many of the metals; soluble in hydrogen gas. *Officinal.*

240. *Molybdenum.* In black powder, or agglutinated, blackish, friable masses, having little metallic brilliancy; specific gravity 8.611; by a strong heat changes into a white brilliant oxide in needles, and very acidifiable: oxidizable by boiling sulphuric acid, and acidifiable by the nitric acid. It forms a sulphuret; and its alloys are granulated and friable; acid white, pulverulent, styptic; specific gravity 8.400.

241. *Chromum.* Agglutinated masses of a whitish-grey colour; very hard, very brittle, and very infusible; appears to be difficult to oxidize, and easy to disoxidize; does not appear to decompose water; not attacked by the sulphuric or muriatic acids; changed into a green oxide, and afterwards into a red acid, by the nitric acid distilled from it. Oxide of a beautiful emerald green; acid red, and, combined with lead, rich orange-yellow.

COMPOUND OXIDES AND ACIDS.

242. We have already noticed all the binary combinations which oxygenizable substances form with oxygen. These in general have considerable permanence in their characters, and admit of few variations in the proportions of their constituent principles. But oxygen is capable of entering into combination at the same time with more than one simple substance, forming oxides and acids, with double or triple bases, which, in consequence of the increased number of principles, are subject to greater variations in their proportions, and are less permanent in their characters. These are, however, the sub-

stances with which pharmacy is chiefly occupied, as they comprehend almost the whole of the vegetable and animal kingdoms. Chemists, borrowing their arrangement from natural history, have almost always considered them under the title of Vegetable and of Animal Substances. But such an arrangement is so totally unconnected with the principles of chemistry, that the imperfect state of our knowledge is the only apology that can be offered for its continuance; and limited as that knowledge is, we are persuaded that an attempt at a classification of these bodies, on chemical principles, is to be preferred.

COMPOUND OXIDES.

243. The compound oxides are characterized by their great alterability, and by their affording, when burnt with a sufficient quantity of oxygen, both water and carbonic acid. They may be divided into

a. Ternary oxides, containing various proportions of carbon, hydrogen, and oxygen;

b. Quaternary oxides, consisting of nitrogen, carbon, hydrogen, and oxygen.

244. The ternary oxides coincide nearly with the class of vegetable substances; and are characterized

a. By their being converted entirely into water and carbonic acid gas, when completely decomposed by oxygen;

b. By their undergoing the acid fermentation, from the action of air and water;

c. And by their furnishing nitrous gas and carbonic acid, when treated with nitric acid.

245. The quaternary oxides coincide nearly with animal substances, and are characterized

a. By their furnishing, when decomposed by oxygen, ammonia as well as water and carbonic acid gas;

b. By their becoming putrid from the action of air and water;

c. By their furnishing nitrogen gas when treated with nitric acid.

d. And by their furnishing ammonia when triturated with potass.

TERNARY OXIDES.

246. *Alcohol* is a transparent colourless liquid, of an agreeable penetrating smell, and pungent burning taste: specific gravity 0.8. It remains fluid in the greatest natural or artificial cold. It boils at 176°, and in vacuum at 56°. Alcohol unites with water in every proportion. During the combination, caloric is evolved, and the specific gravity of the compound is greater than the mean of those of the components. Alcohol dissolves about 60 of sulphur, when they are presented to each other in a state of vapour. It also dissolves a little phosphorus. These solutions are decomposed by water. It dissolves the boracic and carbonic acids, ammonia, soda, and potass, and is the means employed to obtain the two last in a state of purity. Its action on the salts is various. It dissolves the volatile oils, resins, soaps, balsams, camphor, sugar, tannin, cinchonin, extractive, and in part the gummy resins. Alcohol is very inflammable, and when kindled burns entirely away, with a blue flame without smoke. The products of its combustion are carbonic acid and water. It is also decomposed by being transmitted in the state of vapour through a red-hot porcelain tube; by being heated with the fixed alkalies; and by the action of the sulphuric, nitric, and acetic acids, and of chlorine. From Lavoisier's experiment on the combustion of alcohol, it was found by calculation to consist of 51.72 oxygen, 29.88 charcoal, and 18.40 hydrogen. *Officinal.*

247. *Ether* is a transparent colourless fluid, of a very fragrant odour, and hot pungent taste: specific gravity 0.758. It freezes and crystallizes at —46°. It boils at 98°, and in vacuum at —20°. It is very soluble in air, and during its evaporation it produces an intense degree of cold. It is soluble in ten parts of water, and in alcohol in every proportion. It dissolves a small portion of phosphorus, and the solution is decomposed by alcohol. It absorbs nitrous gas, combines with ammonia, and dissolves the volatile oils, resins, and caoutchouc. Ether is extremely inflammable, and burns with a white flame. Its vapour explodes when kindled in contact with oxygen gas. It is decomposed by sulphuric acid, chlorine, and by being transmitted through a red-hot porcelain tube. Its constituents are oxygen, carbon, and hydrogen; the proportions not ascertained. *Officinal.*

248. *Pyroacetic spirit* is procured in greatest purity by distilling acetate of barytes. It is a white, limpid fluid, taste at first acrid, afterwards cooling, smell resembling a mixture of peppermint and bitter almonds: specific gravity 0.7864, inflammable, boils at 165°. It mixes readily with water, alcohol and volatile oil, and hot olive oil. It dissolves camphor, and, when hot, wax and tallow, and a little sulphur and phosphorus. It dissolves potass, becoming darker coloured. It is changed by sulphuric acid, and is decomposed by nitric.—It enters into combination with muriatic acid, forming with it a peculiar compound. It is contained in vinegar.

249. *Fixed Oils* are transparent, more or less coloured, somewhat viscid, inodorous fluids, having a mild taste and unctuous feel. In the different species the specific gravity varies from 0.9403 to 0.9153. The point of congelation also differs considerably, but in general it is within the range of the ordinary temperatures of the atmosphere. Their boiling point exceeds 600°; and by being converted into vapour, they become empyreumatic. Fixed oils do not seem capable of combining with charcoal, but are freed from impurities by being filtered through hot charcoal. When assisted by heat, they dissolve sulphur and phosphorus. They may be blended with sugar and gum by trituration, as in emulsions, and they dissolve the volatile oils, resins, and gummy resins. With the alkalies and earths they form soaps, and with metallic oxides plasters. They are not soluble in water, but have various habitudes in regard to alcohol. They unite readily with oxygen, which renders them concrescible. Those oils which dry without losing their transparency, as linseed oil, are termed drying oils, in contradistinction to the fat oils, which from exposure become white, opaque and thick, and remain greasy, such as oil of olives or of almonds. When they become rancid, they undergo a farther degree of decomposition, and are found to contain sebacic acid. Oil in the state of vapour is inflammable, and burns with a white flame. When the combustion is complete, the products are carbonic acid gas and water, but in general soot is also deposited. The sulphuric acid renders the fixed oils brown and thick, and converts them into water and charcoal. The nitric acid oxygenizes them. The oxygenized muriatic acid or chlorine blanches them, and renders them concrete, like tallow or wax. The oils oxidize several of the metals, and are oxidized by several of their oxides. From Lavoisier's experiments on the combustion of olive oil, its constituent principles were estimated

at 79 charcoal and 21 hydrogen. *Officinal:* Oil of almonds, linseed, mustard, castor oil, and cocoa butter.

250. *Wax* is a solid of considerable consistence, granulated and crystalline in its fracture, of a white colour, and without any remarkable odour or taste. It softens and becomes plastic when very slightly heated; at 142° it melts; at a higher temperature it is in part vaporized and decomposed, and its vapour is inflammable. It resists in a remarkable degree the action of the acids; but in most of its other properties it resembles the fixed oils. From its combustion it appears to consist of carbon 53.12, hydrogen 16.91, and oxygen 29.97. *Officinal.*

251. *Spermaceti* may be obtained crystallized in white argentine plates, of an unctuous feel and taste, and a vapid smell. It melts between 90° and 95°, and at a higher temperature may be sublimed almost unchanged. Its vapour is inflammable, and its flame is bright, clear, and without smell. By exposure to the air it becomes rancid. It is soluble, especially by the assistance of heat, in alcohol and in ether. In its other properties it agrees with the fixed oils, with which it unites very readily by fusion. Muscular flesh, by long maceration in water, is converted into a substance very analogous to spermaceti, but more fusible, melting at 82°; and biliary calculi often consist of another, which is much less fusible, requiring a heat of 192° for its fusion. For all these varieties, Fourcroy has proposed the generic name *Adipocire*. *Officinal:* Spermaceti.

252. *Soaps* are combinations of the fluid or concrete fixed oils with alkalies, earths, or metallic oxides. The alkaline soaps have an unpleasant taste and peculiar smell, form a milky solution with water, and a transparent one with alcohol, and are powerfully detergent. White soap is made of soda and olive oil or tallow. Brown soap contains also resin. Soft soap consists of potass and whale oil: the white spots in it are from the addition of a little tallow. The volatile liniment of the pharmacopœias is a soap of ammonia and olive oil. The alkaline soaps are decomposed by all the earthy salts. The alkali of the soap combines with the acid of the salts, and an earthy soap is formed from the union of the earth and oil. The earthy soaps are insoluble in water. The alkaline soaps are decomposed in the same way by the metallic salts. The metallic soaps are also insoluble in water; many of them are soluble in oil, and some of them in alcohol. *Officinal:* Soaps of soda and ammonia.

253. *Plasters* are also combinations of oil with metallic oxides. They are prepared by their immediate action on each other. Olive oil and litharge are most commonly employed. *Officinal:* Litharge plaster.

254. *Volatile oils* differ from the fixed oils most remarkably in being vaporized unchanged by heat under 212°; by evaporating completely, without leaving a stain on paper; by being sapid, often pungent and odorous; and by being soluble in alcohol, and to a certain degree in water. They are more inflammable than the fixed oils, and burn with a large white flame, emit a great deal of smoke, and require more oxygen for their combustion. By exposure to the air they become coloured and thick, and are at last converted into an almost inodorous resin. They are also oxidized and converted into resins by muriate of mercury and muriate of antimony; the acids act on them with great violence, and are even capable of inflaming them. On the other hand, they resist considerably the action of the alkalies. In their other general properties they agree with the fixed oils, from which they seem to differ in composition, only in containing a larger proportion of hydrogen. In other respects, these oils are infinitely varied, especially in their taste and odour. Some are as limpid as water, others are viscid, others congeal on a slight diminution of temperature, and are even naturally concrete, and others are capable of forming crystallizations. Their predominant colours are the different shades of yellow and red, but there are also blue, green, and glaucous essential oils. Their specific gravity varies from 0.8697 to 1.0439. *Officinal:* Oil of anise, cajeput, caraway, fennel, juniper, lavender, mace, origanum, pennyroyal, peppermint, pimento, rosemary, rue, sassafras, savine, spearmint, turpentine, cloves, and all aromatic or odorous substances. *Empyreumatic oils:* Oil of amber, of hartshorn, of petroleum.

255. *Resins* are concrete substances, possessing a certain degree of transparency, and generally of an amber or brownish red colour. Their texture is homogeneous, and their fracture vitreous. They are easily reduced to powder, which readily agglutinates. Their specific gravity varies from 1.0452 to 1.2289. They have little taste or smell. They are electrics. Exposed to a certain degree of heat, they melt without suffering alteration, but they are decomposed when converted into vapour. Their vapour is inflammable, and burns with a large strong flame and a great deal of soot. Resins unite by fusion with sulphur, difficultly with phosphorus. They are so-

luble in alcohol, the fixed and the volatile oils, and alkalies, and in nitric acid with evolution of nitric oxide gas. They are insoluble in water, and are not acted upon by metallic oxides. *Officinal:* Pine resins, dragon's blood, balsams of Peru, Tolu, Gilead and Canada, turpentine, benzoin, storax, olibanum, tacamahac, mastiche, sandarac, elemi.

256. *Guaiac* differs from the resins in being soluble in nitric acid without the assistance of heat, and forming oxalic acid instead of tannin; in nitric and oxymuriatic acid, changing the colour of its solutions to green, blue, and brown, successively, and in affording a larger quantity of charcoal. *Off.*

257. *Lac* differs from resin in not being soluble in alcohol without the aid of a boiling temperature, and in being precipitated from it as it cools. Vauquelin analyzed a gum resin from Madagascar, which contained both resin and lac in the proportions of 84 to 6.

258. *Amber, copal,* and about one-fifth of *sandarac,* differ from the resins in not being soluble in alcohol without peculiar management.

259. *Camphor* is a concrete friable substance, of a white colour, with a considerable degree of transparency, and a crystalline appearance, specific gravity 0.9887. Its taste is bitter and acrid, and its smell penetrating and peculiar. It is evaporated unchanged by a heat of 145°, but may be melted by suddenly exposing it to 302°. The vapour when condensed crystallizes in hexagonal plates. Its vapour is exceedingly inflammable, and when kindled, burns with a very white flame and a great deal of smoke, leaving no residuum. The products of its combustion are carbonic acid gas, charcoal, and water. Camphor is soluble in alcohol and in the acids. From these solutions it is precipitated by water. It is also soluble in hot oils, both volatile and fixed, but on cooling separates from them in plumose crystals. It is insoluble in water, and is not acted on by the alkalies, metals, or metallic oxides. By repeated distillation with nitric acid it is converted into camphoric acid. It exists in many vegetables, but is chiefly procured from the *laurus camphora*. *Officinal.*

260. *Starch* is a fine white powder, generally concreted in friable hexagonal columns, smooth to the feel, and emitting a particular sound when compressed. It has neither taste nor smell. It is decomposed by heat. It is not soluble in cold water or in alcohol. Warm water about 190 F. converts it into a kind of mucilage, which on cooling assumes a gelatinous consistence. This jelly, when dried by heat, becomes trans-

parent and brittle like gum, but is not soluble in cold water. Starch, after being thus dissolved in hot water, cannot be reduced to its original state. It is precipitated by infusion of galls, and the precipitate is redissolved on heating the mixture to 120°, but is not soluble in alcohol. At 78 F. its watery solution ferments on the addition of yeast. By roasting it becomes soluble in cold water. Is converted by three or four hours boiling with sulphuric acid into a saccharine liquid. *Officinal:* Wheat, starch, flour, barley, oats.

261. *Asparagin* crystallizes in white, transparent, hard, brittle, rhomboidal prisms; taste cool and nauseous; readily soluble in hot water, sparingly in cold, and insoluble in alcohol. Solution does not affect vegetable blues, infusion of nutgalls, acetate of lead, oxalate of ammonia, muriate of barytes, or hydrosulphuret of potass. Potass disengages no ammonia, but renders it more soluble in water. It dissolves in nitric acid, forming a solution of a yellow colour and bitter taste. It has hitherto been found only in the expressed juice of asparagus.

262. *Inulin* is a white powder, insoluble in cold, but readily soluble in hot water; insoluble in alcohol; burns with the smell of caromel, and yields oxalic acid, when treated with nitric acid.

263. *Sugar* is a hard but brittle substance, of a white colour, disposed to form semi-transparent crystallizations, of a sweet taste, and without smell. When heated sufficiently it melts, is decomposed, emits a peculiar smell (caromel), and becomes inflamed. Sugar at 40° is soluble in its own weight of water, and in still less at 212°. It is also soluble in about four parts of boiling alcohol. It combines with volatile oils, and renders them miscible with water. It also unites with potass and lime. It is decomposed by the concentrated sulphuric and nitric acids. According to Lavoisier's and Dr Thomson's experiments, it consists of about 64 oxygen, 28 charcoal, and 8 hydrogen. *Officinal:* Sugar, honey, manna.

264. *Sarcocoll* (Dr Thomson) does not crystallize; soluble in water and alcohol. Taste bitter sweet. Soluble in nitric acid, and yields oxalic acid. *Officinal:* Sarcocoll, extract of liquorice.

265. *Jelly* is contained in the juice of acid fruits. It is deposited from them in the form of a soft tremulous mass, almost colourless, and agreeable to the taste. It is scarcely soluble in cold water, but very soluble in hot water; and when the solution cools, it again assumes a gelatinous state. With sugar its combination is well known. By long boiling it loses this property of congealing. When dried, it becomes transparent,

hard and brittle, resembling gum. It combines with the alkalies, and is converted by the nitric acid into oxalic acid. *Officinal :* Acidulous fruits.

266. *Tannin*, when completely dried, is a brittle substance, of a black colour, and vitreous fracture ; it is soluble in alcohol ; it is much more soluble in hot than in cold water. The solution has a dark brown colour, astringent taste, and peculiar smell ; it is precipitated by acids, in the form of a viscid fluid, like pitch ; it is also precipitated by carbonate of potass in yellow flakes ; it forms an insoluble elastic precipitate with gelatin, and dark blue or black precipitates with iron. Mr Hatchett has prepared a species of tannin artificially by the action of nitrous acid on charcoal, and various substances containing charcoal. *Officinal :* Galls, uva ursi, tormentil, rhubarb, sarsaparilla, St Lucie cinchona, swietenia, simarouba, filix mas, kino, catechu, salix.

QUATERNARY OXIDES.

267. *Gum*, when pure, is transparent and colourless, easily reduced to powder, without smell, and of a slightly sweetish taste. The solution of gum in water constitutes mucilage ; it is thick and adhesive, and soon dries when exposed to the air. Gum is also soluble in the weak acids ; but is totally insoluble in alcohol, which even precipitates it from mucilage. When triturated with a small quantity of oil or resin, it renders them miscible with water. Gum is very little disposed to spontaneous decomposition ; even mucilage may be kept for many years without change ; but it is decomposed by the strong acids. By oxygenizement with nitric acid, it forms successively mucic, malic, and oxalic acid ; with oxymuriatic acid it forms citric acid. When exposed to heat, it does not melt, but softens, swells, and becomes charred and incinerated. Its products are carbonic acid, and carburetted hydrogen gas, empyreumatic oil, and a considerable quantity of acetic acid, combined with a little ammonia. Fourcroy and Vauquelin say it consists of 65.38 oxygen, 23.08 carbon, and 11.54 hydrogen. Cruickshanks has however demonstrated, that it contains nitrogen and lime ; and has rendered it probable that it differs from sugar, in containing more carbon, and less oxygen. *Officinal :* Gum arabic, linseed, quinceseed.

268. *Tragacanth* is opaque and white, difficultly pulverizable, not sweetish, is very sparingly soluble in water, but absorbs a large proportion, and forms a paste. Its solution is

adhesive, but cannot be drawn out into threads. It moulds readily, and acquires a fetid smell. It is precipitated by nitrate of mercury. It is insoluble in alcohol; and seems to contain more nitrogen and lime than gum does. *Officinal:* Tragacanth.

269. *Ulmin*, a solid, hard, black substance, with considerable lustre; when reduced to powder, brown; insipid, but readily soluble in the mouth; soluble in a small quantity of water; solution transparent, blackish-brown, not mucilaginous or adhesive; insoluble in alcohol or ether; convertible into resin by nitric or oxymuriatic acid. Hitherto examined only by Klaproth, and supposed to be a product of the *ulmus nigra*.

270. *Extractive* is soluble in water, especially when hot, and in alcohol; it is also soluble in the weak acids, but is insoluble in ether. It attracts moisture from the atmosphere; and when dissolved in water, it absorbs oxygen, and becomes insoluble in water; it is also altered and precipitated by oxymuriatic acid; it has a strong affinity for alumina, and decomposes several metallic salts. It is found in almost all plants, but can scarcely be procured separate, so that its characters are not well ascertained. *Officinal:* Saffron, aloes.

271. *Gum-resins*, in strict propriety, should not be noticed here, as they are secondary compounds, and probably vary much in their nature. They seem to be compounds of resin with extractive and essential oil, and perhaps other immediate principles not yet ascertained. *Officinal:* Gum ammoniac, galbanum, scammony, assafœtida, gamboge, myrrh, sagapenum, olibanum.

272. *Bitter principle* (Thomson), intensely bitter, of a yellowish colour, ductile while soft, brittle while dry, not fusible, soluble in alcohol and water, not crystallizable, precipitated by nitrate of silver, acetate of lead. *Officinal:* Quassia, gentian, colocynth, broom, simarouba, dandelion, colomba, marsh, trefoil, lesser centaury, blessed thistle, different species of artemisia, cinchona Jamaicensis.

273. *Narcotic principle*, crystallizable, soluble in about 400 parts of boiling water, in cold water, in 24 parts of boiling alcohol, in hot ether, in all acids, and in hot volatile oils, fusible, not volatile, highly narcotic. *Officinal:* Opium, lactuca, belladona, hyoscyamus, hemlock, stramonium.

274. *Acrid principle*, soluble in alcohol, water, acids, and alkalies, rises in distillation with water and alcohol, not neutralized by alkalies or acids. *Officinal:* Squills, garlic, col-

chicum, asarum, arum, hellebore, bryony, iris, ranunculus, digitalis, viola, scurvygrass, mustard.

275. *Cinchonin*, not acrid, soluble in alcohol and in water, precipitated by infusion of galls; precipitate soluble in alcohol. *Officinal:* Cinchona officinalis, colomba, angustura, ipecacuan, pepper, opium, capsicum.

276. *Indigo* has a deep blue colour, is light and friable, without taste or smell, insoluble in water, alcohol, ether, and oils, forming a deep blue solution with sulphuric acid; when precipitated from acids, soluble in alkalies, becoming green. It is obtained from the indigofera tinctoria and isatis tinctoria.

277. *Caoutchouc*, when smoke has not been employed in drying it, is of a white colour, soft, pliable, extremely elastic, and difficultly torn; specific gravity 0.9335; inalterable by exposure to air; insoluble in water, but softened, so that its edges may be made to adhere to each other; insoluble in alcohol; soluble, without alteration, in ether previously agitated with water, and in rectified petroleum; soluble in volatile oils; and fusible by heat, but altered, so that it remains glutinous after evaporation and cooling; inflammable; insoluble in alkalies, and decomposed by the strong acids. It is obtained principally from Hævea caoutchouc and Jatropha elastica in South America, and the Ficus Indica, Artocarpus integrifolia, and Urceola elastica in the East Indies.

278. *Bird-lime* is a green, gluey, stringy, and tenacious substance, insoluble in water and in cold alcohol; unites readily with the oils, and is soluble in ether, forming a green solution.

279. *Suber* constitutes the epidermis of all vegetables. On the Quercus suber it is thickened by art in a surprising degree, and forms common cork. It is a light elastic substance, very inflammable, burning with a bright white flame, and leaving a very spongy charcoal; it is not soluble in any menstruum; it is decomposed by nitric acid, and is converted into a peculiar acid, and an unctuous substance.

280. *Wood* (lignin?), when separated from all the other matters with which it is combined in vegetables, is a pulverulent, fibrous, or lamellated body, more or less coloured, of considerable weight, without taste or smell, and insoluble in water or alcohol. When exposed to a sufficient heat, it is decomposed without melting or swelling, and is converted into charcoal without any change of form. Its products, by combustion, are carbonic acid, and carburetted hydrogen gas, water, empyreumatic oil, and acetic acid. By nitric acid, it is changed into the malic, oxalic, and acetic acids. It forms the skeleton of all vegetables.

281. *Cotton*, a white fibrous substance, without smell or taste, insoluble in water, alcohol, ether, oils, and vegetable acids; soluble in strong alkaline leys, and when assisted by heat, in nitric acid, forming oxalic acid.

282. *Gelatin*, when exsiccated, is a hard, elastic, semi-transparent substance, resembling horn, having a vitreous fracture: inalterable in the air, soluble in boiling water, and forming with it a gelatinous mass on cooling; it is also soluble, but less readily in cold water. It is soluble in acids, even when much diluted, and also in the alkalies. It is precipitated by tannin, with which it forms a thick, yellow precipitate, soon concreting into an adhesive, elastic mass, readily drying in the air, and forming a brittle substance, of a resinous appearance, resembling over-tanned leather, very soluble in ammonia, and soluble in boiling water. It is also precipitated copiously by carbonate of potass, and by alcohol; both precipitates being soluble in water. The solution of gelatin in water first becomes acid, and afterwards putrid. When decomposed by nitric acid or heat, its products shew that it contains only a small proportion of nitrogen. It is principally contained in the cellular, membranous, and tendinous parts of animals, and forms an important article of nourishment. Glue and isinglass, which are much employed in the arts, are almost pure gelatin. *Officinal:* Isinglass, cornu cervi.

283. *Albumen*, when dried, is a brittle, transparent substance, of a pale yellow colour, and glutinous taste, without smell, readily soluble in cold water, insoluble in boiling water, but softened and rendered opaque and white when thrown into it; insoluble, and retaining its transparency in alcohol; swelling; becoming brown, and decrepitating when suddenly exposed to heat. It generally exists in the form of a viscid, transparent fluid, having little taste or smell, and readily soluble in cold water. When heated to 165°, it coagulates into a white opaque mass, of considerable consistency; it is also coagulated by alcohol and acids, and remarkably by muriate of mercury. Albumen forms with tannin a yellow precipitate, insoluble in water. *Coagulated albumen* is not soluble either in cold or in boiling water. It is soluble, but with decomposition, in the alkalies and alkaline earths. It is also soluble in the acids, greatly diluted, but may be precipitated from them by tannin. When decomposed by nitric acid or heat, it is found to contain more nitrogen than gelatin does. White of egg consists of albumen, combined with a very little soda, sulphur, and phosphate of lime. Albumen also forms a large proportion of the serum of the blood, and is found in the sap

of vegetables. It is highly nutritious. *Officinal:* White of egg.

284. *Fibrin* is of a white colour, without taste or smell, tough and elastic; but when dried, hard and almost brittle. It is not soluble in water or in alcohol. The concentrated caustic alkalies form with it a kind of fluid viscid soap. It is dissolved even by the weak and diluted acids; but it undergoes some change, by which it acquires the properties of jellying, and being soluble in hot water. By maceration in water, it becomes putrid, and is converted into adipocire. By long boiling in water, it is rendered tough and corneous. When decomposed by heat or nitric acid, it is found to contain a large proportion of nitrogen. It forms the basis of the muscular fibre, and is contained in small quantity in the blood. The *gluten* of wheat does not seem to differ from it in any important property. It is eminently nutritious.

285. *Urea* is obtained in the form of brilliant micaceous crystals, in groups, forming a mass of a yellowish-white colour, adhering to the vessel containing it; difficult to cut or break: hard and granulated in its centre, gradually becoming soft, and of the consistency of honey on its surface; of a strong, disgusting, alliaceous odour; of an acrid, pungent, disagreeable taste. It is deliquescent; and during its solution in water, it causes a sensible diminution of temperature; it is also soluble in alcohol, especially when assisted by heat. On cooling, the alcoholic solution deposites crystals of pure urea. By the application of heat, it melts, swells rapidly, and at the same time begins to be decomposed, emitting an insupportably fetid odour, and is converted into carbonate of ammonia, and carburetted hydrogen gas. Urea is charred by concentrated sulphuric acid; diluted sulphuric acid, aided by heat, is capable of converting it entirely into acetic acid and ammonia; concentrated nitrous acid decomposes it with rapidity; diluted nitric acid, aided by heat, changes it almost entirely into carbonic acid gas and nitrogen gas; muriatic acid dissolves and preserves it; oxymuriatic acid converts it into ammonia and carbonic acid; potass, aided by heat, converts it into the carbonate and acetate of ammonia. It influences the form of the crystallization of the muriates of ammonia and soda. The solution of urea in water varies in colour from a deep brown to a pale yellow, according to its quantity. With eight parts of water it is perfectly fluid; it scarcely undergoes spontaneous decomposition when pure, but the addition of some albumen occasions it to putrify rapidly. By repeated distillation it is entirely converted into carbonate of ammonia. With ni-

tric acid it forms a pearly crystalline precipitate; it also forms precipitates with the nitrates of lead, mercury, and silver. It is not precipitated by tannin or gallic acid. Urea is only obtained from urine by evaporating the solution of a thick extract of urin in alcohol.

COMPOUND ACIDS.

286. The compound acids possess the properties of acids in general; but they are distinguished from the acids with simple bases, by their great alterability.

287. The ternary acids coincide nearly with the vegetable acids, and are characterized by their being converted entirely into water and carbonic acid, when completely decomposed by oxygen. They consist of various proportions of carbon, hydrogen, and oxygen.

288. The quaternary acids coincide nearly with the animal acids; and are characterized by their furnishing ammonia, as well as water and carbonic acid, when decomposed.

TERNARY ACIDS.

289. *Acetic acid* is a transparent and colourless fluid, of an extremely pungent smell and a caustic acid taste, capable of reddening and blistering the skin. It is very volatile, and its vapour is highly inflammable; it combines with water in every proportion; it combines with sugar, mucilage, volatile oils, alcohol; it dissolves boracic acid, and absorbs carbonic acid gas; it is formed by the acidification of sugar, and by the decomposition of some other ternary and quaternary compounds by heat or acids. It is decomposed by the sulphuric and nitric acids, and by heat. In its ordinary state, it has only an acid taste, a pleasant odour, specific gravity 1.0005, congeals and crystallizes at —22°, and is vaporized at 212°. *Officinal.*

290 *Formic acid* is in most respects analogous to acetic acid, but has a peculiar smell, and greater specific gravity, being 1.102 to 1.113.

291. *Oxalic acid* is obtained in prismatic crystals, transparent and colourless, of a very acid taste, soluble in their own weight of water at 212°, and in about two waters at 65°. Boiling alcohol dissolves somewhat more than half its weight, and at an ordinary temperature a little more than one-third. It is soluble in the muriatic and acetic acids. It is decomposed by heat, sulphuric acid, and nitric acid. According to Thomson, it consists of 64 oxygen, 32 carbon, and 4 hydrogen.

292. *Mellitic acid* crystallizes in very fine needles, or small short prisms, of a brownish colour, and a sweetish sour, but afterwards bitterish taste; sparingly soluble in water, and decomposed by heat, but not convertible into oxalic acid by nitric acid.

293. *Tartaric acid* varies in the forms of its crystals; its specific gravity is 1.5962; it is permanent in the air; it is decomposed by heat; it dissolves readily in water, and the solution, when very weak, is decomposed by the atmosphere; it may be changed by nitric acid into oxalic acid. According to Fourcroy, it consists of 70.5 oxygen, 19.0 carbon, and 10.5 hydrogen. *Officinal:* Exists in tamarinds, grapes, &c.

294. *Pyrotartaric acid,* extremely acid, soluble in water, and crystallizable; melts and sublimes by heat, precipitates nitrate of mercury, but not nitrate of silver or acetate of lead.

295. *Citric acid* crystallizes in rhomboidal prisms, which suffer no change from exposure to the air, and have an exceedingly acid taste. When sufficiently heated, they melt, swell, and emit fumes, and are partly sublimed unchanged, and partly decomposed. Water, at ordinary temperatures, dissolves one half of its weight of these crystals; at 212° twice its weight. The solution undergoes spontaneous decomposition very slowly. Sulphuric acid chars it, and forms vinegar. Nitric acid converts it into oxalic and acetic acids. *Officinal:* Orange and lemon juice, heps, &c.

296. *Malic acid* is a viscid fluid, incapable of crystallization, of a reddish-brown colour, and very acid taste. It exists in the juice of apples, and, combined with lime, in that of the common house-leek. It forms precipitates in the solution of the nitrates of mercury, lead, and silver. *Officinal:* Barberry, plumb, sloe, elder, &c.

297. *Gallic acid* crystallizes in brilliant colourless plates, of an acid and somewhat austere taste, and of a peculiar odour when heated. It may be sublimed undecomposed, by a gentle heat. It is not altered by exposure to the air, is soluble in $1\frac{1}{2}$ of water at 212°, and in 12 waters at 60, and in four times its weight of alcohol. It has a strong affinity for metallic oxides, especially those of iron. It precipitates gold, copper, and silver brown, mercury orange, iron black, bismuth yellow, and lead white. *Officinal:* It exists in nutgalls, and in most astringent vegetable substances.

298. *Mucic acid* is a white gritty powder, of a slightly acid taste, soluble in 80 times its weight of boiling water.

299. *Benzoic acid* crystallizes in compressed prisms of a pungent taste and smell. It is fusible, and evaporates by heat,

for the most part, without change. It is also inflammable, and burns entirely away. It is permanent in the air. It is very sparingly soluble in cold water; but at 212° it dissolves in about 24 waters. It is also soluble in hot acetic acid. It is soluble, without change, in alcohol, in concentrated sulphuric and nitric acid, and is separated from them by water. *Officinal:* In balsams of Tolu and Peru, benzoin, storax, &c.

300. *Succinic acid* crystallizes in transparent white triangular prisms; may be melted and sublimed, but suffers partial decomposition; more soluble in hot than in cold water: soluble in hot alcohol.

301. *Moroxylic acid* crystallizes in colourless transparent prisms, having the taste of succinic acid, and not altered by exposure to the air; volatile, readily soluble in water and in alcohol.

302. *Camphoric acid* crystallizes in white parallelopipeds of a slightly acid bitter taste, and smell of saffron, efflorescing in the air; sparingly soluble in cold water; more soluble in hot water; soluble in alcohol, the mineral acids, volatile and unctuous oils; melting and subliming by heat.

303. *Suberic acid* is not crystallizable, but is obtained either in the form of thin pellicles, or of a white powder like starch. At 60° it requires 80 times its weight of water for its solution; at 140°, 38; at 212°, only twice its weight. When heated, it melts, and on cooling crystallizes in needles. It may also be sublimed in long needles. It does not precipitate solutions of lime, barytes or strontia, or their salts, nor the sulphates of copper and of zinc. It precipitates nitrate of silver, muriate of tin, sulphate of iron, nitrate and acetate of lead, and nitrate of mercury. It is not acted on by nitric acid. It is soluble in alcohol, and in the alkalies, forming with them neutral salts.

304. *Laccic acid* is obtained in the form of a reddish liquor, having a slightly bitter saltish taste, and the smell of new bread, by expression from the white lac of Madras; but on evaporation it assumes the form of acicular crystals. It rises in distillation. It decomposes with effervescence the carbonates of lime and soda. It renders the nitrate and muriate of barytes turbid. It assumes a green colour with lime water, and a purplish colour with sulphate of iron; and precipitates sulphuret of lime white, tincture of galls green, acetate of lead reddish, nitrate of mercury whitish, and also tartrate of potass; but this last precipitate is not soluble in potass.

305. *Sebacic acid* has no smell, and a slightly acid taste. It is crystallizable, melts like fat, and is not volatile. It is so so-

luble in hot water as to become solid on refrigeration. It is also very soluble in alcohol. It precipitates the nitrates of lead, silver, and mercury, and the acetates of lead and mercury. It does not precipitate the waters of lime, baryta, or strontia.

QUATERNARY ACIDS.

306. *Prussic acid* is a colourless fluid, of a strong smell, like that of bitter almonds, and a sweetish pungent taste. It does not redden vegetable blues. It is easily decomposed by light, heat, and chlorine. It does not act upon the metals, but forms coloured, and generally insoluble combinations with their oxides. It is obtained from animal substances by the action of heat, nitric acid, fixed alkalies, and putrefaction. *Officinal:* Bitter almonds. Prunus lauro-cerasus.

306 *. *Ferrated chyazic acid* is composed of the elements of prussic acid and the black oxide of iron. It is of a pale lemon colour, has no smell, and is decomposed by a gentle heat or strong light. It forms directly with alkalies and earths the salts termed triple prussiates.

306 *. *Sulphuretted chyazic acid* is composed of the elements of prussic acid and sulphur. It is colourless or pinkish, sp. gr. 1.022, smell pungent like strong acetic acid. These two acids were discovered by M. Porret.

307. *Amnic acid* is obtained in white, brilliant, acicular crystals, of an acid taste, reddening the tincture of turnsole, sparingly soluble in cold water, but somewhat more soluble in hot water. It is soluble in alcohol. It is decomposed by heat.

308. *Uric acid* is obtained in the form of acicular brilliant crystals, of a pale yellow colour, almost insoluble in cold, and very sparingly soluble in boiling water, but becoming very soluble when combined with an excess of potass or soda. It is decomposed at a high temperature, and furnishes carbonate of ammonia, and carbonic acid, with very little oil or water, and leaves a charcoal which contains neither lime nor alkali. It is also decomposed by the nitric acid and chlorine.

309. *Rosacic acid*, in many respects analogous to uric acid, but has less tendency to crystallize; is more soluble in hot water, and occasions a violet precipitate in muriate of gold. It is the principal constituent of the lateritious sediment in fevers.

CHARACTERS OF SECONDARY SALTS DERIVED FROM THEIR ACIDS.

310. The *nitrites* are characterized by their emitting the nitrous acid in orange fumes, on the addition of sulphuric acid.

311. The *nitrates*, by the action of fire, furnish impure oxygen gas, mixed with nitrogen, and are reduced to their bases.

By the action of concentrated sulphuric acid, they emit a white vapour; and they are capable of supporting combustion. *Officinal:* Nitrates of potass and of silver.

312. The *carbonates* always preserve their alkaline properties in some slight degree. They are decomposed by all the acids, forming a brisk effervescence, which is colourless. The carbonates of the metals very much resemble their oxides. *Officinal:* Carbonates of baryta, of lime, of magnesia, of potass, of soda, of ammonia, of zinc, of iron.

313. *Borates* are vitrifiable; and their concentrated solutions afford, when heated with the strong sulphuric acid, brilliant lamellated crystals. *Officinal:* Sub-borate of soda.

314. The *sulphites*, by the action of heat, furnish sulphur, and become sulphates. They are also converted into sulphates, with effervescence, and exhalation of sulphurous vapours, by the sulphuric, nitric, muriatic, and other acids, and by exposure to the atmosphere gradually, when dry, and very quickly, when dissolved. *Officinal:* Sulphate of potass with sulphur.

315. The *sulphates* form sulphurets, when heated to redness with charcoal, and furnish copious precipitates with solutions of baryta. *Officinal:* Sulphates of baryta, potass, soda, zinc, copper, iron, mercury.

316. The *phosphites* are fusible, and, when heated in close vessels, furnish a little phosphorus, and become phosphates. When heated in the open air, they emit a phosphorescent light, and often flashes of flame, accompanied by a strong smell of garlic, and a thick white vapour, and are converted into phosphates.

317. The *phosphates* are crystallizable, fixed, fusible, vitrifiable, and phosphorescent. They are not decomposed by charcoal. They are soluble in nitric acid, without effervescence, and precipitable from that solution by lime water. *Officinal:* Phosphate of soda.

318. The *arsenites* are decomposed by heat, and by all the acids.

319. The *arsenates* are decomposed by charcoal at a high temperature.

320. The *molybdates* are generally colourless and soluble, and are precipitated light brown by prussiate of potass.

321. The *chromates* are of a yellow or orange colour.

322. *Columbate* of potass resembles boracic acid in its appearance.

323. *Acetates* are very soluble in water; are decomposed by heat, by exposure of their solutions to the air, and by the stronger acids. *Officinal:* Acetate of potass, lead, zinc, mercury.

324. *Formates* strongly resemble the acetates.

325. *Oxalates* are decomposed by heat; form, with lime-water, a white precipitate, which, after being exposed to a red heat, is soluble in acetic acid. The earthy oxalates are very sparingly soluble in water; the alkaline oxalates are capable of combining with excess of acid, and become less soluble.

326. *Mellates*, crystallizable.

327. *Tartrates*, by a red heat, are converted into carbonates. The earthy tartrates are scarcely soluble in water: the alkaline tartrates are soluble; but when combined with excess of acid, they become much less soluble. The tartaric acid is capable of combining at the same time with two bases. *Officinal:* Supertartrate of potass, tartrate of potass and soda.

328. *Pyrotartrate of potass*, soluble in alcohol, precipitates acetate of lead, but not the salts of barytes and lime.

329. *Citrates* are decomposed by the stronger mineral acids, and also by the oxalic and tartaric, which form an insoluble precipitate in their solutions. The alkaline citrates are decomposed by a solution of barytes.

330. *Malates* having alkalies for their base, are deliquescent. The acidulous malate of lime is soluble in cold water.

331. *Gallates* have not been particularly examined.

332. *Mucates* of potass and soda are crystallizable. Mucates with earthy and metallic bases are nearly insoluble.

333. *Benzoates*, little known, but generally forming feather-shaped crystals, and soluble in water.

334. *Succinates*, little known.

335. *Moroxylate* of lime, needle formed crystals, permanent in the air, soluble in water, and precipitating the solutions of silver, mercury, copper, iron, cobalt, and uranium in nitric acid, and of lead and iron in acetic acid.

336. *Camphorates* have commonly a bitter taste, burn with a blue flame before the blowpipe, and are decomposed by heat, the acid subliming.

337. *Suberates* have in general a bitter taste, and are decomposed by heat.

338. *Laccate* of lime bitterish; of soda deliquescent.

339. *Sebates* are soluble salts.

340. *Prussiates* of alkalies are easily decomposed even by carbonic acid. They form variously coloured precipitates in the solutions of the metallic salts, except those of platinum.

341. *Amnates.* Very soluble in water, and the acid is precipitated from them in the form of a white crystalline powder, by the other acids.

342. The *urates* are almost insoluble in water. The sub-

urates of soda and potass are very soluble, and the uric acid is precipitated from the solutions even by the carbonic acid.

343. *Rosates*, unknown.

344. The *muriates* have a more or less pure salt taste. They are not acted upon by any combustible body. They are all soluble in water, and are the most volatile and most difficultly decomposed by heat of the neutral salts. They emit white fumes with the sulphuric acid, and oxymuriatic acid gas with the nitric. *Officinal:* Muriates of ammonia, soda, baryta, lime, mercury, antimony. According to Sir H. Davy, the first only is a muriate, or combination of muriatic acid; the others are combinations of chlorine, with a metallic base, and should be called sodane, barane, calcane, mercurane, and antimonane, or, what seems better, chlorides of these bases.

345. *Oxymuriates* give out very pure oxygen gas by the action of caloric, and become muriates. They do not destroy vegetable colours. Their acid is expelled from them with noise, by the stronger acids; and they inflame combustible bodies, even spontaneously, and with detonation.

346. *Fluates* afford, when treated with concentrated sulphuric acid, a vapour which corrodes glass, and from which the silica is afterwards precipitated by water.

347. *Fluo-borate of ammonia*, decomposed by heat; fluate of ammonia subliming, and boracic acid remaining behind.

348. *Iodates* are crystallizable, very insoluble; by the action of fire, melt and decompose easily. They detonate by percussion with combustible bodies; precipitate silver white, and very soluble in ammonia.

349. *Hydriodates*, soluble in water, precipitate silver white, and insoluble in ammonia.

CHARACTERS OF SALTS DERIVED FROM THEIR BASES.

CLASS FIRST. *Alkaline salts.* Soluble in water, not precipitated by potass, or oxalic acid.

GENUS I. *Potass.* Sapid, bitter, crystallizable, fusible, calcinable, vitrified, or reduced to their base by heat, decomposed in general by baryta, rarely by lime. *Officinal:* Sulphate, nitrate, carbonate, supertartrate, tartrate, acetate.

G. II. *Soda.* Sapid, bitter, crystallizable, commonly containing much water of crystallization, and therefore efflorescent, and undergoing the watery fusion and exsiccation before they are melted by the fire, decomposed by baryta and potass. *Officinal:* Sulphate, muriate, phosphate, carbonate, tartrate, sub-borate.

G. III. *Ammonia.* Sapid, acrid, very soluble, either sublimed unchanged, or decomposed, losing their base partially or totally by heat, base also expelled by baryta, potass, soda, strontia, and lime. *Officinal:* Muriate, carbonate, acetate, hydrosulphuret.

CLASS SECOND. *Earthy salts.* Either insoluble in water, or, if soluble, precipitated by sulphuric acid and carbonate of potass.

GENUS I. *Baryta.* Generally insoluble in water, and indecomposable by fire; all poisonous and decomposed by the alkaline carbonates. *Officinal:* Sulphate, carbonate, and muriate.

G. II. *Strontia.* Generally insoluble in water, and indecomposable by fire; not poisonous, and decomposed by the alkaline carbonates, potass, soda, and baryta.

G. III. *Lime.* Generally sparingly soluble in water, decomposed by the alkaline carbonates, potass, soda, baryta, and strontia, and by oxalic acid. *Officinal:* Carbonate, muriate, phosphate.

G. IV. *Magnesia.* Generally soluble in water, and bitter; decomposed by baryta, potass, soda, strontia, and partially by ammonia. Magnesian salts, when added to ammoniacal salts, containing the same acid, quickly deposite crystals of a triple ammoniaco-magnesian salt. *Officinal:* Sulphate, carbonate.

G. V. *Glucina.* Taste sweetish; decomposed by all the preceding bases; when recently precipitated by an alkali, soluble in carbonate of ammonia, precipitated by an infusion of nutgalls, and succinate of potass.

G. VI. *Alumina.* Generally soluble in water, taste sweetish and styptic; decomposed by all the preceding bases; when recently precipitated, soluble in the alkalies, and in sulphuric acid, precipitated by hydrosulphuret of potass. *Officinal:* Supersulphate.

G. VII. *Yttria.* Sweetish styptic taste; decomposed by all the preceding bases; precipitated by prussiate of potass and iron, and by infusion of galls.

G. VIII. *Zirconia.* Taste austere; decomposed by all the preceding bases; precipitate not soluble in the alkalies, and when redissolved in muriatic acid, precipitated by hydrosulphuret of potass, prussiate of potass and iron, and infusion of galls.

G. IX. *Silica.* Forms only one salt with fluoric acid, which is crystallizable, soluble in excess of acid, and in the alkaline fluates.

CLASS THIRD. *Metalline salts.*

1. Soluble in water, precipitated by hydrosulphuret of potass;
2. Insoluble in water, fusible with borax into a coloured glass, or with charcoal into a metallic button.

GENUS. I. *Gold.* Soluble in water, solution yellow, metal precipitated by sulphate of iron, sulphurous acid, and infusion of galls; prussiate of potass and iron gives a yellowish-white, and muriate of tin a purplish precipitate.

G. II. *Platinum.* Solution in water brownish, not precipitated by prussiate of potass and iron, or infusion of galls, coloured bright red by muriate of tin, metal precipitated by sulphuretted hydrogen, precipitated orange by prussiate of mercury, and in small red crystals by potass and ammonia.

G. III. *Silver.* Metal precipitated by copper and sulphate of iron. Precipitated white by muriatic acid and the prussiates, black by hydrosulphuret of potass, and yellowish-brown by infusion of galls. *Officinal:* Nitrate.

G. IV. *Copper.* Soluble in water; solution blue or green, rendered bright blue by ammonia, metal precipitated by iron, precipitated black by hydrosulphuret of potass, greenish-yellow by prussiate of potass and iron, green by alkaline arsenites and arseniates, and brown by oxalic acid. *Officinal:* Sulphate, ammoniaret.

G. V. *Iron.* Soluble in water. Solution green or brownish red; precipitated blue by the triple prussiates, and purple or black by infusion of galls. *Officinal:* Sulphate, tartrate, acetate, carbonate.

G. VI. *Lead.* Insoluble salts easily reduced. Soluble salts colourless; precipitated white by triple prussiate, infusion of galls and zinc, and black by hydrosulphuret of potass. *Officinal:* Acetate, subacetate.

G. VII. *Tin.* Soluble, not precipitated by infusion of galls; precipitated white by triple prussiate and lead, black by hydrosulphuret of potass, and brown by sulphuretted hydrogen.

G. VIII. *Zinc.* Soluble; colourless; not precipitated by any metal or infusion of galls; precipitated white by alkalies, triple prussiate, hydrosulphuret of potass, and sulphuretted hydrogen. *Officinal:* Sulphate.

G. IX. *Mercury.* Volatile; precipitate by copper metallic, by triple prussiate and muriatic acid white, by hydrosulphuret of potass black, and by infusion of galls orange. *Officinal:* Muriate, submuriate, subsulphate, subnitrate.

G. x. *Tellurium.* Not precipitated by triple prussiate. Precipitate by zinc black and metallic, by hydrosulphuret of potass brown, by infusion of galls yellow, and by alkalies white, and soluble when the alkali is added in excess.

G. xi. *Antimony.* Precipitate by iron or zinc black, by hydrosulphuret of potass orange. *Officinal:* Muriate, phosphate, tartrate.

G. xii. *Bismuth.* Solution, colourless. Precipitate by copper metallic, by water and triple prussiate white, by infusion of galls orange, and by hydrosulphurets black.

G. xiii. *Manganese.* Soluble, not precipitated by gallic acid. Precipitated by alkalies, triple prussiate, and hydrosulphurets, white.

G. xiv. *Nickel.* Salts soluble; colour green, precipitate by triple prussiate dull green, by hydrosulphuret black, by infusion of galls greyish-white, and by iron, &c. metallic.

G. xv. *Cobalt.* Soluble, reddish, precipitated by alkalies blue or reddish-brown, by triple prussiate brown with a shade of blue.

G. xvi. *Uranium.* Soluble, yellow, precipitate by alkalies yellow, by alkaline carbonates white, soluble in excess of alkali, by triple prussiate brownish-red, by hydrosulphuret of potass brownish-yellow, and by infusion of glass chocolate.

G. xvii. *Titanium.* Precipitate by alkaline carbonates flaky, white, by triple prussiate and hydrosulphuret green, and by infusion of galls reddish-brown, solution coloured red by tin, and blue by zinc.

G. xviii. *Chromium.* Precipitate by triple prussiate and hydrosulphuret green, and by infusion of galls brown.

G. xix. *Molybdenum.* Solutions blue, precipitate by triple prussiate and tincture of galls brown.

G. xx. *Tungsten.* Unknown.

G. xxi. *Arsenic.* Precipitate by water and triple prussiate white, by hydrosulphuret of potass yellow, by sulphate of copper green, by nitrate of silver yellow.

G. xxii. *Columbium.* Colourless; precipitate by alkaline carbonates and zinc white, by triple prussiate green, by hydrosulphuret of ammonia chocolate, and by tincture of galls orange.

G. xxiii. *Iridium.* Muriatic and sulphuric solution green, nitric red; precipitate by alkalies green and red.

G. xxiv. *Osmium.* Alkaline solution coloured purple and vivid blue by infusion of galls.

G. xxv. *Rhodium.* Triple salt with soda and muriatic acid not precipitated by prussiate of potass, muriate or hydrosulphuret of ammonia, or alkaline carbonates, but by pure alkalies yellow.

G. XXVI. *Palladium.* Acid solutions red; precipitated by prussiate of mercury yellowish-white; by prussiate of potass, brown.

G. XXVII. *Cerium.* Acid solutions precipitated by alkalies white.

SECT. II.

PHARMACEUTICAL OPERATIONS.

COLLECTION AND PRESERVATION OF SIMPLES.

350. EACH of the kingdoms of nature furnishes substances which are employed in medicine, either in their natural state, or after they have been prepared by the art of pharmacy.

351. In collecting these, attention must be paid to select such as are most sound and perfect, to separate from them whatever is injured or decayed, and to free them from all foreign matters.

352. Those precautions must be taken which are best fitted for preserving them. They must, in general, be defended from the effects of moisture, too great heat or cold, and confined air.

353. When their activity depends on volatile principles, they must be preserved from the contact of the air as much as possible.

354. As the vegetable kingdom presents us with the greatest number of simples, and the substances belonging to it are the least constant in their properties, and most subject to decay, it becomes necessary to give a few general rules for their collection and preservation.

355. Vegetable matters should be collected in the countries where they are indigenous; and those which grow wild, in dry soils and high situations, fully exposed to the air and sun, are in general to be preferred to those which are cultivated, or which grow in moist, low, shady, or confined places.

356. Roots which are annual, should be collected before

they shoot out their stalks or flowers; biennial roots in the autumn of the first, or spring of the second year; perennial roots either in spring before the sap has begun to mount, or in harvest after it has returned.

357. Those which are worm-eaten, except some resinous roots, or which are decayed, are to be rejected. The others are immediately to be cleaned with a brush and cold water, letting them lie in it as short a time as possible; and the fibres and little roots, when not essential, are to be cut away.

358. Roots which consist principally of fibres, and have but a small tap, may be immediately dried. If they be juicy, and not aromatic, this may be done by heat, not exceeding 100° of Fahrenheit; but if aromatic, by simply exposing them, and frequently turning them in a current of dry air; if very thick and strong, they are to be split or cut into slices, and strung upon threads; if covered with a tough bark, they may be peeled fresh, and then dried. Farinaceous roots are to be dipt in boiling water before they are dried. Such as lose their virtues by drying, or are directed to be preserved in a fresh state, are to be kept buried in dry sand. Ginger is peeled and preserved in syrup.

359. No very general rule can be given for the collection of herbs and leaves: some of them acquiring activity from their age; and others, as the mucilaginous leaves, from the same cause, losing the property for which they are officinal. Aromatics are to be collected after the flower-buds are formed; annuals, not aromatic, when they are about to flower, or when in flower; biennials, before they shoot; and perennials, before they flower, especially if their fibres become woody.

360. They are to be gathered in dry weather, after the dew is off them, or in the evening, before it falls, and are to be freed from decayed, or foreign leaves. They are usually tied in bundles, and hung up in a shady, warm, and airy place; or spread upon the floor, and frequently turned. If very juicy, they are laid upon a sieve, and dried by a gentle degree of artificial warmth.

361. Sprouts are collected before the buds open; and stalks are gathered in autumn.

362. Barks and woods are collected in spring or in autumn, when the most active parts of the vegetable are concentrated in them. Spring is preferred for resinous barks, and autumn for the others which are not resinous, but rather gummy. Barks should be taken from young trees, aud freed from decayed parts, and all impurities.

363. The same rules are to be followed in collecting woods;

which, however, must not be taken from very young trees. Among the resinous woods, the heaviest, which sink in water, are selected. The alburnum is to be rejected.

364. Flowers are to be collected in clear dry weather, before noon, but after the dew is off, either when they are just about to open, or immediately after they have opened. Of some the petals only are preserved, and the colourless claws are even cut away; of others whose calyx is odorous, the whole flower is kept. Flowers which are too small to be pulled singly, are dried with part of the stalk; these are called heads or tops.

365. Flowers are to be dried nearly in the same manner as leaves, but more quickly, and with more attention. As they must not be exposed to the sun, it is best done by a slight degree of artificial warmth; and in some cases they should be put up in paper bags. When they lose their colour and smell, they are unfit for use.

366. Seeds and fruits, unless when otherwise directed, are to be gathered when ripe, but before they fall spontaneously. The emulsive and farinaceous seeds are to be dried in an airy, cool place; the mucilaginous seeds by the heat of a stove. Some pulpy fruits are freed from their core and seeds, strung upon thread, and dried artificially, by exposing them repeatedly to the heat of a stove. They are in general best preserved in their natural coverings, although some, as the colocynth, are peeled, and others, as the tamarind, immersed in syrup. Many seeds and fruits are apt to spoil, or become rancid; and as they are then no longer fit for medical use, no very large quantity of them should be collected at a time.

367. The proper drying of vegetable substances is of the greatest importance. It is often directed to be done in the shade, and slowly, that the volatile and active particles may not be dissipated by too great heat: but this is an error; for they always lose infinitely more by slow than by quick drying. When, on account of the colour, they cannot be exposed to the sun, and the warmth of the atmosphere is insufficient, they should be dried by an artificial warmth, less than 100° Fahrenheit, and exposed to a free current of air. When perfectly dry and friable, they have little smell; but after being kept some time, they attract moisture from the air, and regain their proper odour.

368. The boxes and drawers in which vegetable substances are kept, should not impart to them any smell or taste; and more certainly to avoid this, they should be lined with paper. Such as are volatile, of a delicate texture, or subject to suffer

from insects, must be kept in well-covered glasses. Fruits and oily seeds, which are apt to become rancid, must be kept in a cool and dry, but by no means in a warm or moist place.

369. Oily seeds, odorous plants, and those containing volatile principles, should be collected fresh every year; others, whose properties are more permanent, and not subject to decay, will keep for several years.

370. Vegetables collected in a moist and rainy season, are in general watery, and apt to spoil. In a dry season, on the contrary, they contain more oily and resinous particles, are more active, and keep much better.

MECHANICAL OPERATIONS OF PHARMACY.

a. The determination of the weight and bulk of bodies.
b. The division of bodies into more minute particles.
c. The separation of their integrant parts by mechanical means.
d. Their mixture, when not attended by any chemical action.

WEIGHTS AND MEASURES.

371. The quantities of substances employed in pharmaceutical operations are most accurately determined by the process called weighing. For this purpose, there should be sets of beams and scales of different sizes; and it would be advisable to have a double set, one for ordinary use, and another for occasions when greater accuracy is necessary. A good beam should remain in equilibrium both by itself and when the scales are suspended, one to either end indifferently; and it should turn sensibly with a very small proportion of the weight with which it is loaded. Balances should be defended as much as possible from acid and other corrosive vapours, and should not be overloaded, or left suspended longer than is necessary, as their delicacy is thereby very much impaired. It is unfortunately not unnecessary to mention, that the scales and weights, as well as measures, funnels, mortars, &c. should be kept extremely clean. Some nice apothecaries have their scales made of glass, ivory, or tortoise shell; but in many shops the common brass scales are disgustingly filthy, and covered with verdigris.

372. The want of uniformity of weights and measures is attended with many inconveniences. In this country, druggists and grocers sell by avoirdupois weight; and the apothecaries

are directed to sell by troy weight, although, in fact, they seldom use the troy weight for more than two drachms. But as the troy pound is less than the avoirdupois, and the ounce and drachm greater, numerous and culpable errors must arise. Comparative tables of the value of the troy, avoirdupois, and new French decimal weights, are given in the Appendix.

373. The errors arising from the promiscuous use of weights and measures, have induced the Edinburgh college to reject the use of measures entirely, and to direct that the quantity of every fluid, as well as solid, shall be determined by troy weight: but as the London and Dublin colleges sanction the use of measures, and as, from the much greater facility of their employment, apothecaries will always use them, tables of measures are also inserted in the Appendix.

374. For measuring fluids, the graduated glass measures are always to be preferred: they should be of different sizes, according to the quantities they are intended to measure. Elastic fluids are also measured in glass tubes and jars, graduated by inches and their decimals.

375. The practice of administering active fluids by drops has been long known to be inaccurate; but the extent of the evil has been only lately ascertained, by the accurate experiments of Mr Shuttleworth, surgeon, of Liverpool. Not only do the drops of different fluids from the same vessel, and of the same fluids from different vessels, differ much in size; but it appears that the drops of the same fluid differ, even to the extent of a third, from different parts of the lip of the same vessel. The custom of dropping active fluids should, therefore, be abolished entirely; and, as weighing is too troublesome and difficult for general use, we must have recourse to small measures, accurately graduated, in the manner of Lane's *drop* measure, and the *grain* measure recommended by the Edinburgh college; but we must not be misled by their names; for they are measures of bulk, not of drops or of grains.

SPECIFIC GRAVITY.

376. Specific gravity is the comparative weights of equal bulks of different bodies. As a standard of comparison, distilled water has been generally assumed as unity. The specific gravity of any solid is ascertained, by comparing the weight of the body in the air with its weight when suspended in water. The quotient obtained by dividing its weight in air, by the difference between its weight in air and its weight in water, is its specific gravity. The specific gravity of fluids may

be ascertained by comparing the weight of a solid body, such as a piece of crystal, when immersed in distilled water, with its weight when immersed in the fluid we wish to examine; by dividing its loss of weight in the fluid by its loss of weight in the water, the quotient is the specific gravity of the fluid: or a small phial, containing a known weight of distilled water, may be filled with the fluid to be examined, and weighed, and by dividing the weight of the fluid by the weight of the water, the specific gravity is ascertained.

Although these are the only general principles by which specific gravities are ascertained, yet as the result is always influenced by the state of the thermometer and barometer at the time of the experiments, and as the manipulation is a work of great nicety, various ingenious instruments have been contrived to render the process and calculation easy. Of all these, the gravimeter of Morveau seems to deserve the preference.

It would be of material consequence to science and the arts, if specific gravities were always indicated by the numerical term expressing their relation to the specific gravity of distilled water. This, however, is unfortunately not the case. The excise in this country collect the duties paid by spiritous liquors, by estimating the proportion which they contain of a standard spirit, about 0.933 in specific gravity, which they call hydrometer proof; and they express the relation which spirits of a different strength have to the standard spirit, by saying that they are above or under hydrometer proof. Thus, one to six, or one in seven below hydrometer proof, means, that it is equal in strength to a mixture of six parts of proof spirit with one of water.

The only other mode of expressing specific gravities, which it is necessary to notice, is that of Baumé's areometer, as it is often used in the writings of the French chemists, and is little understood in this country. For substances heavier than water, he assumes the specific gravity of distilled water as zero, and graduates the stem of his instrument downwards, each degree being supposed by him to express the number of parts of muriate of soda contained in a given solution; which, however, is not at all the case. For substances lighter than water the tube is graduated upwards, and this zero is afforded by a solution of 1 of salt in 9 water. In the appendix, tables are given of the specific gravities, corresponding with all the degrees of both of these areometers, from Nicolson's Journal.

The specific gravity of the gases differs so much from that of water, that the lightest of them, hydrogen gas, has lately been assumed as unity in regard to them.

MECHANICAL DIVISION.

377. By mechanical division, substances are reduced to a form better adapted for medical purposes; and by the increase of their surface, their action is promoted, both as medical and chemical agents.

378. It is performed by cutting, bruising, grinding, grating, rasping, filing, pulverization, trituration, and granulation, by means of machinery or of proper instruments.

379. *Pulverization* is the first of these operations that is commonly employed in the apothecary's shop. It is performed by means of pestles and mortars. The bottom of the mortars should be concave; and their sides should neither be so inclined as not to allow the substance operated on to fall to the bottom between each stroke of the pestle, nor so perpendicular as to collect it too much together, and to retard the operation. The materials of which the pestles and mortars are formed, should resist both the mechanical and chemical action of the substances for which they are used. Wood, iron, marble, siliceous stones, porcelain, and glass, are all employed; but copper, and metals containing copper, are to be avoided.

380. They should be provided with covers, to prevent the finest and lightest parts from escaping, and to defend the operator from the effects of disagreeable or noxious substances. But these ends are more completely attained, by tying a piece of pliable leather round the pestle, and round the mouth of the mortar. It must be closely applied, and at the same time so large, as to permit the free motion of the pestle.

381. In some instances, it will be even necessary for the operator to cover his mouth and nostrils with a wet cloth, and to stand with his back to a current of air, that the very acrid particles which arise may be carried from him.

382. The addition of a little water or spirit of wine, or of a few almonds, to very light and dry substances, will prevent their flying off. But almonds are apt to induce rancidity, and powders are always injured, by the drying which is necessary when they have been moistened. Water must never be added to substances which absorb it, or are rendered cohesive by it.

383. Too great a quantity of any substance must never be put into the mortar at a time, as it very much retards the operation.

384. All vegetable substances must be previously dried. Resins and gummy resins, which become soft in summer, must be powdered in very cold weather, and must be beaten gently, or they will be converted into a paste, instead of being powdered. Woods, roots, barks, horn, bone, ivory, &c. should be previously cut, split, chipped, or rasped. Fibrous woods and roots should be finely shaved after their bark is removed, for otherwise their powders will be full of hair-like filaments, which can scarcely be separated. Some substances will even require to be moistened with mucilage of tragacanth, or of starch, and then dried before they can be powdered. Camphor may be conveniently powdered by the addition of a little spirit of wine, or almond oil. The emulsive seeds cannot be reduced to powder, unless some dry powder be added to them. To aromatic oily substances, sugar is the best addition.

385. All impurities and inert parts having been previously separated, the operation must be continued and repeated upon vegetable substances, till no residuum is left. The powders obtained at different times must then be intimately mixed together, so as to bring the whole to a state of perfect uniformity.

386. Very hard stony substances must be repeatedly heated to a red heat, and then suddenly quenched in cold water, until they become sufficiently friable. Some metals may be powdered hot in a heated iron mortar, or may be rendered brittle by alloying them with a little mercury.

387. *Trituration* is intended for the still more minute division of bodies. It is performed in flat mortars of glass, agate, or other hard materials, by giving a rotatory motion to the pestle; or on a levigating stone, which is generally of porphyry, by means of a muller of the same substance. On large quantities it is performed by rollers of hard stone, turning horizontally upon each other, or by one vertical roller turning on a flat stone.

388. *Levigation* differs from trituration only in the addition of water or spirit of wine to the powder operated upon, so as to form the whole mass into a kind of paste, which is rubbed until it be of sufficient smoothness or fineness. Earths, and some metallic substances, are levigated.

389. The substances subjected to this operation are generally previously powdered or ground.

390. *Granulation* is employed for the mechanical division of some metals. It is performed either by stirring the melted metal with an iron rod until it cools, or by pouring it into water, and stirring it continually as before, or by pouring in into a covered box, previously well rubbed with chalk, and shaking

it until the metal cools, when the rolling motion will be converted into a rattling one. The adhering chalk is then to be washed away.

MECHANICAL SEPARATION.

391. *Sifting.* From dry substances, which are reduced to the due degree of minuteness, the coarser particles are to be separated by sieves of iron-wire, hair-cloth, or gauze, or by being dusted through bags of linen. For very light and valuable powders, or acrid substances, compound sieves, having a close lid and receiver, must be used. The particles which are not of sufficient fineness to pass through the interstices of the sieve, may be again powdered.

392. *Elutriation* is performed on mineral substances, on which water has no action, for separating them from foreign particles and impurities, of a different specific gravity, in which case they are said to be washed; or for separating the impalpable powders, obtained by trituration and levigation from the coarser particles. This process depends upon the property that very fine or light powders have of remaining for some time suspended in water; and is performed by diffusing the powder or paste formed by levigation through plenty of water, letting it stand a sufficient time, until the coarser particles settle at the bottom, and then pouring off the liquid in which the finer or lighter particles are suspended. Fresh water may be poured on the residuum, and the operation repeated; or the coarser particles which fall to the bottom may be previously levigated a second time. The fine powder which is washed over with the water, is separated from it, by allowing it to subside completely, and by decanting off the water very carefully.

393. *Decantation* is very frequently made use of for separating the clear from the turbid part of a fluid, and for separating fluids from solids, which are specifically heavier, especially when the quantity is very large, or the solid so subtile as to pass through the pores of most substances employed for filtration, or the liquid so acrid as to corrode them.

394. *Filtration.* For the purposes of separating fluids from solids, straining and filtration are often used. These differ only in degree, and are employed when the powder either does not subside at all, or too slowly and imperfectly for decantation.

395. The instruments for this purpose are of various materials, and must in no instance be acted upon by the substan-

ces for which they are employed. Fats, resins, wax, and oils, are strained through hemp or flax, spread evenly over a piece of wire cloth or net stretched in a frame. For saccharine and mucilaginous liquors, fine flannel may be used; for some saline solutions, linen. Where these are not fine enough, unsized paper is employed, but it is extremely apt to burst by hot watery liquors. Very acrid liquors, such as acids, are filtered by means of a glass funnel, filled with powdered quartz, a few of the larger pieces being put in the neck, smaller pices over these, and the fine powder placed over all. The porosity of this last filter retains much of the liquor; but it may be obtained by gently pouring on it an equal quantity of distilled water; the liquor will then pass through, and the water will be retained in its place.

396. Water may be filtrated in large quantities through basins of porous stone, or artificial basins of nearly equal parts of fine clay and coarse sand. In large quantities it may be easily purified *per ascensum*, the purified liquor and impurities thus taking opposite directions. The simplest apparatus of this kind is a barrel, divided perpendicularly, by a board perforated with a row of holes along the lower edge. Into each side, as much well washed sand is put as will cover these holes an inch or two, over which must be placed a layer of pebbles to keep it steady. The apparatus is now fit for use. Water poured into the one half will sink through the sand in that side, pass through the holes in the division to the other, and rise through the sand in the other half, from which it may be drawn by a stop-cock.

397. The size of the filters depends on the quantity of matter to be strained. When large, the flannel or linen is formed into a conical bag, and suspended from a hoop or frame; the paper is either spread on the inside of these bags, or folded into a conical form, and suspended by a funnel. It is of advantage to introduce glass rods or quills between the paper and funnel, to prevent them from adhering too closely.

398. What passes first is seldom fine enough, and must be poured back again, until by the swelling of the fibres of the filter, or filling up of its pores, the fluid acquires the requisite degree of limpidity. The filter is sometimes covered with charcoal powder, which is a useful addition to muddy and deep-coloured liquors. The filtration of some viscid substances is much assisted by heat.

399. *Expression* is a species of filtration, assisted by mechanical force. It is principally employed to obtain the juices of fresh vegetables, and the unctuous vegetable oils. It is per-

formed by means of a screw press, with plates of wood, iron, or tin. The subject of the operation is previously beaten, ground, or bruised. It is then inclosed in a bag, which must not be too much filled, and introduced between the plates of the press. The bags should be of hair-cloth, or canvas inclosed in hair-cloth. Hempen and woollen bags are apt to give vegetable juices a disagreeable taste. The pressure should be gentle at first, and increased gradually.

400. Vegetables intended for this operation should be perfectly fresh, and freed from all impurities. In general they should be expressed as soon as they are bruised, for it disposes them to ferment; but subacid fruits give a larger quantity of juice, and of finer quality, when they are allowed to stand some days in a wooden or earthen vessel after they are bruised. To some vegetables which are not juicy enough, the addition of a little water is necessary. Lemons and oranges must be peeled, as their skins contain a great deal of essential oil, which would mix with the juice. The oil itself may be obtained separately, by expression with the fingers on a piece of glass.

401. For unctuous seeds iron plates are used; and it is customary not only to heat the plates, but to warm the bruised seeds in a kettle over the fire, after they have been sprinkled with water, as by these means the product is increased, and the oil obtained is more limpid. But as the oils obtained in this way are more disposed to rancidity, this process should either be laid aside altogether, or changed to exposing the bruised seeds, inclosed in a bag, to the steam of hot water.

402. *Despumation* is generally practised on thick and clammy liquors, which contain much slimy and other impurities, not easily separable by filtration. The scum is made to arise, either by simply heating the liquor, or by *clarifying* it, which last is done by mixing with the liquor, when cold, white of egg well beaten with a little water, which on being heated coagulates, and rises to the surface, carrying with it all the impurities. The liquor may now be filtered with ease, or may be skimmed with a perforated laddle. Spiritous liquors are clarified, without the assistance of heat, by means of isinglass dissolved in water, or of any albuminous fluid, as milk, which coagulates with the action of alcohol. Some expressed juices, as those of all the antiscorbutic plants, are instantly clarified by the addition of any vegetable acid, as the juice of bitter oranges.

403. Fluids can only be separated from each other, when they have no tendency to combine, and when they differ in

specific gravity. The separation may be effected by skimming off the lighter fluid with a silver or glass spoon; or by drawing it off by a syringe or syphon; or by means of a glass separatory, which is an instrument having a projecting tube, terminating in a very slender point, through which the heavier fluid alone is permitted to run; or by means of the capillary attraction of a spongy woollen thread; for no fluid will enter a substance whose pores are filled by another, for which it has no attraction; and, lastly, upon the same principle, by means of a filter of unsized paper, previously soaked in one of the fluids, which in this way readily passes through it, while the other remains behind.

404. *Mechanical mixture* is performed by agitation, trituration, or kneading; but these will be best considered in treating of the forms in which medicines are exhibited.

APPARATUS.

405. Before entering on the chemical operations, it will be necessary to make a few remarks on the instruments employed in performing them. They may be divided into

a. The vessels in which the effects are performed;
b. Fuel, or the means of producing heat; and
c. The means of applying and regulating the heat, or lamps and furnaces.

VESSELS.

406. The vessels, according to the purposes for which they are intended, vary

a. In form; and
b. In materials.

407. The different forms will be best described when treating of the particular operations.

408. No substance possesses properties which render it proper to be employed as a material in every instance We are therefore obliged to select those substances which possess the properties more especially required in the particular operations for which they are intended.

409. The properties most generally required, are

a. The power of resisting chemical agents;
b. Transparency;

c. Compactness;
d. Strength;
e. Fixity and infusibility;
f. And the power of bearing sudden variations of temperature without breaking.

410. The metals in general possess the four last properties in considerable perfection, but they are all opaque. Iron and copper are apt to be corroded by chemical agents, and the use of the latter is often attended with dangerous consequences. These objections are in some measure, but not entirely, removed by tinning them. Tin and lead are too fusible. Platinum, gold, and silver, resist most of the chemical agents, but their expence is an insurmountable objection to their general use.

411. Good earthen ware resists the greatest intensity of heat, but is deficient in all the other properties. The basis of all kinds of earthen ware is clay, which possesses the valuable quality of being very plastic when wrought with water, and of becoming extremely hard when burnt with an intense heat. But it contracts so much by heat, that it is extremely apt to crack and split, on being exposed to sudden changes of temperature; it is therefore necessary to add some substance which may counteract this property. Siliceous sand, clay reduced to powder, and then burnt with a very intense heat, and plumbago, are occasionally used. These additions, however, are attended with other inconveniences; plumbago, especially, is liable to combusion, and sand diminishes the compactness, so that it becomes necessary to glaze most kinds of earthen ware; but when glazed, they are acted upon by chemical agents. The vessels manufactured by Messrs Wedgwood are the best of this description, except those of porcelain, which are too expensive.

412. Glass possesses the three first qualities in an eminent degree, and may be heated red hot without melting. Its greatest inconvenience is its disposition to crack, or break in pieces, when suddenly heated or cooled. As this is occasioned by its unequal expansion or contraction, glass vessels should be made very thin, and of a round form. They should also be well annealed, that is cooled very slowly, when blown, by placing them immediately in a heated oven, while they are yet in a soft state. When ill annealed, or cooled suddenly, glass is apt to fly in pieces on the slightest change of temperature, or touch of a sharp point. We sometimes take advantage of this imperfection; for by means of a red-hot wire, charcoal, or bit of a tobacco-pipe, glass-vessels may be cut into any shape. When there is not a crack already in the glass, the point of

the wire is applied near the edge, a crack is formed, which is afterwards easily led in any direction.

413. Reaumeur's porcelain, on the contrary, is glass, which by surrounding it with hot sand, is made to cqol so slowly, that it assumes a crystalline texture, which destroys its transparency, but imparts to it every other quality wished for in chemical vessels. The coarser kinds of glass are commonly used in making it; but as there is no manufacture of this valuable substance, its employment is still very limited.

LUTES.

414. Lutes also form a necessary part of chemical apparatus. They are compositions of various substances, intended,

a. To close the joinings of vessels;
b. To coat glass vessels.
c. To line furnaces.

415. Lutes of the first description are commonly employed to confine elastic vapours. They should therefore possess the following properties:

a. Viscidity, plasticity, and compactness;
b. The power of resisting acrid vapours;
c. The power of resisting certain degrees of heat.

416. The viscidity of lutes depends on the presence either of

a. Unctuous or resinous substances;
b. Mucilaginous substances; or
c. Clay or lime.

417. Lutes of the first kind possess the two first class of properties in an eminent degree; but they are in general so fusible, that they cannot be employed when they are exposed even to very low degrees of heat, and they will not adhere to any substance that is at all moist. Examples.

a. Eight parts of yellow wax, melted with one of oil of turpentine, with or without the addition of resinous substances, according to the degree of pliability and consistence required. Lavoisier's lute.
b. Four parts of wax, melted with two of varnish and one of olive oil. Saussure's lute.
c. Three parts of powdered clay, worked up into a paste, with one of drying oil, or, what is better, amber

varnish. The drying oil is prepared by boiling 22.5 parts of litharge in 16 of linseed oil until it be dissolved. Fat lute.

d. Chalk and oil, or glazier's putty, is well fitted for luting tubes permanently into glass vessels, for it becomes so hard that it cannot be easily removed.

e. Equal parts of litharge, quicklime, and powdered clay, worked into a paste with oil varnish, is sometimes applied over the cracks in glass vessels, so as to fit them for some purposes.

f. Melted pitch and brick dust.

418. Mucilaginous substances, such as flour, starch, gum, and glue, mixed with water, are sufficiently adhesive, are dried by moderate degrees of heat, and are easily removed after the operation, by moistening them with water; but a high temperature destroys them, and they do not resist corrosive vapours. The addition of an insoluble powder is often necessary to give them a sufficient degree of consistency. Examples.

a. Slips of bladder, softened in water, and applied with the inside next the vessels. They are apt, however, from their great contraction in drying, to break weak vessels.

b. One part of gum-arabic with six or eight of chalk, formed into a paste with water.

c. Flour worked into a paste with powdered clay or chalk.

d. Almond or linseed meal formed into a paste with mucilage or water.

e. Quicklime in fine powder, hastily mixed with white of egg, and instantly applied, sets very quickly, but becomes so hard that it can scarcely be removed.

f. Slaked lime in fine powder, with glue, does not set so quickly as the former.

g. The cracks of glass vessels may be cemented by daubing them and a suitable piece of linen over with white of egg, strewing both over with finely powdered quicklime, and instantly applying the linen closely and evenly.

419. Earthy lutes resist very high temperatures, but they become so hard that they can scarcely be removed, and often harden so quickly after they are mixed up, that they must be applied immediately. Examples.

a. Quicklime well incorporated with a sixth part of muriate of soda.

b. Burnt gypsum, made up with water.

c. One ounce of borax dissolved in a pound of boiling water, mixed with a sufficient quantity of powdered clay. Mr Watt's fire lute.

d. One part of clay with four of sand, formed into a paste with water. This is also used for coating glass vessels, in order to render them stronger, and capable of resisting intense heat. It is then made into a very thin mass, and applied in successive layers, taking care that each coat be perfectly dry before another be laid on.

420. The lutes for lining furnaces will be described when treating of furnaces.

421. The junctures of vessels which are to be luted to each other, should previously be accurately and firmly fitted, by introducing between them, when necessary, short pieces of wood or cork, or, if the disproportion be very great, by means of a cork fitted to the one vessel, having a circular hole bored through it, through which the neck of the other vessel or tube may pass.

422. After being thus fitted, the lute is either applied very thin, by spreading it on slips of linen or paper, and securing it with thread; or if it is a paste lute, it is formed into small cylinders, which are successively applied to the junctures, taking care that each piece be made to adhere firmly and perfectly close in every part before another is put on. Lastly, the whole is secured by slips of linen or bladder.

423. In many cases, to permit the escape of elastic vapours, a small hole is made through the lute with a pin, or the lute is perforated by a small quill, fitted with a stopper.

HEAT AND FUEL.

424. As caloric is an agent of the most extensive utility in the chemical operations of pharmacy, it is necessary that we should be acquainted with the means of employing it in the most economical and efficient manner.

425. The rays of the sun are used in the drying of many vegetable substances; and the only attentions necessary, are to expose as large a surface as possible, and to turn them frequently, that every part may be dried alike. They are also sometimes used for promoting spontaneous evaporation.

426. Combustion is a much more powerful and certain source of heat. Alcohol, oil, tallow, wood, turf, coal, charcoal, and coke, are all occasionally employed.

427. Alcohol, oil, and melted tallow, can only be burnt on porous wicks, which draw up a portion of the fluid to be volatilized and inflamed. Fluid inflammables are therefore burnt in lamps of various constructions. But although commonly used to produce light, they afford an uniform, but not high temperature. This may however be increased, by increasing the number and size of the wicks. Alcohol produces a steady heat, no soot, and, if strong, leaves no residuum. Oil gives a higher temperature, but on a common wick produces much smoke and soot. These are diminished, and the light and heat increased, by making the surface of the flame bear a large proportion to the centre; which is best done by a cylindrical wick, so contrived that the air has free access both to the outside and inside of the cylinder, as in Argand's lamp, invented by Mr Bolton of Birmingham. In this way, oil may be made to produce a considerable temperature, of great uniformity, and without the inconvenience of smoke.

428. Wicks have the inconvenience of being charred by the high temperature to which they are subjected, and becoming so clogged as to prevent the fluid from rising in them. They must then be trimmed; but this is seldomer necessary with alcohol and fine oils than with the coarser oils. Lamps are also improved by adding a chimney to them. It must admit the free access of air to the flame, and then it increases the current, confines the heat, and steadies the flame. The intensity of the temperature of flame may be greatly increased by forcing a small current of hot air through it, as by the blowpipe

429. Wood, turf, coal, charcoal, and coke, solid combustibles, are burnt in grates and furnaces. Wood has the advantage of kindling readily, but affords a very unsteady temperature, is inconvenient from its flame, smoke, and soot, and requires much attention. The heavy and dense woods give the greatest heat, burn longest, and leave a dense charcoal.

430. Dry turf gives a steady heat, and does not require so much attention as wood; but it consumes fast, its smoke is copious and penetrating, and the empyreumatic smell which it imparts to every thing it comes in contact with, adheres to them with great obstinacy. The heavy turf of marshes is preferable to the light surface turf.

431. Coal is the fuel most commonly used in this country.

Its heat is considerable, and sufficiently permanent, but it produces much flame and smoke.

432. Charcoal, especially of the dense woods, is a very convenient and excellent fuel. It burns without flame or smoke, and gives a strong, uniform, and permanent heat, which may be easily regulated, especially when it is not in too large pieces, and is a little damp. But it is costly, and burns quickly.

433. Coke, or charred coal, possesses similar properties with charcoal; it is less easily kindled, but is capable of producing a higher temperature, and burns more slowly.

434. When an open grate is used for chemical purposes, it should be provided with cranes to support the vessels, that they may not be overturned by the burning away of the fuel.

FURNACES.

435. In all furnaces, the principal objects are, to produce a sufficient degree of heat, with little consumption of fuel, and to be able to regulate the degree of heat.

436. An unnecessary waste of fuel is prevented by forming the sides of the furnace of very imperfect conductors of caloric, and by constructing it so that the subject operated on may be exposed to the full action of the fire.

437. The degree of heat is regulated by the quantity of air which comes in contact with the burning fuel. The quantity of air is in the compound ratio of the size of the aperture through which it enters, and its velocity. The velocity is increased by mechanical means, as by bellows, or by increasing the height and width of the chimney.

438. The size and form of furnaces, and the materials of which they are constructed, are various, according to the purposes for which they are intended.

439. The essential parts of a furnace are,

a. A body for the fuel to burn in;
b. A grate for it to burn upon;
c. An ash-pit to admit air and receive the ashes;
d. A chimney for carrying off the smoke and vapours.

440. The ash-pit should be perfectly close, except the door, which should be furnished with a register-plate, to regulate the quantity of air admitted.

441. The bars of the grate should be triangular, and placed with an angle pointed downwards, and not above half an inch distant. The grate should be fixed on the outside of the body.

442. The body may be cylindrical or elliptical, with aper-

tures for introducing the fuel and the subjects of the operation, and for conveying away the smoke and vapours.

443. When the combustion is supported by the current of air naturally excited by the burning of the fuel, it is called a wind-furnace; when it is accelerated by increasing the velocity of the current by bellows, it forms a blast-furnace; and when the body of the furnace is covered with a dome, which terminates in the chimney, it constitutes a reverberatory furnace.

444. Furnaces are either fixed and built of fire-brick, or portable, and fabricated of plate-iron. When of iron, they must be lined with some badly conducting and refractory substance, both to prevent the dissipation of heat, and to defend the iron against the action of the fire. A mixture of scales of iron and powdered tiles, worked up with blood, hair, and clay, is much recommended; and Professor Hagen says, that it is less apt to split and crack when exposed at once to a violent heat, than when dried gradually, according to the common directions. Dr Black employed two different coatings. Next to the iron, he applied a composition of three parts, by weight, of charcoal, and one of fine clay, first mixed in the state of fine powder, and then worked up with as much water as permitted the mass to be formed into balls, which were applied to the sides of the furnace, and beat very firm and compact with the face of a broad hammer, to the thickness of about one inch and a half, in general, but so as to give an elliptical form to the cavity. Over this, another lute, composed of six or seven parts of sand, and one of clay, was applied, in the same manner, to the thickness of about half an inch. These lutes must be allowed to become perfectly dry before the furnace is heated, which should at first be done gradually. They may also be lined with fire-bricks of a proper form, accurately fitted and well-cemented together before the top-plate is screwed on.

445. The general fault of furnaces is, that they admit so much air, as to prevent us from regulating the temperature, which either becomes too violent and unmanageable, or when more cold air is admitted than what is necessary for supporting the combustion, the heat is carried off, and the temperature cannot be raised sufficiently. The superior merit of Dr Black's furnace consists in the facility with which the admission of air is regulated; and every attempt hitherto made to improve it, by increasing the number of its apertures, have in reality injured it.

446. Heat may be applied to vessels employed in chemical operations,

a. Directly, as in the open fire and reverberatory furnace;
b. Or through the medium of sand; the sand bath;
c. Of water; the water bath;
d. Of steam; the vapour bath;
e. Of air, as in the muffle.

CHEMICAL OPERATIONS.

447. In all chemical operations, combination takes place, and there are very few of them in which decomposition does not also occur. For the sake of method, we shall consider them as principally intended to produce,

a. Change in the form of aggregation;
b. Combination;
c. Decomposition.

448. The form of aggregation may be altered by,

a. Fusion;
b. Vaporization;
c. Condensation;
d. Congelation;
e. Coagulation.

449. *Liquefaction* is commonly employed to express the melting of substances, as tallow, wax, resin, &c. which pass through intermediate states of softness before they become fluid.

450. *Fusion* is the melting of substances which pass immediately from the solid to the fluid state, as the salts and the metals, except iron and platinum. Substances differ very much in the degrees of their fusibility; some, as water and mercury, existing as fluids in the ordinary temperatures of the atmosphere; while others, as the pure earths, cannot be melted by any heat we can produce.

451. When a substance acquires by fusion a degree of transparency, a dense uniform texture, and great brittleness, and exhibits a conchoidal fracture, with a specular surface, and the edges of the fragments very sharp, it is said to be *vitrified*.

452. In general, simple substances are less fusible than compounds; thus the simple earths cannot be melted singly, but when mixed are easily fused. The additions which are sometimes made to refractory substances to promote their fusion, are termed *fluxes*.

453. These fluxes are generally saline bodies.

a. The alkalies, potass, and soda, promote powerfully the fusion of siliceous stones; but they are only used for accurate experiments. The *white flux* is a mixture of a little potass with carbonate of potass, and is prepared by deflagrating together equal parts of nitrate of potass and supertartrate of potass. When an oxide is at the same time to be reduced, the *black* flux is to be preferred, which is produced by the deflagration of two parts of supertartrate of potass, and one of nitrate of potass. It differs from the former only in containing a little charcoal. Soap promotes fusion by being converted by the fire into carbonate of soda and charcoal.

b. Aluminous stones have their fusion greatly promoted by the addition of sub-borate of soda.

c. Muriate of soda, the mixed phosphate of soda and ammonia, and other salts, are also occasionally employed.

454. An open fire is sufficient to melt some substances; others require the heat of a furnace.

455. The vessels in which fusion is performed, must resist the heat necessary for the operation. In some instances, an iron or copper ladle or pot may be used; but most commonly crucibles are employed. *Crucibles* are of various sizes.—The large crucibles are generally conical, with a small spout for the convenience of pouring out: the small ones are truncated triangular pyramids, and are commonly sold in nests.

456. The Hessian crucibles are composed of clay and sand, and when good, will support an intense heat for many hours, without softening or melting; but they are disposed to crack when suddenly heated or cooled. This inconvenience may be on many occasions avoided, by using a double crucible, and filling up the interstice with sand, or by covering the crucible with a lute of clay and sand, by which means the heat is transmitted more gradually and equally. Those which give a clear sound when struck, and are of an uniform thickness, and have a reddish-brown colour, without black spots, are reckoned the best.

457. Wedgwood's crucibles are made of clay mixed with

baked clay finely pounded, and are in every respect superior to the Hessian, but they are expensive.

458. The black lead crucibles, formed of clay and plumbago, are very durable, resist sudden changes of temperature, and may be repeatedly used; but they are destroyed when saline substances are melted in them, and suffer combustion when exposed red-hot to a current of air.

459. When placed in a furnace, crucibles should never be set upon the bars of the grate, but always upon a support. Dr Kennedy found the hottest part of a furnace to be about an inch above the grate. They may be covered, to prevent the fuel or ashes from falling into them, with a lid of the same materials, or with another crucible inverted over them.

460. When the fusion is completed, the substance may be either permitted to cool in the crucible, or poured into a heated mould anointed with tallow, never with oil, or, what is still better, covered with a thin coating of chalk, which is applied by laying it over with a mixture of chalk diffused in water, and then evaporating the water completely by heat. To prevent the crucible from being broken by cooling too rapidly, it should be either replaced in the furnace, to cool gradually with it, or covered with some vessel to prevent its being exposed immediately to the air.

461. Fusion is performed with the intentions,

a. Of weakening the attraction of aggregation,
   1. To facilitate mechanical division;
   2. To promote chemical action.

b. Of separating from each other, substances of different degrees of fusibility.

462. *Vaporization* is the conversion of a solid or fluid into vapour by the agency of caloric. Although vaporability be merely a relative term, substances are said to be permanently elastic, volatile, or fixed. The permanently elastic fluids or gases are those which cannot be condensed into a fluid or solid form by any abstraction of caloric we are capable of producing. Fixed substances, on the contrary, are those which cannot be converted into vapour, by great increase of temperature. The pressure of the atmosphere has a very considerable effect in varying the degree at which substances are converted into vapour. Some solids, unless subjected to very great pressure, are at once converted into vapour, although most of them pass through the intermediate state of fluidity.

463. Vaporization is employed,

a. To separate substances differing in volatility.
b. To promote chemical action, by disaggregating them.

464. When employed with either of these views, either

a. No regard is paid to the substances volatilized,
1. From solids, as in ustulation and charring;
2. From fluids, as in evaporation;

b. Or the substances vaporized are condensed in proper vessels,
1. In a liquid form, as in distillation,
2. In a solid form, as in sublimation;

c. Or the substances disengaged are permanently elastic, and are collected in their gaseous form, in a pneumatic apparatus.

465. *Ustulation* is almost entirely a metallurgic operation, and is employed to expel the sulphur and arsenic contained in some metallic ores. It is performed on small quantities in tests placed within a muffle. Tests are shallow vessels made of bone ashes, or baked clay. Muffles are vessels of baked clay, of a semi-cylindrical form, the flat side forming the floor, and the arched portion the roof and sides. The end and sides are perforated with holes for the free transmission of the heated air, and the open extremity is placed at the door of the furnace, for the inspection and manipulation of the process. The reverberatory furnace is commonly employed for roasting, and the heat is at first very gently, and slowly raised to redness. The process is accelerated by exposing as large a surface of the substance to be roasted as possible, and by stirring it frequently, so as to prevent any agglutination, and to bring every part in succession to the surface.

466. *Charring* may be performed on any of the compound oxides, by subjecting them to a degree of heat sufficient to expel all their hydrogen, nitrogen, and oxygen, while the carbon, being a fixed principle, remains behind in the state of charcoal. The temperature necessary for the operation may be produced either by the combustion of other substances, or by the partial combustion of the substance to be charred. In the former case, the operation may be performed in any vessel which excludes the air while it permits the escape of the vapours formed. In the latter, the access of air must be regulated in such a manner, that it may be suppressed whenever the combustion has reached the requisite degree; for if continued to be admitted, the charcoal itself would be dissi-

pated in the form of carbonic acid gas, and nothing would remain but the alkaline and earthy matter, which these substances always contain. When combustion is carried this length, the process is termed *incineration*. The vapours which arise in the operation of charring, are sometimes condensed, as in the manufacture of tar.

467. *Evaporation* is the conversion of a fluid into vapour, by its combination with caloric. In this process, the atmosphere is not a necessary agent, but rather a hindrance, by its pressure. This forms a criterion between evaporation and spontaneous evaporation, which is merely the solution of a fluid in air.

468. It is performed in open, shallow, or hemispherical vessels of silver, tinned copper or iron, earthen-ware or glass. The necessary caloric may be furnished by means of an open fire, a lamp or a furnace, and applied either directly, or by the intervention of sand, water, or vapour. The degree of heat must be regulated by the nature of the substance operated on. In general, it should not be greater than what is absolutely necessary.

469. Evaporation may be,

a. Partial:
 1. From saline fluids, Concentration;
 2. From viscid fluids, Inspissation.

b. Total, Exsiccation.

470. *Concentration* is employed,

a. To lessen the quantity of diluting fluids; Deflegmation:

b. As a preliminary step to Crystallization.

471. *Inspissation* is almost confined to animal and vegetable substances; and as these are apt to be partially decomposed by heat, or to become empyreumatic, the process should always be performed, especially towards the end, in a water or vapour bath.

472. *Exsiccation* is here taken in a very limited sense; for the term is also with propriety used to express the drying of vegetables by a gentle heat, the efflorescence of salts, and the abstraction of moisture from mixtures of insoluble powders with water, by means of chalk-stones, or powdered chalk pressed into a smooth mass. At present, we limit its meaning to the total expulsion of moisture from any body by means of caloric.

473. The exsiccation of compound oxides should always be performed in the water bath.

474. Salts are deprived of their water of crystallization by exposing them to the action of heat in a glass vessel or iron ladle. Sometimes they first dissolve in their water of crystallization (or undergo what is called the *watery fusion*), and are afterwards converted into a dry mass by its total expulsion; as in the calcination of borax or burning of alum.

475. When exsiccation is attended with a crackling noise, and splitting of the salt, as in muriate of soda, it is termed *decrepitation*, and is performed by throwing into a heated iron vessel, small quantities of the salt at a time, covering it up, and waiting until the decrepitation be over, before a fresh quantity is thrown in.

476. Exsiccation is performed on saline bodies, to render them more acrid or pulverulent, or to prepare them for chemical operations. Animal and vegetable substances are exsiccated to give them a solid form, and to prevent their fermentation.

477. *Condensation* is the reverse of expansion, and is produced either,

a. By mechanical pressure forcing out the caloric in a sensible form, as water is squeezed out of a sponge; or,

b. By the chemical abstraction of caloric, which is followed by an approximation of the particles of the substance.

478. The latter species of condensation only is the object of our investigation at present. In this way we may be supposed to condense,

a. Substances existing naturally as gases or vapours;

b. Substances, naturally solid or fluid, converted into vapours by adventitious circumstances.

479. The former instance is almost supposititious; for we are not able, by any diminution of temperature, to reduce the permanently elastic fluids to a fluid or solid state.

480. The latter instance is always preceded by vaporization, and comprehends those operations in which the substances vaporised are condensed in proper vessels. When the product is a fluid, it is termed distillation; when solid, sublimation.

481. *Distillation* is said to be performed,

a. *Viâ humidâ*, when fluids are the subject of the operation;

b. Viâ siccâ, when solids are subjected to the operation, and the fluid product arises from decomposition, and a new arrangement of the constituent principles.

482. The objects of distillation are,

a. To separate more volatile fluids from less volatile fluids or solids;
b. To promote the union of different substances;
c. To generate new products by the action of fire.

483. In all distillations, the heat applied should not be greater than what is necessary for the formation of the vapour, and even to this degree it should be gradually raised. The vessels also in which the distillation is performed, should never be filled above one-half, and sometimes not above one-fourth, lest the substance contained in them should boil over.

484. As distillation is a combination of evaporation and condensation, the apparatus consists of two principal parts;

a. The vessels in which the vapours are formed;
b. The vessels in which they are condensed.

485. The vessels employed for both purposes are variously shaped, according to the manner in which the operation is conducted. The first difference depends on the direction of the vapour after its formation. It either

a. Descends; distillation *per descensum:*
b. Ascends; distillation *per ascensum:*
c. Or passes off by the side; distillation *per latus.*

486. In the distillation *per descensum*, a perforated plate, generally of tinned iron, is fixed within any convenient vessel, so as to leave a space beneath it. The subject of the operation is laid on this plate, and is covered by another, accurately fitting the vessel, and sufficiently strong to support the fuel which is burnt upon it. Thus the heat is applied from above, and the vapour is forced to descend into the inferior cavity, where it is condensed. In this way the oil of cloves is prepared, and on the same principles tar is manufactured, and mercury and zinc are separated from their ores.

487. In the distillation *per ascensum* the vapour is allowed to arise to some height, and then is conveyed away to be condensed. The vessel most commonly employed for this purpose is the common copper-still, which consists of a body for containing the materials, and a head into which the vapour

ascends. From the middle of the head a tube arises a short way, and is then reflected downwards, through which the steam passes to be condeneds. Another kind of head, rising to a great height before it is reflected, is sometimes used for separating fluids, which differ little in volatility, as it was supposed that the less volatile vapours would be condensed, and fall back into the still, while only the more volatile vapours would arise to the top, so as to pass to the refrigeratory. The same object may be more conveniently attained by managing the fire with caution and address. The greater the surface exposed, and the less the height the vapours have to ascend, the more rapidly does the distillation proceed; and so well are these principles understood by the Scotch distillers, that they do not take more than three minutes to discharge a still containing 50 gallons of fluid.

488. The condensing apparatus used with the common still is very simple. The tube in which the head terminates, is inserted into the upper end of a pipe, which is kept cool by passing through a vessel filled with water, called the Refrigeratory. This pipe is commonly made of a serpentine form; but as this renders it difficult to be cleaned, Dr Black recommends a sigmoid pipe. The refrigeratory may be furnished with a stop-cock, that when the water it contains becomes too hot, and does not condense all the vapour produced, it may be changed for cold water. From the lower end of the pipe, the product of the distillation drops into the vessel destined to receive it; and we may observe, that when any vapour issues along with it, we should either diminish the power of the fire, or change the water in the refrigeratory.

489. *Circulation* was a process formerly in use. It consisted in arranging the apparatus, so that the vapours were no sooner condensed into a fluid form, than this fluid returned back into the distilling vessels, to be again vaporised; and was effected by distilling in a glass vessel, with so long a neck that the vapours were condensed before they escaped at the upper extremity, or by inverting one matrass within another.

490. When corrosive substances are distilled *per ascensum*, the cucurbit and alembic are used; but these substances are more conveniently distilled *per latus*.

491. The distillation *per latus* is performed in a retort, or pear-shaped vessel, having the neck bent to one side. The body of a good retort is well rounded, uniform in its appearance, and of an equal thickness, and the neck is sufficiently bent to allow the vapours, when condensed, to run freely

away, but not so much as to render the application of the receiver inconvenient, or to bring it too near the furnace. The passage from the body into the neck must be perfectly free and sufficiently wide, otherwise the vapours produced in the retort only circulate in its body, without passing over into the receiver. For introducing liquors into the retort without soiling its neck, which would injure the product, a bent funnel is necessary. It must be sufficiently long to introduce the liquor directly into the body of the retort; and in withdrawing it, we must keep it carefully applied to the upper part of the retort, that the drop hanging from it may not touch the inside of the neck. In some cases, where a mixture of different substances is to be distilled, it is convenient and necessary to have the whole apparatus properly adjusted before the mixture is made, and we must therefore employ a tubulated retort, or a retort furnished with an aperture, accurately closed with a ground stopper.

492. The tubulature should be placed on the upper convex part of the retort before it bends to form the neck, so that a fluid poured through it may fall directly into the body without soiling the neck.

493. Retorts are made of various materials. Flint-glass is commonly used when the heat is not so great as to melt it. For distillations which require excessive degrees of heat, retorts of earthen ware, or coated glass retorts, are employed. Quicksilver is distilled in iron retorts.

494. The simplest condensing apparatus used with the retort, is the common glass receiver; which is a vessel of a conical or globular form, having a neck sufficiently wide to admit the neck of a retort. To prevent the loss and dissipation of the vapours to be condensed, the retort and receiver may be accurately ground to each other, or secured by some proper lute. Means must also be used to prevent the receiver from being heated by the caloric evolved during the condensation of the vapours. It may either be immersed in cold water, or covered with snow or pounded ice; or a constant evaporation may be supported from its surface, by covering it with a cloth, kept moist by means of the descent of water, from a vessel placed above it, through minute syphons or spongy worsted threads. But as, during the process of distillation, permanently elastic fluids are often produced, which would endanger the breaking of the vessels, these are permitted to escape, either through a tubulature, or hole in the side of the receiver, or rather through a hole made in the luting. Receivers having a spout issuing from their side, are used

when we wish to keep separate the products obtained at different periods of any distillation. For condensing very volatile vapours, a series of receivers, communicating with each other, termed Adopters, were formerly used; but these are now entirely superseded by Woulfe's apparatus.

495. This apparatus consists of a tubulated retort, adapted to a tubulated receiver. With the tubulature of the receiver, a three-necked bottle is connected by means of a bent tube, the further extremity of which is immersed, one or more inches, in some fluid contained in the bottle. A series of two or three similar bottles are connected with this first bottle in the same way. In the middle tubulature of each bottle, a glass tube is fixed, having its lower extremity immersed about a quarter of an inch in the fluid. The height of the tube above the surface of the fluid must be greater than the sum of the columns of fluid standing over the farther extremities of the connecting tubes, in all the bottles or vessels more remote from the retort. Tubes so adjusted are termed Tubes of safety, for they prevent that reflux of fluid from the more remote into the nearer bottles, and into the receiver itself, which would otherwise inevitably happen, on any condensation of vapour taking place in the retort, receiver, or nearer bottles. Different contrivances for the same purpose have been described by Messrs Welter and Burkitt; and a very ingenious mode of connecting the vessels without lute has been invented by Citizen Girard, but they would not be easily understood without plates. The further tubulature of the last bottle is commonly connected with a pneumatic apparatus, by means of a bent tube. When the whole is properly adjusted, air blown into the retort should pass through the receiver, rise in bubbles through the fluids contained in each of the bottles, and at last escape by the bent tube. In the receiver, those products of distillation are collected, which are condensable by cold alone. The first bottle is commonly filled with water, and the others with alkaline solutions, or other active fluids; and as the permanently elastic fluids produced are successively subjected to the action of all these, only those gases will escape by the bent tube which are not absorbable by any of them.

PNEUMATIC APPARATUS.

496. The great importance of the elastic fluids in modern chemistry, has rendered an acquaintance with the means of collecting and preserving them indispensable.

497. When a gas is produced by any means, it may be received either,

a. Into vessels absolutely empty; or
b. Into vessels filled with some fluid, on which it exerts no action.

498. The first mode of collecting gases, may be practised by means of a bladder, moistened sufficiently to make it perfectly pliable, and then compressed so as to empty it entirely. In this state it may be easily filled with any gas. An oiled silk bag will answer the same purpose, and is more convenient in some respects, as it may be made of any size or form.

499. Glass or metallic vessels, such as balloons, may also be emptied for the purpose of receiving gases, by fitting them with a stop-cock, and exhausting the air from them by means of an air-pump.

500. But the second mode of collecting gases is the most convenient and common.

501. The vessels may be filled either,

a. With a fluid lighter; or
b. Heavier than the gas to be received into it.

502. The former method is seldom employed; but if we conduct a stream of any gas heavier than atmospheric air, such as carbonic acid gas, muriatic acid gas, &c. to the bottom of any vessel, it will gradually displace the air, and fill the vessel.

503. On the contrary, a gas lighter than the atmospheric air, such as hydrogen, may be collected in an inverted vessel by conducting a stream of it to the top.

504. But gases are most commonly collected by conducting the stream of gas into an inverted glass jar, or any other vessel filled with water or mercury. The gas ascends to the upper part of the vessel, and displaces the fluid. In this way gas may be kept a very long time, provided a small quantity of the fluid be left in the vessels, which prevents both the escape of the gas, and the admission of atmospheric air.

505. The vessels may be of various shapes; but the most commonly employed are cylindrical. They may be either open only at one extremity, or furnished at the other with a stop-cock.

506. The manner of filling these vessels with fluid, is to immerse them completely in it, with the open extremity directed a little upwards, so that the whole air may escape from them, and then inverting them with their mouths downwards.

507. For filling them with convenience, a trough or cistern is commonly used. This either should be hollowed out of a solid block of wood or marble; or, if it be constructed of wood, it should be well painted, or lined with lead or tinned copper. Its size may vary very much; but it should contain a sufficient depth of fluid to cover the largest transverse diameter of the vessels to be filled in it. At one end or side, there should be a shelf for holding the vessels after they are filled. This shelf should be placed about an inch and a half below the surface of the fluid, and should be perforated with several holes, forming the apices of corresponding conical excavations on the lower side, through which, as through inverted funnels, gaseous fluids may be more easily introduced into the vessels placed over them. In general, the vessels used with a mercurial apparatus should be stronger and smaller than those for a water-cistern.

508. We should also have a variety of glass and elastic tubes for conveying the gases from the vessels in which they are formed to the funnels under the shelf.

509. *Rectification* is the repeated distillation of any fluid. When distillation renders the fluid stronger, or abstracts water from it, it is termed *Dephlegmation*. When a fluid is distilled off from any substance, it is called *Abstraction*; and if the product be redistilled from the same substance, or a fresh quantity of the substance, it is denominated *Cohobation*.

510. *Sublimation* differs from distillation only in the form of the product. When it is compact, it is termed a Sublimate; when loose and spongy, it formerly had the improper appellation of Flowers. Sublimation is sometimes performed in a crucible, and the vapours are condensed in a paper cone, or in another crucible inverted over it; sometimes in the lower part of a glass flask, cucurbit, or phial, and the condensation is effected in the upper part or capital, and sometimes in a retort with a very short and wide neck, to which a conical receiver is fitted. The heat is most commonly applied through the medium of a sand-bath; and the degree of heat, and the depth to which the vessel is inserted in it are regulated by the nature of the sublimation.

511. *Congelation* is the reduction of a fluid into a solid form, in consequence of the abstraction of caloric. The means employed for abstracting caloric are the evaporation of volatile fluids, the solution of solids, and the contact of cold bodies.

512. *Coagulation* is the conversion of a fluid into a solid of greater or less consistence, merely in consequence of a new

arrangement of its particles, as during the process there is no separation of caloric or any other substance. The means of producing coagulation are, increase of temperature, and the addition of certain substances, as acids and runnets.

COMBINATION.

513. Chemical combination is the intimate union of the particles of at least two heterogeneous bodies. It is the effect resulting from the exertion of the attraction of affinity, and is therefore subjected to all the laws of affinity.

514. To produce the chemical union of any bodies, it is necessary,

1. That they possess affinity for each other;
2. That their particles came into actual contact;
3. That the strength of the affinity be greater than any counteracting causes which may be present.

515. The principal counteracting causes are,

1. The attraction of aggregation;
2. Affinities for other substances.

516. The means to be employed for overcoming the action of other affinities will be treated of under Decomposition.

517. The attraction of aggregation is overcome by means of

1. Mechanical division.
2. The action of caloric.

518. Combination is facilitated by increasing the points of actual contact.

1. By mechanical agitation;
2. By condensation; compression.

519. The processes employed for producing combination, may be considered,

1. With regard to the nature of the substances combined; and,
2. To the nature of the compound produced.

Gases,

1. Combine with gases;
2. Dissolve fluids or solids;
3. Or are absorbed by them.

Fluids,

1. Are dissolved in gases;
2. Or absorb them;
3. Combine with fluids;
4. And dissolve solids;
5. Or are rendered solid by them.

Solids,

1. Are dissolved in fluids and in gases; or,
2. Absorb gases;
3. And solidify fluids.

520. The combination of gases with each other, in some instances, takes place when simply mixed together: thus nitrous and oxygen gases combine as soon as they come into contact; in other instances, it is necessary to elevate their temperature to a degree sufficient for their inflammation, either by means of the electric spark, or the contact of an ignited body, as in the combination of oxygen gas with hydrogen or nitrogen gas.

521. When gases combine with each other, there is always a considerable diminution of bulk, and not unfrequently they are condensed into a liquid or solid form. Hydrogen and oxygen gases form water: muriatic acid and ammonia gases form solid muriate of ammonia. But when the combination is effected by ignition, a violent expansion, which endangers the bursting of the vessels, previously takes place, in consequence of the increase of temperature.

522. *Solution* is the diminution of aggregation in any solid or fluid substance, in consequence of its entering into chemical combination. The substance, whether solid or fluid, whose aggregation is lessened, is termed the *Solvend*; and the substance, by whose agency the solution is effected, is often called the *Menstruum* or *Solvent*.

523. Solution is said to be performed *via humida*, when the natural form of the solvent is fluid; but when the agency of heat is necessary to give the solvent its fluid form, the solution is said to be performed *via sicca*.

524. The dissolving power of each menstruum is limited, and is determinate with regard to each solvend. The solubility of bodies is also limited and determinate with regard to each menstruum.

525. When any menstruum has dissolved the greatest possible quantity of any solvend, it is said to be saturated with it.

But, in some cases, although saturated with one substance, it is still capable of dissolving others. Thus a saturated solution of muriate of soda will dissolve a certain quantity of nitrate of potass, and after that a portion of muriate of ammonia.

526. The dissolving power of solvents, and consequently the solubility of solvends, are generally increased by increase of temperature; and conversely, this power is diminished by diminution of temperature; so that, from a saturated solution, a separation of a portion of the solvend generally takes place on any reduction of temperature. This property becomes extremely useful in many chemical operations, especially in crystallization.

527. Particular terms have been applied to particular cases of solution.

528. The solution of a fluid in the atmosphere is termed *spontaneous evaporation*. It is promoted by exposing a large surface, by frequently renewing the air in contact with the surface, and by increase of temperature.

529. Some solids have so strong an affinity for water, that they attract it from the atmosphere in sufficient quantity to dissolve them. These are said to *deliquesce*. Others, on the contrary, retain their water of crystallization with so weak a force, that the atmosphere attracts it from them, so that they crumble into powder. These are said to *effloresce*. Both operations are promoted by exposing large surfaces, and by a current of air; but the latter is facilitated by a warm dry air, and the former by a cold humid atmosphere.

530. Solution is also employed to separate substances (for example, saline bodies), which are soluble in the menstruum, from others which are not. When our object is to obtain the soluble substance in a state of purity, the operation is termed *lixiviation*. In this as small a quantity of the menstruum as is possible is used. When, however, solution is employed to free an insoluble substance from soluble impurities, it is termed *edulcoration*, which is best performed by using a very large quantity of the menstruum.

531. Organic products being generally composed of heterogeneous substances, are only partially soluble in the different menstrua. To the solution of any of these substances, while the others remain undissolved, the term *extraction* is applied; and when, by evaporation, the substance extracted is reduced to a solid form, it is termed an Extract, which is hard or soft, watery or spiritous, according to the degree of consistency it acquires, and the nature of the menstruum employed.

532. *Infusion* is employed to extract the virtues of aromatic and volatile substances, which would be dissipated by decoction, and destroyed by maceration, and to separate substances of easy solution from others which are less soluble. The process consists in pouring upon the substance to be infused, placed in a proper vessel, the menstruum, either hot or cold, according to the direction, covering it up, agitating it frequently and after a due time straining or decanting off the liquor, which is then termed the Infusion.

533. *Maceration* differs from infusion, it being continued for a longer time, and can only be employed for substances which do not easily ferment or spoil.

534. *Digestion*, on the other hand, differs from maceration only in the activity of the menstruum being promoted by a gentle degree of heat. It is commonly performed in a glass matrass, which should only be filled one-third, and covered with a piece of wet bladder, pierced with one or more small holes, so that the evaporation of the menstruum may be prevented as much as possible, without risk of bursting the vessel. The vessel may be heated, either by means of the sun's rays, of a common fire, or of the sand-bath; and when the last is employed, the vessel should not be sunk deeper in the sand than the portion that is filled. Sometimes, when the menstruum employed is valuable, a distilling apparatus is used to prevent any waste of it. At other times, a blind capital is luted on the matrass, or a smaller matrass is inverted within a larger one; and as the vapour which arises is condensed in it, and runs back into the larger, the process in this form has got the name of *Circulation.*

535. *Decoction* is performed by subjecting the substances operated on to a degree of heat, which is sufficient to convert the menstruum into vapour, and can only be employed with advantage for extracting principles which are not volatile, and from substances whose texture is so dense and compact as to resist the less active methods of solution. When the menstruum is valuable, that portion of it which is converted into vapour is generally saved by condensing it in a distilling apparatus.

536. Solutions in alcohol are termed Tinctures, and in vinegar or wine, Medicated vinegars or wines. The solution of metals in mercury is termed Amalgamation. The combinations of other metals with each other form Alloys.

537. *Absorption* is the condensation of a gas into a fluid or solid form, in consequence of its combination with a fluid or solid. It is facilitated by increase of surface and agitation;

and the power of absorption in fluids is much increased by compression and diminution of temperature, although in every instance it be limited and determinate. Dr Nooth invented an ingenious apparatus for combining gases with fluids; and Messrs Schweppe, Henry, Paul, and Cuthbertson, have very advantageously employed compression.

538. *Consolidation.* Fluids often become solid by entering into combination with solids; and this change is always accompanied by considerable increase of temperature, as in the slaking of lime.

DECOMPOSITION.

539. *Decomposition* is the separation of bodies which were chemically combined.

540. It can only be effected by the agency of substances possessing a stronger affinity for one or more of the constituents of the compound, than these possess for each other.

541. Decomposition has acquired various appellations, according to the phenomena which accompany it.

542. *Dissolution* differs from solution in being accompanied by the decomposition, or a change in the nature of the substance dissolved. Thus, we correctly say, a solution of lime in muriatic acid, and a dissolution of chalk in muriatic acid.

543. Sometimes a gas is separated during the action of bodies on each other. When this escapes with considerable violence and agitation of the fluid, it is termed *effervescence.* The gas is very frequently allowed to escape into the atmosphere, but at other times is either collected in a pneumatic apparatus, or made to enter into some new combination.—The vessels in which an effervescing mixture is made, should be high and sufficiently large, to preveut any loss of the materials from their running over; and in some cases the mixture must be made slowly and gradually.

544. *Precipitation* is the reverse of solution. It comprehends all those processes in which a solid is obtained by the decomposition of a solution. The substance separated is termed a Precipitate, if it sink to the bottom of the fluid; or a Cream, if it swim above it. Precipitation, like solution, is performed either *via humida*, or *via sicca.*

545. The objects of precipitation are,

1. The separation of substances from solutions in which they are contained;

2. The purification of solutions from precipitable impurities;
3. The formation of new combinations.

546. Precipitation is effected,

1. By lessening the quantity of the solvent by evaporation;
2. By diminishing its solvent power, as by reduction of temperature, or dilution;
3. Or by the addition of some chemical agent, which from its more powerful affinities,
   - *a.* Either combines with the solvent, and precipitates the solvend,
   - *b.* Or forms itself an insoluble compound with some constituent of the solution.

547. The two first means of precipitation have been already noticed. Indeed they are rarely considered as instances of precipitation, as the effect is gradual, and the precipitated matter most commonly assumes determinate figures.

548. In performing it in the last manner, we may observe the following rules:

1. The solution and precipitant must possess the requisite degree of purity.
2. The solution should be perfectly saturated, to avoid unnecessary consumption of the solvent or precipitant.
3. The one is to be added slowly and gradually to the other.
4. After each addition, they are to be thoroughly mixed by agitation.
5. We must allow the mixture to settle, after we think that enough of the precipitant has been added, and try a little of the clear solution, by adding to it some of the precipitant: if any precipitation takes place, we have not added enough of the precipitant. This precaution is necessary, not only to avoid loss, but, in many instances, the precipitant, if added in excess, redissolves, or combines with, the precipitate.

549. After the precipitation is completed, the precipitate is to be separated from the supernatant fluid by some of the means already noticed.

550. When the precipitate is the chief object of our process, and when it is not soluble in water, it is often advisable to dilute, to a considerable degree, both the solution and pre-

cipitant, before performing the operation. When it is only difficultly soluble, we must content ourselves with washing the precipitate, after it is separated by filtration. In some cases, the separation of the precipitate is much assisted by a gentle heat.

552. *Crystallization* is a species of precipitation, in which the particles of the solvend, on separating from the solution, assume certain determinate forms.

552. The conditions necessary for crystallization are,

1. That the integrant particles have a tendency to arrange themselves in a determinate manner when acted on by the attraction of aggregation;
2. That they be disaggregated, at least so far as to possess sufficient mobility to assume their peculiar arrangement;
3. That the causes disaggregating them be slowly and gradually removed.

553. Notwithstanding the immense variety in the forms of crystals, M. Hauy has rendered it probable, that there are only three forms of the integrant particles:

1. The parallelopiped.
2. The triangular prism.
3. The tetrahedron.

554. But as these particles may unite in different ways, either by their faces or edges, they will compose crystals of various forms.

555. The primitive forms have been reduced to six.

1. The parallelopiped.
2. The regular tetrahedron.
3. The octohédron with triangular faces.
4. The six-sided prism.
5. The dodecahedron terminated by rhombs.
6. The dodecahedron with isosceles triangular faces.

556. Almost all substances, on crystallizing, retain a portion of water combined with them, which is essential to their existence as crystals, and is therefore denominated water of crystallization. Its quantity varies very much in different crystallized substances.

557. The means by which the particles of bodies are disaggregated, so as to admit of crystallization, are solution, fusion, vaporization, or mechanical division and suspension in a fluid medium.

558. The means by which the disaggregating causes are removed, are, evaporation, reduction of temperature, and rest.

559. When bodies are merely suspended in a state of extreme mechanical division, nothing but rest is necessary for their crystallization.

560. When they are disaggregated by fusion or vaporization, the regularity of their crystals depends on the slowness with which their temperature is reduced; for if cooled too quickly, their particles have not time to arrange themselves, and are converted at once into a confused or unvaried solid mass. Thus glass, which, when cooled quickly, is so perfectly uniform in its appearance, when cooled slowly, has a crystalline texture. But in order to obtain crystals by means of fusion, it is often necessary, after the substance has begun to crystallize, to remove the part which remains fluid; for otherwise it would fill up the interstices among the crystals first formed, and give the whole the appearance of one solid mass. Thus, after a crust has formed on the top of melted sulphur, by pouring off the still fluid part, we obtain regular crystals.

561. The means by which bodies, which have been disaggregated by solution, are made to crystallize most regularly, vary according to the habitudes of the bodies with their solvents and caloric.

562. Some saline substances are much more soluble in hot than in cold water; therefore, a boiling saturated solution of any of these will deposite, on cooling, the excess of salt, which it is unable to dissolve when cold. These salts commonly contain much water of crystallization.

563. Other salts are scarcely, if at all, more soluble in hot than in cold water; and therefore, their solutions must be evaporated, either by heat, or spontaneously. These salts commonly contain little water of crystallization.

564. The beauty and size of the crystals depend upon the purity of the solution, its quantity, and the mode of conducting the evaporation and cooling.

565. When the salt is not more soluble in hot than in cold water, by means of gentle evaporation, a succession of pellicles is formed on the top of the solution, which either are removed, or permitted to sink to the bottom by their own weight; and the evaporation is continued until the crystallization be completed.

566. But when the salt is capable of crystallizing on cooling, the evaporation is only continued until a drop of the solution, placed upon some cold body, shews a disposition to crystallize, or at farthest only until the first appearance of a

pellicle. The solution is then covered up, and set aside to cool; and the more slowly it cools, the more regular are the crystals. The mother-water, or solution which remains after the crystals are formed, may be repeatedly treated in the same way as long as it is capable of furnishing any more salt.

567. When very large and beautiful crystals are wanted, they may be obtained by laying well-formed crystals in a saturated solution of the same salt, and turning them every day. In this way their size may be considerably increased, though not without limitation; for after a certain time, they grow smaller instead of larger.

568. Crystallization is employed,

1. To obtain crystallizable substances in a state of purity;
2. To separate them from each other, by taking advantage of their different solubility at different temperatures.

OXYGENIZEMENT.

569. The combination of oxygen is the object of many chemical and pharmaceutical processes.

570. With regard to the manner of combination, the oxygenizement may take place, either,

a. Without the production of heat and light, to express which there is no other than the generic term *oxygenizement*; or,

b. With the production of heat and light; *combustion.*

1. In substances which remain fixed at the temperature necessary for their combustion, there is no other more specific term;
2. In substances which exist as gases, or are previously reduced to the state of vapour by the temperature necessary, it is termed *inflammation*; and if it proceed with very great violence and rapidity, *deflagration.*

571. Combustion and inflammation have been already described.

572. *Deflagration*, from its violence, must always be performed with caution. The common mode of conducting this process is, to introduce the substances to be deflagrated together into any convenient vessel, commonly an iron pot, or crucible, heated to redness. But to obviate any inconvenience, and to insure the success of the process, they are previously

made perfectly dry, reduced to powder, and thoroughly mixed together. The compound is then deflagrated gradually, generally by spoonfuls; but we must take care always to examine the spoon, lest a spark should adhere to it, which might set fire to the whole mass. During the process, the portion introduced should be frequently stirred.

573. The oxygen necessary for the process of oxygenation may be derived from the decomposition,

a. Of oxygen gas, or atmospheric air;
b. Of oxides, particularly water;
c. Of acids and their combinations.

574. The different modes of oxygenizement are intended, either,

a. To produce heat and light;
b. To obtain an oxygenized product;
 1. An oxide, when the process may be termed *Oxidizement.*
 2. An acid, *Acidification.*
c. To remove an oxygenizable substance.

575. Hydrogen, carbon, and nitrogen, are never, unless for experiment, oxygenized as simple substances.

576. Sulphur is converted into sulphuric acid by burning it in leaden chambers, or by deflagrating it with nitrate of potass: and phosphorus is acidified by inflammation in the atmosphere.

577. Of all the simple oxygenizable substances, the metals are most frequently combined with oxygen; and, as in consequence of this combination, they lose their metallic appearance, they were formerly said to be calcined or corroded.

578. Metals differ very much in the facility with which they are oxygenized by the contact of oxygen gas. For some, as iron and manganese, the ordinary temperature of the atmosphere is necessary; but others, as potassium and sodium, are oxygenized even by the contact of ice; while others, as gold, and platinum, scarcely undergo any change in the most violent heat. Upon these the operation is performed by heating them to the requisite temperature, and exposing them to the action of the air: and on the fusible metals it is promoted by stirring them when melted.

579. Metals also differ in the mode of their action upon water. They are either capable of decomposing water,

a. At every temperature, as potassium and sodium.
b. At ordinary temperatures, as iron, zinc, manganese, &c.
c. At elevated temperatures, as antimony and tin; or
d. When acted upon at the same time by an acid or an alkali, as copper, lead, bismuth; or, lastly,
e. They are incapable of decomposing it, as gold, silver, mercury, platinum.

580. The oxygenizement of metals by water is promoted by the action of air. Iron, for example, is more quickly rusted by being merely moistened with water, than when totally immersed in water.

581. But the acids are the most powerful agents in oxygenizing metals. They act, in two ways, either,

1. By enabling them to decompose water;
2. By being decomposed themselves.

582. The metals are susceptible of different degrees of oxygenizement, some of them even of acidification, and, in general, they are more oxygenized according to the rapidity of the process. When proceeding too slowly, it may be accelerated by heat; when too violent, it must be checked by diminution of temperature, as by plunging the vessel in which the operation is performed into cold water.

583. When the degree of oxygenizement is not very great, the oxide formed generally enters into combination with the acid employed, and forms a metallic salt; but when carried to its highest degree, the oxide is often insoluble.

DISOXYGENIZEMENT OF METALLIC OXIDES AND ACIDS.

584. This process was formerly termed *reduction*, from its restoring the metals to their metallic splendour, and is performed by causing some body to act upon them, which has a greater affinity for oxygen than they have. The different metals themselves vary very much in the degree of this affinity, so that thay are reduced with very different degrees of facility. Gold, silver, platinum, and mercury, are reduced by merely exposing them to a sufficient degree of heat in close vessels. The oxygen at this temperature has a greater affinity for caloric than for the metals, and is therefore driven off in the form of very pure oxygen gas.

585. Some other metallic oxides which resist the simple action of heat, may be reduced by melting them in contact with

charcoal, or substances which may be charred, such as oil, fat, resin, pitch, &c. Besides the charcoal, different saline fluxes are also added to facilitate the fusion of the oxide.

586. The oxide to be reduced is mixed with a sufficient quantity of any of these substances, and placed in the bottom of a crucible, which is afterwards filled up with charcoal powder, to prevent entirely the access of the air, and exposed for a length of time to a sufficiently high temperature, when a button of the metal will commonly be found in the bottom of the crucible. Upon the volatile metals, such as arsenic and zinc, this operation must be performed in a distilling or subliming apparatus. Some metallic oxides, such as those of platinum, columbium, &c. cannot be reduced, from our being unable to produce a degree of heat sufficient to melt them.

587. But galvanism is by far the most powerful disoxygenizing process. By means of it the metallic bases of the alkalies and earths have been discovered.

588. Metals may be also obtained from the metallic salts, by inserting in a solution of these a plate of another metal, possessing a stronger affinity for oxygen than for the acid. Thus copper is precipitated by iron, and arsenic by zinc. We must only take care that the two metals have no remarkable affinity for each other, as in that case an alloy is commonly produced. For example, when mercury is placed in a solution of silver, a crystallized amalgam of silver is obtained, formerly called the Arbor Dianæ.

589. The compound oxides, (vegetable and animal substances), may be further oxygenized, by treating them with nitric acid. In this way various oxides and acids are formed, according to the nature of the oxide operated on, the quantity of the acid, and the mode of conducting the process.

590. These substances also undergo changes by gradually combining with the oxygen of the atmosphere. In some cases, this combination is attended with remarkable phenomena, which have been classed under the term *fermentation*.

591. There are several species of fermentation, which have been named from the products they afford.

1. The saccharine, which produces sugar.
2. The vinous, which produces wine, beer, and similar fluids.
3. The panary, which produces bread.
4. The acetous, which produces vinegar.
5. The putrefactive, which produces ammonia.

592. The same substances are sometimes capable of undergoing the first, second, fourth, and fifth; or third, fourth, and fifth, successively, but never in a retrograde order.

593. The conditions necessary for all of them are,

1. The presence of a sufficient quantity of fermentable matter;
2. The presence of a certain proportion of water;
3. The contact of atmospheric air; and,
4. A certain temperature.

594. *The saccharine fermentation.*—The seeds of barley, when moistened with a certain quantity of water, and exposed to the contact of the atmospheric air, at a temperature of not less than 50°, swell, and shew marks of incipient vegetation, by pushing forth the radicle. If at this period the fermentation be checked, by exposing them to a considerable degree of heat, and drying them thoroughly, the insipid amylaceous matter, of which the seeds principally consisted, will be found to be changed in part into a sweet saccharine substance. The oxygen of the air, in contact with the seeds, is at the same time converted into carbonic acid gas, by combining with part of the carbon of the seeds; and there is a considerable increase of temperature in the fermenting mass, even to such a degree as sometimes to set it on fire. Similar phenomena occur in the maturation of fruits; in the cookery of some roots and fruits, and during the heating of hay, when put up too wet.

595. *The vinous fermentation.*—The conditions necessary for the vinous fermentation, are, the presence of proper proportions of sugar, acid, extract, and water, and a temperature of about 70°. When these circumstances exist, an intestine motion commences in the fluid; it becomes thick and muddy, its temperature increases, and carbonic acid gas is evolved. After a time the fermentation ceases, the feces rise to the top, or subside to the bottom, the liquor becomes clear, it has lost its saccharine taste, and assumed a new one, and its specific gravity is diminished. If the fermentation has been complete, the sugar is entirely decomposed, and the fermented liquor consists of a large proportion of water, of alcohol, of malic acid, of extract, of essential oil, and colouring matter. The substances most commonly subjected to this fermentation are must, which is the expressed juice of the grape, and which produces the best wines; the juice of the currant and gooseberry, which, with the addition of sugar, form our home-made wines; the juices of the apple and pear, which give cyder and

perry; and an infusion of malt, which, when fermented with yeast, forms beer. The briskness and sparkling of some of these liquors depend on their being put into close vessels before the fermentation is completed, by which means a portion of carbonic acid gas is retained.

596. *The acetous fermentation.*—All vinous liquors are susceptible of the acetous fermentation, provided they be exposed to the action of the atmosphere, in a temperature not less than 70°. An intestine motion and hissing noise sensibly take place in the fluid; it becomes turbid, with filaments floating in it, and its temperature increases; it exhales a pungent acid smell, without any disengagement of carbonic acid gas. Gradually these phenomena cease; the temperature decreases, the motion subsides, and the liquor becomes clear, having deposited a sediment and red glairy matter, which adheres to the sides of the vessel. During this process, the alcohol and malic acid disappear entirely, oxygen is absorbed, and acetous acid formed.

597. *The panary and colouring fermentation*—is less understood than those already described. A paste of wheat-flour and water, exposed to a temperature of 65°, swells, emits a small quantity of gas, and acquires new properties. The gluten disappears, and the paste acquires a sour disagreeable taste. If a just proportion of this fermented paste or leaven, or, what is still better, if some barm, be formed into a paste with wheat-flour and water, the same fermentation is excited, without the disagreeable taste being produced; the gas evolved is prevented from escaping by the viscidity of the paste, which therefore swells, and if baked, forms light spongy bread.

598. *The putrefactive fermentation.*—Although vegetable substances, when they are destroyed by spontaneous decomposition, are said to putrefy, we shall consider this fermentation as belonging exclusively to animal substances, or those which contain nitrogen as an elementary principle. The essential conditions of putrefaction are humidity, and a temperature between 45° and 110°. The presence of air, the diminution of pressure, and the addition of ferments, are not essential, but accelerate its progress. The smell is at first vapid and disagreeable, but afterwards insupportably fetid, although the fetor for a time, is somewhat diminished by the mixture of an ammoniacal odour. Liquids become turbid and flocculent. Soft substances melt down into a gelatinous mass, in which there is a kind of gentle motion and swelling up, from the slow and scanty formation of elastic fluids. Solids, beside the general softening, exude a serosity of various colours, and by de-

grees the whole mass dissolves, the swelling ceases, the matter settles, and its colour deepens; at last its odour becomes somewhat aromatic, its elements are finally dissipated, and there remains only a kind of fat, viscid, and still fetid mould. The products of putrefaction are carburetted, sulphuretted, and phosphuretted hydrogen gases, water, ammonia, azote, and carbonic acid. These are all dissipated in the form of gas or vapour. When in contact with air, oxygen is absorbed. Acetic acid, a fatty matter, a soap composed of this fat and ammonia, and often the nitric acid, fixed by a salifiable base, are also produced; and the ultimate remains, besides salts, composed of acid and earths, contain for a long time a portion of fat charry matter.

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APPENDIX.

WEIGHTS AND MEASURES.

ENGLISH.

APOTHECARIES WEIGHT, L.

Pound.		*Ounces.*		*Drams.*		*Scruples.*		*Grains.*		*Grammes.*
℔ 1	=	12	=	96	=	288	=	5760	=	372.96
		℥ 1	=	8	=	24	=	480	=	31.08
				ʒ 1	=	3	=	60	=	3.885
						℈ 1	=	20	=	1.295
								gr. 1	=	0.06475

Table for converting Ounces, Drams, and Grains Troy into Decimals of the Troy Pound.

Grain.	*lbs. Troy.*	*Dram.*	*lbs. Troy.*	*Oz.*	*lbs. Troy.*
1 =	.000173611	1 =	.0104166	1 =	.0833
2 =	.000347222	2 =	.0208333	2 =	.1666
3 =	.000520833	3 =	.0312500	3 =	.2500
4 =	.000694444	4 =	.0416666	4 =	.3333
5 =	.000868055	5 =	.0520833	5 =	.4166
6 =	.001041666	6 =	.0625000	6 =	.5000
7 =	.001215277	7 =	.0729166	7 =	.5833
8 =	.001388888			8 =	.6666
9 =	.001562500			9 =	.7500
				10 =	.8333
				11 =	.9166

Table for converting Decimals of the Troy Pound into Troy Ounces, Drams, and Grains.

lb.	oz.	dr.	grs.	lb.	oz.	dr.	grs.	lbs.	grains.
.1 =	1 :	1 :	36	.01 =	0 :	0 :	57.6	.001 =	5.76
.2 =	2 :	3 :	12	.02 =	0 :	1 :	55.2	.002 =	11.52
.3 =	3 :	4 :	48	.03 =	0 :	2 :	52.8	.003 =	17.28
.4 =	4 :	6 :	24	.04 =	0 :	3 :	50.4	.004 =	23.04
.5 =	6 :	0 :	0	.05 =	0 :	4 :	48.0	.005 =	28.80
.6 =	7 :	1 :	36	.06 =	0 :	5 :	45.6	.006 =	34.56
.7 =	8 :	3 :	12	.07 =	0 :	6 :	43.2	.007 =	40.32
.8 =	9 :	4 :	48	.08 =	0 :	7 :	40.8	.008 =	46.08
.9 =	10 :	6 :	24	.09 =	0 :	8 :	38.4	.009 =	51.84

AVOIRDUPOIS WEIGHT.

Pounds.	Ounces.	Drams.	Troy Grains.	Grammes.
1 =	16 =	256 =	7000 =	453.25
	1 =	16 =	437.5 =	28.32
		1 =	27.34375 =	1.81

Table for converting Avoirdupois Ounces into Decimals of the Avoirdupois Pound.

oz. Av.	lbs. Av.	oz. Av.	lbs. Av.
.25 =	.015625	8 00 =	.5000
.50 =	.03125	9.00 =	.5625
1.00 =	.0625	10.00 =	.6250
2.00 =	.1250	11.00 =	.6875
3.00 =	.1875	12.00 =	.7500
4 00 =	.2500	13 00 =	.8125
5.00 =	.3125	14.00 =	.8750
6 00 =	.3750	15 00 =	.9375
7.00 =	.4375		

Table for converting Decimals of the Avoirdupois Pound into Avoirdupois Ounces and Decimals.

lbs. Av.	oz. Av.	lbs. Av.	oz. Av.
.1 =	1.6	.01 =	.16
.2 =	3.2	.02 =	.32
.3 =	4.8	.03 =	.48
.4 =	6.4	.04 =	.64
.5 =	8.0	.05 =	80
.6 =	9 6	.06 =	.96
.7 =	11.2	.07 =	1 12
.8 =	12.8	.08 =	1.28
.9 =	14.44	.09 =	1.44

Table for converting Troy Pounds into their equivalent Avoirdupois Pounds.

lbs. Troy.		*lbs Avoirdup.*	*lbs. Troy.*		*lbs. Avoirdup.*
1	=	0.82285714	6	=	4.93714285
2	=	1.64571428	7	=	5.76000000
3	=	2.46857142	8	=	6.58285714
4	=	3.29142857	9	=	7.40571428
5	=	4.11428571			

Table expressing the relative Weight in Avoirdupois of various Weights Troy.

TROY. *dr.*		AVOIRDUPOIS. *dr.*		*gr.*	TROY. *dr.*		AVOIRDUPOIS. *dr.*		*gr.*
1	=	2	:	5.3125	5	=	10	:	26.5625
2	=	4	:	10.625	6	=	13	:	4.53125
3	=	6	:	15.9375	7	=	15		9.84375
4	=	8	:	21.25	8	=	17	:	15.15625

TROY. *oz.*		AVOIRDUPOIS. *oz.*		*gr.*	TROY. *oz.*		AVOIRDUPOIS. *oz.*		*gr.*
1	=	1	:	42.5	7	=	7	:	297 5
2	=	2	:	85.	8	=	8	:	340.
3	=	3	:	127.5	9	=	9	:	382.5
4	=	4	:	170.	10	=	10	:	425.
5	=	5	:	212.5	11	=	12	:	30.
6	=	6	:	255.	12	=	13	:	72.5

TROY. *lb.*		AVOIRDUPOIS. *lb.*	*oz.*	*gr.*	TROY. *lb.*		AVOIRDUPOIS. *lb.*	*oz.*	*gr.*
1	=	0	13	72.5	17	=	13	15	359.5
2	=	1	10	145	18	=	14	12	430
3	=	2	7	217.5	19	=	15	10	65
4	=	3	4	290	20	=	16	7	137.5
5	=	4	1	362.5	30	=	24	10	425
6	=	4	14	435	40	=	32	14	275
7	=	5	12	70	50	=	41	2	125
8	=	6	9	142.5	60	=	49	5	412.5
9	=	7	6	215	70	=	57	9	262.5
10	=	8	3	287.5	80	=	65	13	112.5
11	=	8	0	360	90	=	74	0	400
12	=	9	13	432.5	100	=	82	4	250
13	=	10	11	67.5	200	=	164	9	62.5
14	=	11	8	140	300	=	246	13	312.5
15	=	12	5	212.5	400	=	293	2	125
16	=	13	2	285	500	=	411	6	375

Table for converting Avoirdupois Pounds into their equivalent Troy Pounds.

lbs. Avoird.		*lbs. Troy.*	*lbs. Avoird.*		*lbs. Troy.*
1	=	1.215277	6	=	7.291666
2	=	2.430555	7	=	8.506944
3	=	3.645833	8	=	9.722222
4	=	4.861111	9	=	10.937500
5	=	6.076388			

Table expressing the relative value in Troy Weight of various Weights Avoirdupois.

AVOIRDUPOIS. *dr.*		TROY. *dr.*	*gr.*
1	=	0	27.34375
2	=	0	54.68750
3	=	1	22.03125
4	=	1	49.37500
5	=	2	16.71875
6	=	2	44.06250
7	=	3	11.40625
8	=	3	38.75000
9	=	4	6.09375
10	=	4	33.43750
11	=	5	00.78125
12	=	5	28.13500
13	=	5	55.46875
14	=	6	22.81250
15	=	6	50.15625
16	=	7	17.50000

AVOIRDUPOIS. *oz.*		TROY. *oz.*	*dr.*	*gr.*
1	=	0 :	7 :	17.5
2	=	1 :	6 :	35
3	=	2 :	5 :	52.5
4	=	3 :	5 :	10
5	=	4 :	4 :	27.5
6	=	5 :	3 :	55
7	=	6 :	3 :	2.5
8	=	7 :	2 :	20
9	=	8 :	1 :	37.5
10	=	9 :	0 :	55
11	=	10 :	0 :	22.5
12	=	10 :	7 :	50
13	=	11 :	6 :	57.5
14	=	12 :	6 :	5
15	=	13 :	5 :	22.5
16	=	14 :	4 :	40

AVOIRDUPOIS. *lb.*		TROY. *lb.*	*oz.*	*dr.*	*gr.*
1	=	1	2	4	40
2	=	2	5	1	20
3	=	3	7	6	00
4	=	4	10	2	40
5	=	6	0	7	20
6	=	7	3	4	00
7	=	8	6	0	40
8	=	9	8	5	20
9	=	10	11	2	00
10	=	12	1	6	40
11	=	13	4	3	20
12	=	14	7	0	00
13	=	15	9	4	40
14	=	17	0	1	20
15	=	18	2	6	00
16	=	19	5	2	40

AVOIRDUPOIS. *lb.*		TROY. *lb.*	*oz.*	*dr.*	*gr.*
17	=	20	7	7	20
18	=	21	10	4	00
19	=	23	1	0	40
20	=	24	3	5	20
30	=	36	5	4	00
40	=	48	7	2	40
50	=	60	9	1	20
60	=	72	11	0	00
70	=	85	0	6	40
80	=	97	2	5	20
90	=	109	4	4	00
100	=	121	6	2	40
200	=	243	0	5	20
300	=	364	7	0	00
400	=	486	1	2	40
500	=	607	7	5	20

MEASURE, LONDON PHARMACOPŒIA.

Gal.	*Pints.*	*Fluidoun.*	*Fluidr.*	*Minims.*	*Troy Gr.*	*Cub. Inch.*	*Litres.*
1 =	8 =	128 =	1024=	61440=	58443 =	231 =	3.78515
	O 1 =	√16 =	128=	7680=	7305 =	28.875 =	0.47398
		f℥ 1 =	8=	480=	456.5=	1.8047=	0.02957
			fʒ i=	60=	57 =	9.2256=	0.00396
				♏ 1=	0.9=	0.0374=	0.00066

ENGLISH WINE MEASURE.

Ton.	*Pipe or Butt.*	*Punch.*	*Hogsh.*	*Tierce.*	*Gallon.*	*Cub. Inch.*
1 =	2 =	3 =	4 =	6 =	252 =	58212
	1 =	1½ =	2 =	3 =	126 =	29106
		1 =	1⅓ =	2 =	84 =	19404
			1 =	1½ =	63 =	14553
				1 =	42 =	9902
					1 =	231

ENGLISH ALE MEASURE.

Hogsh.	*Barrel.*	*Kilderk.*	*Firkin.*	*Gallon.*	*Quart.*	*Pint.*	*Cub. Inch.*
1 =	1½ =	3 =	6 =	51 =	204 =	408 =	14382
	1 =	2 =	4 =	34 =	136 =	272 =	9588
		1 =	2 =	17 =	68 =	136 =	4794
			1 =	8½ =	34 =	68 =	2397
				1 =	4 =	8 =	282
					1 =	2 =	70½
						1 =	35¼

SCOTS LIQUID MEASURE.

Gal.	*Quart.*	*Pint.*	*Choppin.*	*Mutchkin.*	*Gills.*	*Cub. Inch.*
1 =	4 =	8 =	16 =	32 =	128 =	840
	1 =	2 =	4 =	8 =	32 =	210
		1 =	2 =	4 =	16 =	105
			1 =	2 =	8 =	52.5
				1 =	4 =	26.25
					1 =	6.56

In the preceding Tables, the cubic inch of water is estimated at 253 Troy Grains. In the succeeding Tables calculated by Mr Fletcher, it is estimated at 252.506 Troy Grains 60° Fahr. and 29.5 Bar.

	Cubic Inches.		*Wine Pint.*		*Ale Pint.*
1 lb. Troy,	22.81134	=	0.7900031	=	0.6471302
1 lb. Avoirdupois,	27.72135	=	0.960073	=	0.7864429

	Cubic Inches.	*Troy.*	*lbs. oz. dr.*	*grs.*	*lbs. Avoir.*
1 ale gallon	= 282	= 12.362372	= 12 : 4 : 2 :	48.12672	= 10.172384
1 ale quart	= 70.5	= 3.090568	= 3 : 1 : 0 :	42.03168	= 2.543096
1 ale pint	= 35.25	= 1.545284	= 1 : 6 : 4 :	21.01584	= 1.271543

Table for converting Wine Pints of Water into their equivalent Troy and Avoirdupois Pounds.

Wine Pints.	*lbs. Troy.*	*lbs. Troy.*	*oz.*	*dr.*	*grs.*	*lbs. Avoirdup.*
1 =	1 26581783 =	1 :	3 :	1 :	31.1 =	1.04158725
2 =	2.53163566 =	2 :	6 :	3 :	2.2 =	2.08317450
3 =	3·79745349 =	3 :	9 :	4 :	33.3 =	3·12476175
4 =	5.06327132 =	5 :	0 :	6 :	4.4 =	4.16634900
5 =	6.32908915 =	6 :	3 :	7 :	35.5 =	5.20793625
6 =	7·59490698 =	7 :	7 :	1 :	6.6 =	6.24952350
7 =	8.86072481 =	8 :	10 :	2 :	37.7 =	7.29111075
8 =	10.12654264 =	10 :	1 :	4 :	8.8 =	8.33269800
9 =	11.39236047 =	11 :	4 :	5 :	39.9 =	9.37428525

Table for converting Cubic Inches of Water (at 60° Fahr. and 29.5 Bar.) into their equivalents in Troy Weight.

Cub. Inch of Water.		*Troy grs.*	*oz.*	*dram.*	*grs.*
1	weighs	252.506 =	0 :	4 :	12.506
2		505.012 =	1 :	0 :	25.012
3		757.518 =	1 :	4 :	37.518
4		1010.024 =	2 :	0 :	50.024
5		1262.530 =	2 :	5 :	2.530
6		1515.036 =	3 :	1 :	15.036
7		1767.542 =	3 :	5 :	27.542
8		2020.048 =	4 :	1 :	40.048
9		2272.554 =	4 :	5 :	52.554
1728 (1 cub. foot),		———	909 :	0 :	10.368

Table for converting the Ounce Measure used by Dr Priestley to Cubical Inches.

Ounce Measures.	*French Cubical Inches.*	*English Cubical Inches.*
1	1.567	1.898
2	3.134	3.796
3	4.701	5.694
4	6.268	7.592
5	7.835	9.490
6	9.402	11.388
7	10.969	13.286
8	12.536	15.184
9	14.103	17.082
10	15.670	18.980
20	31.340	37.960
30	47.010	56.940
40	62.680	75.920
50	78.350	94.900
60	94.020	113.880
70	109.690	132.860
80	125.360	151.840
90	141.030	170.820
100	156.700	189.800
1000	1567.000	1898.000

Correspondence between English and Foreign Weights and Measures.

NEW FRENCH.

'To employ, as the fundamental unity of all measures, a type 'taken from nature itself, a type as unchangeable as the globe on 'which we dwell,—to propose a metrical system, of which all the 'parts are intimately connected together, and of which the multiples and subdivisions follow a natural progression, which is 'simple, easy to comprehend:—this is most assuredly a beautiful, great, and sublime idea, worthy of the enlightened age in 'which we live.'

Such were the ideas which influenced the French National Institute, when they chose, as the base of the whole metrical system, the fourth part of the terrestrial meridian, between the equator and the north pole. They adopted the ten millionth part of this arc for the unity of measure, which they denominated *meter*, and applied it both to superficial and solid measures, taking for the unity of the former, *are*, the square of the decuple, and for that of the latter, *litre*, the cube of the tenth part of the metre. They chose for the unity of weight, *gramme*, the quantity of distilled water which the same cube contains when reduced to a constant state presented by nature itself; and, lastly, they decided, that the multiples and submultiples of each kind of measure, whether of weight, capacity, or length, should be always taken in the decimal progression, as being the most simple, the most natural, and the most easy for calculation, according to the system of numeration which all Europe has employed for centuries, and they used the prefixes, *deca*, *hecto*, *kilo*, and *myria*, taken from the Greek numerals, to express the multiplication of the integer by 10, 100, 1000, and 1000 respectively, and *deci*, *centi*, *milli*, taken from the Latin numerals, to express its division.

By a careful measurement of the arc between Dunkirk and Mountjoy, they found the length of the metre to be equal to 443.296 lines of the toise of Peru. The cubic decimetre of distilled water, taken at its maximum of density and weight *in vacuo*, that is, the unity of weight, was found to be 18827.15 grains of the pile of Charlemagne.

The *metre* at 32° = 39.371 English inches at 62°.
The square metre = 1550.075641 English square inches.
The square decimetre = 15.50075 English square inches.
100 *ares* or square decametres = 2 English acres nearly.

Cub. feet cub. inch.
The cubic metre = 61028.028 English cubic inches = 355 48.028.
The cubic decimetre, or *litre* = 61.028 English cubic inches.
Equal to the bulk of a killogramme of water.

Troy gr.
The gramme or weight of a cubic centimetre of water = 15.44402.

MEASURES OF LENGTH:

The Metre being at 32°, and the Foot at 62°.

		English inches.		Mil.	Fur.	Yards.	Feet.	Inch.
Millimetre	=	.03937						
Centimetre	=	.39371						
Decimetre	=	3.93710						
Metre	=	39.37100						
Decametre	=	393.71000	=	0	0	10	2	9.7
Hecatometre	=	3937.10000	=	0	0	109	1	1
Kilometre	=	39371.00000	=	0	4	213	1	10.2
Myriametre	=	393710.00000	=	6	1	156	0	6

Metre.		*Eng. feet.*		*Inches.*
1	=	3	:	3.371
2	=	6	:	6.742
3	=	9	:	10.113
4	=	13	:	1.484
5	=	16	:	4.855
6	=	19	:	8.226
7	=	22	:	11.597
8	=	26	:	2.968
9	=	29	:	6.339

Decimetre.		*Eng. inches.*
1	=	3.9731
2	=	7.8742
3	=	11.8113
4	=	15.7484
5	=	19.6855
6	=	23.6226
7	=	27.5597
8	=	31.4968
9	=	35.4339

MEASURES OF CAPACITY.

		Cubic inches.		ENGLISH. *Tons.*	*Hogs.*	*Wine gal.*	*Pints.*
Millilitre	=	.06103					
Centilitre	=	.61028					
Decilitre	=	6.10280					
Litre	=	61.02800	=	0	0	0.	2.1133
Decalitre	=	610.28000	=	0	0	2.	5.1352
Hecatolitre	=	6102.80000	=	0	0	26.419	
Kilolitre	=	61028.00000	=	1	0	12.19	
Myrialitre	=	610280.00000	=	10	1	58.9	

Litre.		*Eng. cub. inch.*		*Ale pints.*		*Wine pints.*		*Oz. troy of water.*
1	=	61.028	=	1.7313	=	2.11353	=	31.104
2	=	122.056	=	3.4626	=	4.22706	=	64.208
3	=	183.084	=	5.1939	=	6.34059	=	96.312
4	=	244.112	=	6.9252	=	8.45412	=	128.416
5	=	305.140	=	8.6565	=	10.56765	=	160.520
6	=	366.168	=	10.3878	=	12.68118	=	192.624
7	=	427.196	=	12.1191	=	14.79471	=	224.728
8	=	488.224	=	13.8504	=	16.90824	=	256.832
9	=	549.252	=	15.5817	=	19.02177	=	288.936

MEASURES OF WEIGHT.

		English grains.		AVOIRDUPOIS. *Pounds.*	*Oun.*	*Dram.*
Milligramme	=	.0154				
Centigramme	=	.1544				
Decigramme	=	1.5444				
Gramme	=	15.4440				
Decagramme	=	154.4402	=	0	0	5.65
Hecatogramme	=	1544.4023	=	0	3	8.5
Kilogramme	=	15444.0234	=	2	3	5
Myriagramme	=	154440.2344	=	22	1	2

Gram.	*Troy grs.*	*Deca-gram.*	*Troy dram.*	*grs.*	*Hecto-gram.*	*Troy oz.*	*Avoird. oz.*
1. =	15.444	1. =	2 :	34.44	1. =	3.2175 =	3.5279
2. =	30.888	2. =	5 :	8.88	2. =	6.4350 =	7.0558
3. =	46.332	3. =	7 :	43.32	3. =	9.6525 =	10.5837
4. =	61.776	4. =	10 :	17.76	4. =	12.8700 =	14.1116
5. =	77.220	5. =	12 ;	52.20	5. =	16.0875 =	17.6395
6. =	92.664	6. =	15 :	26.64	6. =	19.3050 =	21.1674
7. =	108.108	7. =	18 ;	1.08	7. =	22.5295 =	24.6953
8. =	123.552	8. =	20 ;	35.52	8. =	25.7400 =	28.2232
9. =	138.996	9. =	23 ;	9.96	9. =	28.9575 =	31.7511

The decimal progression of all the French weights and measures renders it only necessary to change the decimal point in order to convert one into the equivalent of any other of the same species and numerically the same, but of a different denomination. Thus as 9 litres are equal to 15.5817 ale pints, 9 hectolitres will be equal to 1558.17 ale pints; and so of the rest.

Weights and Measures used in France before the Revolution.

DIVISION OF FRENCH WEIGHTS.

	Pound.	*Ounces.*	*Gros.*	*Deniers.*	*Grains*	*Troy Grs.*
Poids de Marc	1 =	16 =	128 =	384 =	9216 =	7561
Apothecary	1 =	12 =	96 =	288 =	6912 =	5670.5
Marc	1 =	8 =	84 =	142 =	4808 =	3780.5
		1 =	8 =	24 =	576 =	472.6
			1 =	3 =	72 =	59.1
				1 =	24 =	19.7
					1 =	0.8

Troy grains.

		Troy grains		
The French pound	=	7561	= 1.31268	lb. troy.
ounce	=	472.5625	= 0.984504	oz. troy.
gros	=	59.0703125	= 0.984504	dram.
grain	=	0.820421		

The English troy pound of 12 ounces	=	7021	Paris grains.
The troy ounce - -	=	585.0833	
The dram of 60 grains -	=	73.1351	
The penny-weight or denier, of 24 grains -		29.2544	
The scruple of 20 grains -	=	4.3784	
The grain - - -	=	1.2189	
The avoirdupois pound of 16 ounces, or 7000 troy grains, -	=	8538.	Paris grains.
The ounce - - -	=	533.6250	

To reduce Paris grains to English grains, divide by English grains to Paris grains, multiply by	1.2189
Paris ounces to English troy ounces, divide by English troy ounces to Paris ounces, multiply by	1.015734
Pound (Poids de Marc) to troy pound, multiply by Troy pound to pound Poids de Marc, divide by	1.31268

Table shewing the Comparison between English and French Weights (Poids de Marc.)

English Grs.		French Grs.	English Grs.		French Grs.
1	=	1.2189	9	=	10.9704
2	=	2.4378	10	=	12.1890
3	=	3.6568	20	=	24.378
4	=	4.8757	30	=	36.568
5	=	6.0947	40	=	48.757
6	=	7.3136	50	=	60.947
7	=	8.5325	60	=	73.136

French Grs.		Troy Grs.	French grs.		Troy grs.
1.	=	0.820421	10.	=	8.20421
2.	=	1.640842	20.	=	16.40842
3.	=	2.461263	30.	=	24.61263
4.	=	3.281684	40.	=	32.81684
5.	=	4.102105	50.	=	41.02105
6.	=	4.922526	60.	=	49.22526
7.	=	5.742947	70.	=	57.42947
8.	=	6.563368	72.	=	59.070312
9.	=	7.383789			

Gros.		Drams.	Grs.	Gros.		Drams.	Grs.
1	=	0	59.07	5	=	4	55.35
2	=	1	58.14	6	=	5	54.42
3	=	2	57.21	7	=	6	53.49
4	=	3	56.28				

Fr. oz.		Troy oz.	Drs.	Grs.	Fr. oz.		Troy oz.	Drs.	Grs.
1.	=	0	7	52.56	9.	=	8	6	53.04
2.	=	1	7	45.12	10.	=	9	6	45.60
3.	=	2	7	37.68	11.	=	10	6	38.16
4.	=	3	7	30.24	12.	=	11	6	30.72
5.	=	4	7	22.80	13.	=	12	6	23.28
6.	=	5	7	15.36	14.	=	13	6	15.84
7.	=	6	7	7.92	15.	=	14	6	8.40
8.	=	7	7	0.48					

Fr. pounds.		*Tr. oz. dr. grs.*	*Fr. pounds.*		*Tr. oz. dr. grs.*
1.	=	15 : 6 : 1	6.	=	94 : 4 : 6
2.	=	31 : 4 : 2	7.	=	110 : 2 : 7
3.	=	47 : 2 : 3	8.	=	126 : 0 : 8
4.	=	63 : 0 : 4	9.	=	141 6 : 9
5.	=	78 : 6 : 5			

LONG MEASURE.

		French Inches. *feet.*	*inches.*	*lines.*		*English Inches.*
The French ell, *Aune,*	=	3	7	10.5	=	46.69
The half toise	=	3			=	38.355
		English Foot.				
The foot	=	1.0654167			=	12.785
The inch					=	1.0654
The line					=	0.0888
		French Foot.				*French Inches.*
The English foot	=	0.9386			=	11.2632
The inch					=	0.9386
The line					=	00.7823

To reduce French feet or inches to English feet or inches, multiply by 1.0654167, or divide by 0.9386.

To reduce English long measure to French, multiply by 0.9386, or divide by 1.0654167.

Tables expressing the value of French feet and inches in English Measure.

French feet.		*English inches.*	*Fr. feet or in.*		*Eng. feet or in.*
1.	=	12.785	1	=	1.0654+
2.	=	25.570	2	=	2.1308
3.	=	38.355	3	=	3.1962
4.	=	51.140	4	=	4.2616
5.	=	63.925	5	=	5.3270
6.	=	76.710	6	=	6.3925
7.	=	89.495	7	=	7.4579
8.	=	102.280	8	=	8.5233
9.	=	115.065	9	=	9.5887
10.	=	127.850	10	=	10.6541
			11	=	11.7195
			12	=	12.7850

SQUARE MEASURE.

The French square foot or inch = 1.13510 English.
The English square foot or inch = .88126 French.

To reduce French square measure to English, multiply by 1.13510, or divide by 0.88126.

To reduce English square measure to French, multiply by 0.88126, or divide by 1.13510.

CUBE MEASURE.

The French cubic foot or inch, = 1.209367 English.
The English cubic foot or inch, = 0.8263784 French.

To reduce French cube measure to English, multiply by 1.209367, or divide by 0.8268784.

To reduce English cube measure to French, multiply by 0.8268784, or divide by 1.209367.

When one French cubic inch weighs 1 grain French, or contains 1 grain of any substance; one English cubic inch weighs or contains 0.67839 English grains.

To reduce the weight or contents of French cube measure in French grains, to the weight or contents of English cube measure in Troy grains, multiply by 0.67839.

French cube foot or inch.		*Eng. cube foot or inch.*	*French cube foot or inch.*		*Eng. cube foot or inch.*
1	=	1.2093+	6	=	7.2562
2	=	2.4187	7	=	8.4655
3	=	3·6181	8	=	9.6749
4	=	4.8374	9	=	10.8842
5	=	6.0468	10	=	12.0936

MEASURES OF CAPACITY FROM BAUME.

	Pint.		*chop.*		*demisetier.*		*poisson.*		*demipoisson.*		*oz.*
Pinte	1	=	2	=	4	=	8	=	16	=	32
Chopine			1	=	2	=	4	=	8	=	16
Demisetier					1	=	2	=	4	=	8
Poisson							1	=	2	=	4
Demipoisson									1	=	2
Once										=	1

The legal pint in common use in Paris seems to have been different from that now taken from Baumé, which perhaps is peculiar to apothecaries. Their relations are the following:

	Fr. cub. in.	*Eng. cub. in.*	*Eng. wine pint.*	*Tr. pound.*	*Litres.*
Common pinte	= 48	= 58.05	= 2.01	= 2.54	= 0·95
Baumé's pinte	= 49.52	= 59.89	= 2.07	= 2.62	= 0.98

Table shewing the relative value of the old and new French weights and measures in round numbers. (*Parmentier.*)

Kilogramme	=	2 livres, Poid de Marc
Demikilogramme	=	1 livre
Gramme	=	18 grains
Demigramme	=	9 grains
2 Grammes	=	½ gros
4 Grammes	=	1 gros
8 Grammes	=	2 gros
32 Grammes	=	1 once
Decigramme	=	2 grains
Demidecigramme	=	1 grain
3 Decigramme	=	6 grains
12 Decigramme	=	24 grains
1 Litre	=	1 pinte
Demilitre	=	1 chopine
Quart de Litre	=	demisetier

GERMAN.

COLOGNE WEIGHT.

Marc.	*Oz.*	*Loth.*	*Drs.*	*Pwts.*	*Hellers.*	*As.*	*Eschen.*	*Grs.*	*St. parts.*
1 =	8 =	16 =	64 =	256 =	512 =	1792 =	4352 =	6144 =	65536
	1 =	2 =	8 =	32 =	64 =	224 =	544 =	768 =	8192
		1 =	4 =	16 =	32 =	112 =	272 =	384 =	4096
			1 =	4 =	8 =	28 =	68 =	96 =	1024
				1 =	2 =	7 =	17 =	24 =	256

NUREMBERG, OR APOTHECARIES WEIGHT.

Pound.	*Ounces.*	*Drachms.*	*Scruples.*	*Grains.*	*Troy grs.*
1 =	12 =	96 =	288 =	5760 =	5388
	1 =	8 =	24 =	480 =	460.5
		1 =	3 =	60 =	57.5
			1 =	20 =	19.2
				1 =	0.96

Table shewing the Comparison between Grammes and Troy, French, and Nuremberg Apothecary Grains.

Gramme.		*Troy.*		*Poids de Marc.*		*Nuremberg.*
1	=	15.444	=	18.883	=	16.128
2	=	30.888	=	37.766	=	32.256
3	=	46.332	=	56.648	=	48.384
4	=	61.776	=	75.530	=	64.512
5	=	77.220	=	94.413	=	80.641
6	=	92.664	=	113.296	=	96.769
7	=	108.108	=	132.179	=	112.897
8	=	123.552	=	151.062	=	129.026
9	=	138.996	=	169.944	=	145.154
10	=	154.440	=	188.827	=	161.282

Swedish Weights and Measures, used by Bergman and Scheele.

The Swedish pound, which is divided like the English apothecary, or troy pound, weighs 6556 grains troy.

The kanne of pure water, according to Bergman, weighs 42250 Swedish grains, and occupies 100 Swedish cubical inches. Hence the kanne of pure water weighs 48083.719444 English troy grains, or is equal to 189.9413 English cubic inches; and the Swedish longitudinal inch is equal to 1.238435 English longitudinal inches.

From these data, the following rules are deduced:

1. To reduce Swedish longitudinal inches to English, multiply by 1.2384, or divide by 0.80747.

2. To reduce Swedish to English cubical inches, multiply by 1.9, or divide by 0.5265.

3. To reduce the Swedish pound, ounce, drachm, scruple, or grain, to the corresponding English troy denomination, multiply by 1.1382, or divide by .8786.

4. To reduce the Swedish kannes to English wine-pints, multiply by .1520207, or divide by 6.57804.

5. The lod, a weight sometimes used by Bergman, is the 32d part of the Swedish pound; therefore, to reduce it to the English troy pound, multiply by .03557, or divide by 28.1156.

Tables of Specific Gravities.

METALS.

Platinum	21.5	Arsenic, sulphuret, red	3.225
Gold	19.361	——— yellow	5.315
Tungsten	17.6	Iron	7.788
Mercury at —40°	15.612	—— sulphuret	4.518
——— at 47°	13.545	—— supersulphuret	4.83
Sulphuret of ditto	10.	Cobalt	7.700
Palladium	11.871	Tin	7.299
Rhodium	11.+	Zinc	6.861
Lead	11.352	Manganese	6.850
Sulphuret of ditto	7.	Antimony	6.712
Silver	10.510	——— sulphuret	4.368
—— sulphuret	7.2	Tellurium	6.115
Bismuth	9.822	Sodium	0.935
——— sulphuret	6.131	Potassium	0.85
Uranium	9.	**INFLAMMABLES.**	
Copper	8.895	Sulphur, native	2.033
Nickel	8.666	——— melted	1.990
Molybdenum	8.600	Phosphorus	1.714
——— sulphuret	4.73	Diamond	3.521
Arsenic	8.310	Charcoal	2.+

SALINE SUBSTANCES.

Sulphuric acid	2.125		Potass, carbonate	2.749	M
Nitric	1.504		—— supertartrate	1.953	H
Muriatic	1.194			1.8745	M
Acetic	1.0626		—— tartrate	1.5567	H
Red vinegar	1.025		Soda	1.336	H
White ditto	1.014		—— sulphate	2.246	Wal
Distilled	1.010			1.380	Wat
Phosphoric	1.5575			1.4457	H
Citric	1.0345		—— muriate	2.125	F
Arsenious	1.8731			2.120	K
				2.143	Wat
Potass	1.7085	H		2.200	H
	4.6215	K	—— sub-borate	1.740	K
—— sulphate	2.298	Wal		1.720	Wal
	2.636	Wat		1.757	Wat
	2.4073	H	—— phosphate	1.333	H
—— sulphite	1.586	V	—— subcarbonate	1.3591	H
—— nitrate	1.933	Wat		1.421	K
	1.900	Wal	—— acetate	2.1	H
	1.9369	H	—— and potash tar.	1.757	Wat
	2.15	F	Ammonia, liquid	0.9054	D
—— muriate	1.836	K	——— muriate	1.450	Wat
—— carbonate	2.012	H		1.453	Wal

SALINE SUBSTANCES.

Ammonia, muriate	1.420	K	Magnesia, carbonate	0.2941	H
——— carbonate	0.966	H	Barytes -	4.	K
	1.824	K		2.374	H
	1.5026	M	——— muriate	2.8257	H
	1.450	V	——— carbon. nat.	4.331	
			——— ——— art.	3.763	
Lime - -	2.3908	K	Alumina -	2.000	K
	2.37	M		0.8200	H
	1.5233	H	Alum -	1.7109	H
—— muriate	1.76	H		1.719	Wal
—— carbonate	2.7			1.757	Wat
Magnesia -	2.3298	K		1.738	F
	0.346	H		1.714	N
——— sulphate	1.6603	H		1.726	M

METALLIC SALTS.

Mercury, muriate	5.1398	H	Iron, sulphate of	1.812	Wat
	4.142	Wat	——— ——— calc.	2.636	Wat
——— submuriate	7.1758	H	Lead, sulphate	1.8742	H
——— phosphate	4.9835	H	——— carbonate	7.2357	
——— subsulphate	6.44	Wat	——— acetate	2.345	H
Copper, sulphate of	2.1943	H	Zinc, sulphate	2.3953	M
	2.230	Wat		1.933	Wat
——— acetate	1.779	H		1.912	H
Iron, sulphate of	1.8399	H		1.712	N
	1.880	Wal			

D. Davy. H Hassenfratz. K Kirwan. M Muschenbrock. Wal Wallerius. Wat Watson. F Fahrenheit. V Vauquelin. N. Newton.

EXTRACTS, GUMS, RESINS.

Acacia prunus spinosa	1.5153	Arecha (Catechu ?	1.4573
Aloes hepatic -	1.3586	Arnotto - -	0.5956
—— socotorine	1.3796	Asphaltum, cohesive	{ 1.450 / 2.060 }
Alouchi - -	1.0604		
Amber yellow transparent - -	1.0780	——— compact	{ 1.070 / 1.165 }
——— ——— opaque	1.0855	Assafœtida -	1.3275
——— red -	1.0834	Baras - -	1.0441
——— green -	1.0829	Bdellium -	1.1377
Ambergris -	{ 0.7800 / 0.9263 }	Benzoin -	1.0924
		Bitumen of Judea	1.104
Ammoniac -	1.2071	Cachibou - -	1.0640
Anime, oriental	1.0284	Camphor -	0.9887
——— occidental	1.0426	Caoutchouc -	0.9335
Arabic - -	1.4523	Caragna -	1.1244
Arcanson -	1.0857	Catechu -	1.4573

EXTRACTS, GUMS, RESINS.

Cherry - -	1.4817	Opium - -	1.3365
Copal, opaque -	1.1398	Opoponax - -	1.6226
—— transparent	1.0452	Resin of Jalap -	1.2185
Cork - -	0.2400	Rosin - -	1.0772
Dragon's blood -	1.2045	Sandarac -	1.0920
Elemi - -	1.0682	Sagapenum - -	1.2008
Euphorbium - -	1.1244	Sarcocol -	1.2684
Galbanum - -	1.2120	Scammony of Aleppo	1.2354
Galipot - -	1.0819	———— Smyrna	1.2743
Gamboge - -	1.2216	Inspissated juice of St John's wort -	1.5263
Guaiac - -	1.2289		
Lac - - -	1.1390	Storax - -	1.1098
Honey - -	1.4500	Sugar, white -	1.6060
Hypociste - -	1.5263	Tacamahaca -	1.0463
Liquorice - -	1.7228	Tragacanth -	1.8161
Indigo - -	0.7690	Turpentine - -	0.991
Ivy - - -	1.2948	Wax, ouarouchi -	0.8970
Labdanum -	1.1862	—— bees - -	0.9648
Mastic - -	1.0742	—— white - -	0.9686
Myrrh - -	1.3600	—— shoemakers	0.897
Olibanum - -	1.1732		

OILS.

Volatile.		*Fixed.*	
Cinnamon - -	1.044	Tallow - -	0.9419
Cloves - -	1.036	Fat of beef -	0.9232
Lavender - -	0.894	——— mutton -	0.9235
Mint - -	0.8982	——— veal -	0.9342
Sage - -	0.9016	——— pork -	0.9368
Thyme - -	7.9023	Naphtha - -	0.8475
Rosemary -	9.9057	Butter - -	0.9423
Calamint -	0.9116	Gaiva butter -	0.8916
Scurvy-grass -	0.9427	Oil of filberts -	0.916
Wormwood -	0.9073	——— walnut -	0.9227
Tansy - -	0.9949	——— hemp-seed	0.9258
Chamomile -	0.8943	——— poppies -	0.9238
Savine - -	0.9294	——— rape-seed	0.9193
Fennel - -	0.9294	——— lint-seed	0.9403
——— seed -	1.0083	——— whale -	0.9233
Coriander seed -	0.8655	——— ben -	0.9119
Caraway seed -	0.9049	——— beechmast	9.9176
Dill seed - -	0.9128	——— cod-fish	0.9233
Anise seed -	0.9867	——— olives -	0.9153
Juniper - -	0.8577	——— almonds	0.9170
Turpentine -	0.8697	Spermaceti -	0.9433
Amber - -	0.8867		
Orange flower -	0.8798		
Hyssop - -	0.8892		

WOODS, BARKS, &c.

Cinchona - -	0.7840	Mahogany - -	1.0630
Logwood - -	0.9130	Red saunders -	1.1280
Madder - -	0.7650	Sassafras - -	0.4820

ALCOHOL, ETHERS.

Sulphuric - -	0.7396	Acetic - -	0.8664
Nitric - -	0.9088	Alcohol - -	0.8293
Muriatic - -	0.7296	Proof-spirit -	0.916

SPECIFIC GRAVITY OF GASES.

	Weights of 100 *cubic inches in Troy grains.*	*Specific gravity.*	*Authority.*
Hydrogen, - -	2.23	0.07321	Biot and Arrago.
Phosphuretted hydrogen,	13.265	0.4347	Sir H. Davy.
Ditto, - - -	25.98	0.8518	Dalton and Henry.
Arseniated hydrogen,	16.13	0.529	Tromsdorf.
Carburetted hydrogen,		0.538	Berthollet.
Ditto from stagnant water,	20.66	0.666	Dalton.
Ammonia, - -	18.18	0.596	Allen and Pepys.
Steam, - - -		0.622	Gay Lussac.
Hydrophosphoric, -	26.53	0.870	Sir H. Davy.
Carbonic oxide, -	30.19	0.967	Cruickshank.
Azote, - - -	29.55	0.9691	Biot and Arrago.
Olefiant, - - -	29.72	0.974	Thomson.
Air, - - -	30.50	1.000	Sir G. Schuckburgh.
Percarburetted hydrogen,		1.000	T. Saussure.
Nitrous gas, - -	32.	1.049	Sir H. Davy.
Ditto, - - -	31.684	1.0388	Berard.
Oxygen - -	33.82	1.1088	Allen and Pepys.
Ditto, - - -		1.10359	Biot and Arrago.
Sulphuretted hydrogen,	35 89	1.177	Sir H. Davy.
Ditto, - - -		1.1912	Gay Lussac and Thenard.
Muriatic acid, - -	38.97	1.278	Sir H. Davy and Biot.
Carbonic acid, - -	47.26	1.5495	Allen and Pepys.
Ditto, - - -	46.31	1.518	Saussure.
Nitrous oxide, - -	49.227	1.614	Sir H. Davy.
Vapour of alcohol, -	65.	2.100	Dalton.
Ditto, - - -		1.5	Gay Lussac.
Nitrous acid, - -		2.10999	Gay Lussac.
Sulphurous acid, -	66.89	2.193	Sir H. Davy.
Ditto, - - -		2.2553	Gay Lussac and Thenard.
Muriatic ether, - -		2.219	Thenard.
Vapour of sulphuric ether,	70.	2.250	Dalton.
Ditto, - - -		2.396	Gay Lussac.
Fluoboracic, -	72.31	2.370	John Davy.
Euchlorine - -	74.	2.409	
Hyperoxymuriatic acid,		2.41744	John Davy.
Carburetted sulphur, vapour,		2.670	Gay Lussac.
Nitric acid, - -	76.[illegible]	2.425	Sir H. Davy.
Chlorine, - -	76.50	2.5082	Sir H. Davy.
Silicated fluoric, -	91.19	2.990	John Davy.
Chloride of carbonic oxide,	111.91	3.669	John Davy.
Hydriodic, - -		4.4288	
Iodine in vapour, -	117.71		
Water, - - -	252.506		Fletcher,

SOLUTIONS OF SALTS at 42° FAHRENHEIT.	Saturated.	WATSON. In 12 waters.
Lime	1.001	
Arsenious acid	1.005	
Sub-borate of soda	1.010	
Muriate of mercury	1.037	
Alum	1.033	
Sulphate of soda	1.052	1.029
——— potass	1.054	
Muriate of soda	1.198	1.059
Arseniate of potass	1.184	
Muriate of ammonia	1.072	1.026
Carbonate of ditto	1.077	
Oxalate of ammonia (Thomson)	1.0186	
Nitrate of potass	1.095	1.050
Tartrate of potass and soda	1.114	
Sulphate of copper	1.150	1.052
——— iron	1.157	1.043
——— magnesia	1.218	
——— zinc	1.386	1.045
Subcarbonate of potass	1.534	

Table of Specific Gravities indicated in the different Pharmacopœias.

	Dublin.	*London.*	*Edinburgh.*
Sulphuric ether	765		
Nitrous ether	900		
Spirit of nitrous ether	850		
Alcohol	815	815	
Rectified spirit (alcohol)	840	835	835
Proof spirit	930	930	935
Acetic acid	1070		
Distilled vinegar	1006		
Oxymuriatic acid	1003		
Muriatic acid	1170	1160	1170
——— diluted	1080		
Nitrous acid	1500	1500	1550
——— diluted	1280		
Sulphuric acid	1845	1850	1850
——— diluted	1090		
Solution of potass	1100	1050	
——— ammonia	936	960	
——— carbonate of ammonia	1095		
——— carbonate of soda, saturated	1220		
——— oxymuriate of potass	1087		
——— sulphuret of potass	1120		
Tincture of muriate of iron (red)	1050		

Table for reducing the Degrees of Baumé's Hydrometer to the Common Standard.

BAUME'S HYDROMETER FOR LIQUIDS LIGHTER THAN WATER.

Temperature 55° Fahrenheit, or 10° Reaumur.

Deg.	*Sp. Gr.*	*Deg.*	*Sp. Gr.*	*Deg.*	*Sp. Gr.*	*Deg.*	*Sp. Gr.*
10	1.000	18	.942	26	.892	34	.847
11	.990	19	.935	27	.886	35	.842
12	.982	20	.928	28	.880	36	.837
13	.977	21	.922	29	.874	37	.832
14	.970	22	.915	30	.867	38	.827
15	.963	23	.909	31	.871	39	.822
16	.955	24	.903	32	.856	40	.817
17	.949	25	.897	33	.852		

LIQUIDS HEAVIER THAN WATER.

Deg.	*Sp. Gr.*	*Deg.*	*Sp. Gr.*	*Deg.*	*Sp. Gr.*	*Deg.*	*Sp. Gr.*
0	1.000	21	1.170	42	1.414	63	1.779
3	1.020	24	1.200	45	1.455	66	1.848
6	1.040	27	1.230	48	1.500	69	1.920
9	1.064	30	1.261	51	1.547	72	2.000
12	1.089	33	1.295	54	1.594		
15	1.114	36	1.333	57	1.659		
18	1.140	39	1.373	60	1.717		

HEAT.

CORRESPONDENCE BETWEEN DIFFERENT THERMOMETERS.

Fahrenheit's thermometer is universally used in this kingdom. In it the range between the freezing and boiling points of water is divided into 180 degrees; and as the greatest possible degree of cold was supposed to be that produced by mixing snow and muriate of soda, it was made the zero; hence the freezing point became 32°, and the boiling point 212°.

The Centigrade thermometer places the zero at the freezing point, and divides the range between it and the boiling point into 100°. This has long been used in Sweden, under the title of Celsius's thermometer.

Reaumur's thermometer, which was formerly used in France, divides the space between the freezing and boiling of water into 80°, and places the zero at the freezing point.

Wedgwood's pyrometer is only intended to measure very high temperatures. According to its author, its zero corresponds with 1077° of Fahrenheit's, and each degree of Wedgwood is equal to 130 of Farenheit. Guyton Morveau has, however, given good reason for believing that the zero is placed too high, and that the measure of the degree of this scale has been much overrated; and he accordingly fixes the zero of Wedgwood at 517.579 Fahrenheit, and reduces the measure of the degree of Wedgwood to 62.5.

De Lisle's thermometer is used in Russia. The graduation begins at the boiling point, and increases towards the freezing point. The boiling point is marked 0, and the freezing point 150.

Therefore $180° F = 100° C = 80° R = \frac{18}{13} W$, or $= \frac{180}{62.5} W$.

Formulae.

1. To reduce centigrade degrees to those of Fahrenheit, multiply by 9, and divide by 5, and to the quotient add 32, that is, $\frac{C \times 9}{5} + 32 = F$.

2. To reduce Fahrenheit's degrees to centigrade, $\frac{F - 32 \times 5}{9} = C$.

3. To reduce Reaumur's to Fahrenheit's, $\frac{R \times 9}{4} + 32 = F$.

4. To convert Fahrenheit to Reaumur, $\frac{F - 32 \times 4}{9} = R$.

5. To reduce Wedgwood's degrees to those of Fahrenheit, $W \times 130 + 1077 = F$; or, according to Guyton Morveau's estimate, $W \times 62.5 + 517.579 = F$.

6. Inversely, to reduce Fahrenheit to Wedgwood, $\frac{F - 1077}{130} = W$;

or according to Guyton Morveau, $\frac{F - 517.579}{62.5} = W$.

Table of the Effects of Heat.

1. FREEZING POINTS OF LIQUIDS.

Reaum.	Cent.	Fahren.	
		—90	Greatest artificial cold observed
—44	—66	—55	Strongest nitric acid freezes (Cavendish)
—35	—43	—46	Ether and liquid ammonia
—32	—39	—39	Mercury
—30	—37	—36	Sulphuric acid (Thomson)
—23	—30	—22	Acetous acid
—19	—24	—11	2 Alcohol, 1 water
—17	—14	—7	Brandy ; Snow 3 parts, with salt 2
—14	—17	+1	Strongest sulphuric acid (Cavendish)
—7	—9	16	Oil of turpentine (Margueron)
—5	—6	20	Strong wines
—4	—5	23	Fluoric acid
			Oils of bergamot and cinnamon
—3	—4	25	Human blood
—2	—2.5	28	Vinegar
—1	--12.5	30	Milk
0	0	32	Water freezes
+2	+ 2.5	36	Olive oil
6	7	45	Sulphuric acid, specific gravity, 1·78 (Keir)
14	17	64	Oil of aniseeds, 50 (Thomson)

2. MELTING POINTS OF SOLIDS.

Reaum.	Cent.	Fahren.	
4	5	40	Equal parts sulphur and phosphorus.
22	28	82	Adipocire of muscle
29	36	97	Lard (Nicolson)
30	37	99	Phosphorus (Pelletier)
32	40	104	Resin of bile
34	43	109	Myrtle wax (Cadet)
36	45	112	Spermaceti (Bostock)
42	53	127	Tallow (Nicolson) (92 Thomson)
49	61	142	Bees wax
50	63	145	Ambergris (La Grange)
		150	Potassium
55	79	155	Bleached wax (Nicolson)
75	94	200	Sodium perfectly fluid
80	100	210	Bismuth 5 parts, tin 3, lead 2, 210 (Dalton)
	107		Iodine (Gay Lussac)
89	111	234	Sulphur (Hope)
90	116	235	Adipocire of biliary calculi (Fourcroy)
112	140	283	Tin and bismuth, equal parts
120	150	303	Camphor
134	168	334	Tin 3, lead 2 ; or tin 2, bismuth 1
182	227	442	Tin (Crichton) (413 Irvine)
190	238	460	Tin 1, lead 4
197	247	476	Bismuth (Irvine)
214	267	512	Tin (Guyton Morveau)

Reaum.	*Cent.*	*Fahren.*		*Wedg.*
258	325	612	Lead (Crichton (594 Irvine) (540 Newton)	
297	371	700	Zinc	
945	432	809	Antimony	
1678	2100	3807	Brass	21
2024	2530	4587	Copper	27
2082	2602	4717	Silver	28
2313	2780	5237	Gold	32
7475	9850	17977	Cobalt, cast iron	130
9131	11414	20577	Nickel	150
9325	11680	21097	Soft nails	154
9602	12801	21637	Iron	158
9708	12136	21877	Manganese	160
10280	12857	23177	Platina, Tungsten, Molybdena, Uranium, Titanium, &c.	170+

3. SOLIDS AND LIQUIDS VOLATILIZED.

29	36	98	Ether
48	60	140	Liquid ammonia
50	63	145	Camphor (Venturi)
61	77	170	Sulphur (Kirwan)
64	80	176	Alcohol (174 Black)
80	100	212	Water and essential oils
82	104	219	Phosphorus (Pelletier)
83	110	230	Muriate of lime (Dalton)
93	116	242	Nitrous acid
96	120	248	Nitric acid
112	140	283	White oxide of arsenic ?
226	282	540	Arsenic ?
232	290	554	Phosphorus in close vessels
239	299	570	Sulphur
248	310	590	Sulphuric acid (Dalton) (546 Black)
252	315	600	Linseed oil, Sulphur (Davy)
279	350	660	Mercury (Dalton) (644 Secondat) (600 Black)

4. MISCELLANEOUS EFFECTS OF HEAT.

—54	—68	—90	Greatest cold produced by Mr Walker
—36	—44	—50	Natural cold observed at Hudson's Bay
—24	—30	—23	Observed on the surface of the snow at Glasgow, 1780
—20	—25	—14	At Glasgow 1780
—14	—18	0	Equal parts, snow and salt
+5	+6	+43	Phosphorus burns slowly
12	15	59	Vinous fermentation begins
15	18	66	to 135, Animal putrefaction
19	24	75	to 80, Summer heat in Britain
20	25	77	Vinous fermentation rapid, acetous begins
21	26	80	Phosphorus burns in oxygen, (104 Gottling)

Reaum.	*Cent.*	*Fahren.*		*Wedg.*
25	31	88	Acetification ceases, phosphorus ductile	
28	35	96	to 100 Animal temperature	
33	41	107	Feverish heat	
40	50	122	Phosphorus burns vividly (Fourcroy) (148 Thomson)	
44	54	130	Ammonia disengaged from water	
59	74	165	Albumen coagulates (156 Black)	
120	150	303	Sulphur burns slowly	
		600	Boracium burns	
269	335	635	Lowest ignition of iron in the dark	
315	384	750	Iron bright in the dark	
341	427	800	Hydrogen burns, (1000 Thomson)	
342	428	802	Charcoal burns (Thomson)	
380	475	884	Iron red in twilight	
448	560	1050	Iron red hot in a common fire	
462	577	1077	Iron red in daylight	1
564	705	1300	Azotic gas burns	+2
737	986	1807	Enamel colours burned	6
1451	1814	2897	Diamond burns (Mackenzie) (5000 Morveau)	14
2313	2780	5237	Settling heat of plate glass	29
2880	3580	6507	Delft ware fired	40
3750	4680	8480	Working heat of plate glass	57
4450	5610	10177	Flint glass furnace	70
5370	6770	12257	Cream-coloured ware fired	86
5800	7330	13297	Worcester china vitrified	94
6270	7850	14337	Stone ware fired	102
6520	8150	14727	Chelsea china fired	105
6925	8650	15637	Derby china fired	112
7025	8770	15897	Flint glass furnace, greatest heat	114
7100	8880	16007	Bow china vitrified	121
7460	9320	16807	Plate glass greatest heat	124
7650	9600	17327	Smith's forge	125
9131	11414	20577	Hessian crucible fused	150
11106	13900	25127	Greatest heat observed	185
			Extremity of Wedgwood	240

Table of High Degrees of Heat, according to the correction of Wedgwood's scale by Guyton Morveau.

Reaum.	*Cent.*	*Fahr.*	*Wedg.*	
215.9	269.9	517.76	0	Red heat in day light
252.4	315.6	599.6		Linseed oil boils
257.8	322.2	612.		Lead melts
271.4	339.3	642.75	2	Mercury boils
299.2	374.	705.25	3	Zinc melts
382.6	478.2	892.74	6	Enamels melt
410.2	512.9	955.23	7	Antimony melts
438.1	547.6	1017.73	8	Copper 1 and tin 3 melt
465.8	582.3	1080.23	9	Silver 1 and tin 1 melt
521.8	651.8	1205.22	11	Copper and tin, equal parts, melt
632.6	790.7	1455.21	15	Copper 3 and tin 1 melt

Reaum.	*Cent.*	*Fahren.*	*Wedg.*	
799.2	998.9	1836.17	21	Brass melts
827.	1033.7	1892.67	22	Silver melts
965.9	1207.3	2205.15	27	Copper melts
1104.8	1380.9	2517.63	32	Gold melts
2715.8	3394.7	6196.40	90	Iron, sweating heat
2854.7	3568.3	6508.88	95	Iron, welding heat
3549.1	4436.3	8071.28	120	Porcelain of China softens
3688.	4609.9	8383.76	125	Smith's forge
3826.9	4783.5	8696.24	130	Cast iron melts
4243.6	5651.5	9633.68	155	Porcelain melts
4382.4	5825.1	10517.12	160	Manganese melts
4821.3	5998.7	10829.60	165	Heat of Macquer's furnace
4938.0	6172.3	11142.08	170	Furnace with three blasts
5076.9	6345.9	11454.56	175	Soft iron melts
*	*	*	*	Nickel melts
				Platinum melts

TABLES,

Frigorific Mixtures, selected from Mr Walker's Publication, 1808, communicated by the Author.

Frigorific Mixtures, *without Ice.*

Mixtures.		Thermometer sinks.	Degr. of cold produced.
Muriate of ammonia Nitrate of potash Water - -	5 parts 5 16	From + 50° to + 10°	40
Sulphate of soda Diluted nitric acid	3 parts 2	From + 50 to — 3	53
Sulphate of soda Nitrate of ammonia Diluted nitric acid	6 parts 5 4	From + 50 to — 14	64
Phosphate of soda Nitrate of ammonia Diluted nitric acid	9 parts 6 4	From + 50 to — 21	71

N. B. If the materials are mixed at a *warmer* temperature than that expressed in the table, the effect will be proportionally *greater*; thus, if the most powerful of these mixtures be made when the air is + 85°, it will sink the thermometer to + 2°.

Frigorific Mixtures, *with Ice.*

Mixtures.	Thermometer sinks.	Degr. of cold produced.
Snow, or pounded ice, 2 parts Muriate of soda. - 1	*From any Temperature.* to — 5°	*
Snow, or pounded ice, 12 parts Muriate of soda 5 Nitrate of ammonia 5	*From any Temperature.* to — 25	*
Snow - 3 Diluted sulphuric acid 2	From + 32 to — 23	55
Snow - 2 parts Cryst. muriate of lime 3	From + 32 to — 50	82

N. B. The reason for the *omissions* in the last column of this table is, the thermometer sinking in these mixtures to the degree mentioned in the preceding column, *and never lower*, whatever may be the temperature of the materials at mixing.

Combinations of Frigorific Mixtures.

Mixtures.	Thermometer sinks.	Degr. of cold produced.
Snow - - 3 parts Diluted nitric acid 2	From 0 to —46	46
Snow - - 8 parts Diluted sulphuric acid 3 Diluted nitric acid 3	From —10 to —56	46
Snow - - 2 parts Muriate of lime - 3	From —15 to —68	53
Snow - - 8 parts Diluted sulphuric acid 10	From —68 to —91	23

N. B. The materials in the first column are to be cooled, previously to mixing, to the temperature required, by mixtures taken from either of the preceding tables.

TABLES OF SIMPLE AFFINITY.

OXYGEN.
Carbon,
Manganese,
Zinc,
Iron,
Tin,
Antimony,
Hydrogen,
Phosphorus,
Sulphur,
Arsenic,
Nitrogen,
Nickel,
Cobalt,
Copper,
Bismuth,
Caloric?
Mercury,
Silver,
Arsenious acid,
Nitric oxide,
Gold,
Platinum,
Carbonic oxide,
Muriatic acid,
White oxide of manganese,
White oxide of lead.

OXYGEN *.
Titanium,
Manganese,
Zinc,
Iron,
Tin,
Uranium,
Molybdenum,
Tungsten,
Cobalt,
Antimony,
Nickel,
Arsenic,
Chromum,
Bismuth,
Lead,
Copper,
Tellurium,
Platinum,
Mercury,
Silver,
Gold.

CARBON.
Oxygen,
Iron,
Hydrogen.

NITROGEN.
Oxygen,
Sulphur?
Phosphorus,
Hydrogen.

HYDROGEN.
Chlorine,
Oxygen,
Iodine,
Sulphur,
Carbon,
Phosphorus,
Nitrogen.

SULPHUR.
PHOSPHORUS?
Potass,
Soda,
Iron,
Copper,
Tin,
Lead,
Silver,
Bismuth,
Antimony,
Mercury,
Arsenic,
Molybdenum.

POTASS, SODA, AND AMMONIA.
Acids. Sulphuric,
Nitric,
Muriatic,
Phosphoric,
Fluoric,
Oxalic,
Tartaric,
Arsenic,
Succinic,
Citric,
Lactic,
Benzoic,
Sulphurous,
Acetic,
Mucic,

Acids. Boracic,
Nitrous,
Carbonic,
Prussic,
Oil,
Water,
Sulphur.

BARYTA.
Acids. Sulphuric,
Oxalic,
Succinic,
Fluoric,
Phosphoric,
Mucic,
Nitric,
Muriatic,
Suberic,
Citric.
Tartaric,
Arsenic,
Lactic,
Benzoic,
Acetic,
Boracic,
Sulphurous,
Nitrous,
Carbonic,
Prussic,
Sulphur,
Phosphorus,
Water,
Fixed oil.

STRONTIA.
Acids. Sulphuric,
Phosphoric,
Oxalic,
Tartaric,
Fluoric,
Nitric,
Muriatic,
Succinic,
Acetic,
Arsenic,
Boracic,
Carbonic.
Water.

LIME.
Acids. Oxalic,
Sulphuric,

Acids. Tartaric,
Succinic,
Phosphoric,
Mucic,
Nitric,
Muriatic,
Suberic,
Fluoric,
Arsenic,
Lactic,
Citric,
Malic,
Benzoic,
Acetic,
Boracic,
Sulphurous,
Nitrous,
Carbonic,
Prussic,
Sulphur,
Phosphorus,
Water,
Fixed oil.

MAGNESIA.
Acids. Oxalic,
Phosphoric,
Sulphuric,
Fluoric,
Arsenic,
Mucic,
Succinic,
Nitric,
Muriatic,
Tartaric,
Citric,
Malic?
Lactic,
Benzoic,
Acetic,
Boracic,
Sulphurous,
Nitrous,
Carbonic,
Prussic,
Sulphur.

ALUMINA.
Acids. Sulphuric,
Nitric,
Muriatic,
Oxalic,

* Vauquelin's table of the affinity of the metals for oxygen, according to the difficulty with which their oxides are decomposed by heat.

Tables of Simple Affinity,—continued.

Acids. Arsenic,
Fluoric,
Tartaric,
Succinic,
Mucic,
Citric,
Phosphoric,
Lactic,
Benzoic,
Acetic,
Boracic,
Sulphurous,
Nitrous,
Carbonic,
Prussic.

SILICA.
Acid. Fluoric,
Potass.

OXIDE OF PLATINUM.
OXIDE OF GOLD*.
Acids. Gallic,
Muriatic,
Nitric,
Sulphuric,
Arsenic,
Fluoric,
Tartaric,
Phosphoric,
Oxalic,
Citric,
Acetic,
Succinic,
Prussic,
Carbonic,
Ammonia.

OXIDE OF SILVER.
Acids. Gallic,
Muriatic,
Oxalic,
Sulphuric,
Mucic,
Phosphoric,
Sulphurous,
Nitric,
Arsenic,
Fluoric,
Tartaric,
Citric,
Lactic,
Succinic,
Acetic,
Prussic,

Acids. Carbonic,
Ammonia.

OXIDE OF MERCURY.
Acids. Gallic,
Muriatic,
Oxalic,
Succinic,
Arsenic,
Phosphoric,
Sulphuric,
Mucic,
Tartaric,
Citric,
Malic,
Sulphurous,
Nitric,
Fluoric,
Acetic,
Benzoic,
Boracic,
Prussic,
Carbonic.

OXIDE OF LEAD.
Acids. Gallic,
Sulphuric,
Mucic,
Oxalic,
Arsenic,
Tartaric,
Phosphoric,
Muriatic,
Sulphurous,
Suberic,
Nitric,
Fluoric,
Citric,
Malic,
Succinic,
Lactic,
Acetic,
Benzoic,
Boracic,
Prussic,
Carbonic,
Fixed oils,
Ammonia.

OXIDE OF COPPER.
Acids. Gallic,
Oxalic,
Tartaric,
Muriatic,
Sulphuric,

Acids. Mucic,
Nitric,
Arsenic,
Phosphoric,
Succinic,
Fluoric,
Citric,
Lactic,
Acetic,
Boracic,
Prussic,
Carbonic,
Fixed alkalies,
Ammonia,
Fixed oils.

OXIDE OF ARSENIC.
Acids. Gallic,
Muriatic,
Oxalic,
Sulphuric,
Nitric,
Tartaric,
Phosphoric,
Fluoric,
Succinic,
Citric,
Acetic,
Prussic,
Fixed alkalies,
Ammonia,
Fixed oils,
Water.

OXIDE OF IRON.
Acids Gallic,
Oxalic,
Tartaric,
Camphoric,
Sulphuric,
Mucic,
Muriatic,
Nitric,
Phosphoric,
Arsenic,
Fluoric,
Succinic,
Citric,
Lactic,
Acetic,
Boracic,
Prussic,
Carbonic.

OXIDE OF TIN †.
Acids. Gallic,
Muriatic,
Sulphuric,
Oxalic,
Tartaric,
Arsenic,
Phosphoric,
Nitric,
Succinic,
Fluoric,
Mucic,
Citric,
Lactic,
Acetic,
Boracic,
Prussic,
Ammonia.

OXIDE OF ZINC.
Acids. Gallic,
Oxalic,
Sulphuric,
Muriatic,
Mucic,
Nitric,
Tartaric,
Phosphoric,
Citric,
Succinic,
Fluoric,
Arsenic,
Lactic,
Acetic,
Boracic,
Prussic,
Carbonic,
Fixed alkalies,
Ammonia.

OXIDE OF ANTIMONY
Acids Gallic,
Muriatic,
Benzoic,
Oxalic,
Sulphuric,
Nitric,
Tartaric,
Mucic,
Phosphoric,
Citric,
Succinic,
Fluoric,
Arsenic,
Lactic,

* Omitting the oxalic, citric, succinic, and carbonic, and adding sulphuretted hydrogen after ammonia.

† Bergman places the tartaric before the muriatic.

Tables of Simple Affinity,—continued.

Acids. Acetic,
Boracic,
Prussic,
Fixed alkalies,
Ammonia.

SULPHURIC ACID.
PRUSSIC *.

Baryta,
Strontia,
Potass,
Soda,
Lime,
Magnesia,
Ammonia,
Glucina,
Gadolina,
Alumina,
Zirconia,
Metallic oxides.

SULPHUROUS ACID.
SUCCINIC †.

Baryta,
Lime,
Potass,
Soda,
Strontia,
Magnesia,
Ammonia,
Glucina,
Alumina,
Zirconia,
Metallic oxides.

PHOSPHORIC ACID.
CARBONIC ‡.

Baryta,
Strontia,
Lime,
Potass,
Soda,
Ammonia,
Magnesia,
Glucina,
Alumina,
Zirconia,
Metallic oxides,
Silica.

PHOSPHOROUS ACID §.

Lime,
Baryta,
Strontia,
Potass,
Soda,
Ammonia,
Glucina,
Alumina,
Zirconia,
Metallic oxides.

NITRIC ACID.
MURIATIC ‖.

Baryta,
Potass,
Soda,
Strontia,
Lime,
Magnesia,
Ammonia,
Glucina,
Alumina,
Zirconia,
Metallic oxides.

FLUORIC ACID.
BORACIC ¶.
ARSENIC **.
TUNGSTIC.

Lime,
Baryta,
Strontia,
Magnesia,
Potass,
Soda,
Ammonia,
Glucina,
Alumina,
Zirconia,
Silica.

ACETIC ACID.
LACTIC. SUBERIC.

Baryta,
Potass,
Soda,
Strontia,
Lime,
Ammonia,
Magnesia,
Metallic oxides,
Glucina,
Alumina,
Zirconia.

OXALIC ACID.
TARTARIC.
CITRIC ††.

Lime,
Baryta,
Strontia,
Magnesia,
Potass,
Soda,
Ammonia,
Alumina,
Metallic oxides,
Water,
Alcohol.

BENZOIC ACID.

White oxide of arsenic,
Potass,
Soda,
Ammonia,
Baryta,
Lime,
Magnesia,
Alumina.

CAMPHORIC ACID.

Lime,
Potass,
Soda,
Baryta,
Ammonia,
Alumina.
Magnesia.

FIXED OILS.

Lime,
Baryta,
Potass,
Soda,
Magnesia,
Oxide of mercury,
Other metallic oxides,
Alumina.

ALCOHOL.

Water,
Ether,
Volatile oil,
Alkaline sulphurets.

SULPHURETTED HYDROGEN.

Baryta,
Potass,
Soda,
Lime,
Ammonia,
Magnesia,
Zirconia.

* With the omission of all after ammonia.

† Ammonia should come before magnesia; and strontia, glucina, and zirconia should be omitted.

‡ Magnesia should stand above ammonia, and alumina and silica should be omitted.

§ Ammonia should stand above magnesia.

‖ Silica should be omitted, and, instead of it, water and alcohol be inserted.

¶ Except silica.

** With the omission of strontia, metallic oxides, glucina, and zirconia.

†† Zirconia after alumina.

Relative Attractions at the lowest temperature of Visible Ignition, by Sir H. Davy.

OXYGEN.	CHLORINE.	SULPHUR.	PHOSPHORUS.
Potassium	Potassium	Potassium	Potassium
Sodium	Sodium	*Sodium*	*Sodium*
Barium	Zinc	Iron	Platinum
Boron	Iron	Copper	Zinc
Carbon	Lead	Palladium	Antimony
Manganesum	Silver	Lead	Sulphur.
Zinc	Antimony	*Silver*	
Iron	Bismuth		
Tin	Phosphorus		
Phosphorus	Copper		
Antimony	Sulphur		
Bismuth	Mercury		
Lead	Platinum		
Sulphur	Gold		
Arsenic			
Tungstenum			
Azote			
Palladium			
Mercury			
Silver			
Gold			
Platinum			

Cases of Mutual Decomposition.

1. FROM SIMPLE AFFINITY.

Sulphate of potass	- with	Muriate of baryta
——— soda	- —	Nitrate of potass
——— ammonia	- —	Muriate of potass
——— magnesia	- —	Carbonate of potass
Supersulphate of alumina	—	Muriate of lime
Nitrate of potass	- —	——— baryta
——— ammonia	- —	Phosphate of soda
Muriate of baryta	- —	All the sulphates and nitrates
——— soda	- —	Carbonate of potass
——— lime	- —	Sub-borate of soda
——— ammonia	- —	Carbonate of potass
Phosphate of soda	- —	Muriate of ammonia
Sub-borate of soda	- —	Carbonate of potass
Nitrate of silver	- —	Muriate of soda
Acetate of lead	- —	Citrate of potass
Sulphate of mercury	- —	Muriate of soda
Soap of potass	- —	——— soda
——— soda	- —	Sulphate of lime

2. FROM COMPOUND AFFINITY.

Sulphate of baryta	-	with	Carbonate of potass
——— baryta	-	—	——— soda
——— potass	-	—	Muriate of lime
——— soda	-	—	Ditto
Muriate of baryta	-	—	Phosphate of soda
Ditto	- -	—	Sub-borate of soda
Ditto	- -	—	Carbonate of potass
Ditto	- -	—	——— soda
Ditto	- -	—	——— ammonia
Muriate of lime	-	—	——— ammonia
Phosphate of soda	-	—	——— lime
Acetate of lead	-	—	Sulphate of zinc
Ditto	- -	—	Nitrate of mercury.

Cases of Disposing Affinity.

The formation of water by the action of the sulphuric acid on the compound oxides.

The oxidation of metals by water, in consequence of the presence of an acid.

Table of Incompatible Salts *.

SALTS	INCOMPATIBLE WITH
1. Fixed alkaline sulphates	Nitrates of lime and magnesia Muriates of lime and magnesia
2. Sulphate of lime	Alkalies Carbonate of magnesia Muriate of barytes
3. Alum	Alkalies Muriate of barytes Nitrate, muriate, carbonate of lime Carbonate of magnesia
4. Sulphate of magnesia	Alkalies Muriate of barytes Nitrate and muriate of lime
5. Sulphate of iron	Alkalies Muriate of barytes Earthy carbonates
6. Muriate of barytes	Sulphates Alkaline carbonates Earthy carbonates

* That is, salts which cannot exist together in solution, without mutual decomposition.

SALTS	INCOMPATIBLE WITH
7. Muriate of lime	Sulphates, except of lime Alkaline carbonates Carbonate of magnesia
8. Muriate of magnesia	Alkaline carbonates Alkaline sulphates
9. Nitrate of lime	Alkaline carbonates Carbonates of magnesia and alumina Sulphates, except of lime

Table of the Specific Heats of equal Weights of some Bodies compared with Water.

	Crawford.	*Dalton's hypothesis.*	*De La Roche and Berard.*
Water - -	1.000	1.000	1.000
Atmospheric air - -	1.790	1.759	0.2669
Hydrogen gas - -	21.400	9.382	3.2936
Carbonic acid gas -	1.045	0.491	0.2210
Oxygen gas - -	4.749	1.333	0.2361
Azotic gas - -	0.793	1.866	0.2754
Nitrous oxide - - -		0.549	0.2369
Nitrous gas - - -		0.777	
Olefiant gas - - -		1.555	0.4207
Carbonic oxide gas - -		0.777	0.2884
Steam - - - -		1.166	0.8470
Ammoniacal gas - -		1.555	
Carburetted hydrogen - -		1.333	
Nitric acid gas - -		0.491	
Sulphuretted hydrogen - -		0.583	
Muriatic acid gas - - -		0.424	
Ether vapour - - -		0.848	
Alcohol vapour - - -		0.586	

Colour of the Precipitates thrown down from Metallic Solutions by various Re-agents. Henry.

Metal.	*Prussiated Alkalies.*	*Tincture of Galls.*	*Water impregnated with Sulphuretted Hydrogen.*	*Hydrosulphurets.*
Gold	Yellowish-white	Solution turned green, precipitate brown of reduced gold	Yellow	Yellow
Platina	No precipitate but an orange one by prussiate of mercury	Dark-green, becoming paler	Precipitated in a metallic state	
Silver	White	Yellowish brown	Black	Black
Mercury	White changing to yellow	Orange yellow	Black	Brownish black
Palladium	Olive * deep orange †		Dark-brown	Dark-brown
Rhodium	No precipitate			No precipitate
Iridium	None; colour discharged	None; colour discharged		
Osmium		Purple changing to vivid blue		
Copper	Bright reddish-brown	Brownish	Black	Black
Iron, 1 green salts	White changing to blue	No precipitate	Not precipitated	Black
Iron, 2 red salts	Deep blue	Black		
Nickel	Green	Greyish-white	Not precipitated	Black
Tin	White	No precipitate	Brown	Black
Lead	White	White	Black	Black
Zinc	White	No precipitate	Yellow	White
Bismuth	White	Orange	Black	Black
Antimony	White	A white oxide from dilution	Orange	Orange
Tellurium	No precipitate	Yellow		Blackish
Arsenic	White	Little change	Yellow	Yellow
Cobalt	Brownish-yellow	Yellowish white	Not precipitated	Black
Manganese	Yellowish white	No precipitate	Not precipitated	White
Chrome	Green	Brown		Green
Molybdena	Brown	Deep-brown	Brown	
Uranium	Brownish-red	Chocolate		Brownish-yellow
Tungsten				
Titanium	Grass-green with some brown	Reddish-brown	Not precipitated	Grass-green
Columbium	Olive	Orange		Chocolate
Tantalium				
Cerium		Yellowish		Brown, becoming deep-green

* Chenevix † Wollaston

Table of the Solubility of Saline and other Substances, in 100 parts of Water, at the Temperature of 60° *and* 212°

	60°	212°
ACIDS.		
Sulphuric	unlimited	unlimited
Nitric	do	do
Acetic	do	do
Prussic	do	do
Phosphoric, Tartaric, Malic, Lactic, Laccic — very soluble		
Arsenic	150	
Arsenious acid	1.25	6.
Citric	133	200
Oxalic	50	100
Gallic	8.3	66
Boracic	2.8	8
Mucic	0.84	1.25
Succinic	4 / 1.04	50
Suberic	0.69	50
Camphoric	1.04	8.3
Benzoic	0.208	4.17
Molybdic		0.1
Chromic, unknown		
Tungstic, insoluble		
SALIFIABLE BASES.		
Potass	50	more
Soda, somewhat less than potass		
Baryta	5	50
—— crystallized	57	unlimited
Strontia	0.6	
—— crystallized	1.9	50
Lime	0.2	
SALTS.		
Sulphate of potass	6.25	20
Supersulphate of potass	50	100 +
Sulphate of soda	37.4	125
—— of ammonia	50	100
—— magnesia	100	133
—— alumina, very soluble, proportion unknown		
Supersulphate of alumina and potass / —— ammonia	alum 5	133
Nitrate of baryta	8	25
—— potass	14.25	100 +
—— soda	33	100

	Temperatures 60°	212°
Nitrate of strontia - -	100	200
——— lime - - -	400	any quantity
——— ammonia - -	50	200
——— magnesia - -	100	100 +
Muriate of baryta - - -	20	
——— potass - - -	33	
——— soda - - -	35.42	36.16
——— strontia - - -	150	any quantity
——— lime - - -	200	
——— ammonia - - -	33	100
——— magnesia - -	100	
Oxymuriate of potass - -	6	40
Phosphate of potass, very soluble		
——— soda - - -	25	50
——— ammonia - -	25	25+
——— magnesia - -	6.6	
Sub-borate of soda - - -	8.4	50.
Carbonate of potass - - -	25	83.3
——— soda - - -	50	100+
——— magnesia - -	2	
——— ammonia - -	50+	100
Acetate of potass - -	100	
——— soda - -	35	
——— ammonia, very soluble		
——— magnesia, ditto		
——— strontia - - -		40.8
Supertartrate of potass - -	1.67	3.3
Tartrate of potass - - -	25	
——— and soda - -	25	
Oxalate of potass - -	33	
——— ammonia - -	4.5	
Super-oxalate of potass - - -		10
Citrate of potass, very soluble		
Prussiate of potass and iron		
Nitrate of silver, very soluble		
Muriate of mercury (corrosive sublimate)	5	50
Sulphate of copper - -	25	50
Acetate of copper, very soluble		
Sulphate of iron - - -	50	133
Muriate of iron, very soluble		
Tartrate of iron and potass		
Acetate of mercury		
Sulphate of zinc - - -	44	44+
Acetate of zinc, very soluble		
——— of lead (Ed. Pharm.) Bostock	27	
——— as it exists in Goulard's extract, more sol.		
Tartrate of antimony and potass, Duncan	6.6	83
Alkaline soaps, very soluble		
Sugar - - - -	100	any quantity

	Temperatures 60	212°
Gum, very soluble		
Starch	0	very soluble
Jelly	sparingly	abundantly
Gelatine	soluble	more so
Urea, very soluble		
Cinchonin		

Salts not soluble in 100 *times their Weight of Water.*

Sulphates of baryta, strontia, and lime, and subsulphate of mercury.
Phosphates of baryta, strontia, lime, magnesia, and mercury.
Fluate of lime.
Carbonates of baryta, strontia, and lime.
Muriates of lead and silver, and submuriate of mercury (Calomel).
Subacetate of copper.

Solubility of Saline and other Substances in 100 *Parts of Alcohol, at the temperature of* 176°

All the acids, except the sulphuric, nitric, and oxymuriatic, which decompose it, and the phosphoric and metallic acids.
Potass, soda, and ammonia, very soluble.
Red sulphate of iron.

Muriate of iron	100
——— lime	100
Nitrate of ammonia	89.2
Muriate of mercury	88.3
Camphor	75.
Nitrate of silver	41.7
Refined sugar	24.6
Muriate of ammonia	7.1
Arseniate of potass	3.75
Nitrate of potass	2.9
Arseniate of soda	1.7

Muriate of soda (Mr Chenevix). Alkaline soaps. Magnesian do. Extractive. Tannin. Volatile oils. Adipocire. Resins. Urea. Cinchonin.

Substances insoluble in Alcohol.

Earths.
Phosphoric and metallic acids.
Almost all the sulphates and carbonates.
The nitrates of lead and mercury.
The muriates of lead, silver and soda.
The sub-borate of soda.
The tartrate of soda and potass, and the supertartrate of potass.
Fixed oils, wax, and starch.
Gum, caoutchouc, suber, lignin, gelatin, albumen, and fibrin.

Table of the Solubility of Fats in 100 parts of alcohol and sulphuric ether. By P. F. G. Boullay.

	Alcohol, sp. gr. 0.828. 48 Fahr.	74 boiling.	Ether. 48 Fahr.
Hogs lard	1.04	1.74	25
Mutton suet	0.69	1.39	10
Spermaceti	1.39	8.33	20

Table of the Solubility of Fixed Fluid Oils in 100 parts of Alcohol and Acetic Ether at 55° Fahr. By L. A. Planche.

	Alcohol sp. gr. 0.28.	Acetic Ether.
Castor oil	every proportion.	800 and upwards.
Poppy seed oil, a year old	0.8	-
Linseed oil	0.6	50.
Walnut oil	0.6	50.
Poppy seed oil, new	0.4	33.
Beech mast oil	0.4	40.
Olive oil	0.3	20.
Oil of sweet almonds	0.3	25.
Oil of bitter almonds	0.3	-
Nut oil	0.3	14.

Proportion of Oil and Suet in various Fats according to Braconnot.

	Oil.	*Suet.*
Melted butter, summer	60	40
———— winter	35	65
Hogs lard	62	38
Beef marrow	24	76
Mutton marrow	74	26
Goose grease	72	32
Turkey grease	74	26
Olive oil	72	28
Oil of almonds	76	24
——— colsa	54	46

Table of the Absorption of Gases by 100 *Parts of Water at* 60° *F.*

	Volume.	
Nitric acid	361000.	
Muriatic acid	51500.	Thomson
Ammonia	47500.	Davy
———	78000.	Thomson
Sulphurous acid	12109.	Fourcroy
———	3300.	Thomson
———	1440.	Priestley
Carbonic acid	108.	Henry
Sulphuretted hydrogen	108.	Henry
Nitrous oxide	86.	Henry
Olefiant gas	12.5	Dalton
Nitric oxide	5.	Henry
Oxygen	3.7	Henry
Phosphuretted hydrogen	2.14	Henry
Carbonic oxide	2.01	Henry
Hydrogen	1.61	Henry
Nitrogen	1.53	Henry
Carburetted hydrogen	1.40	Henry

Table of Efflorescent Salts (Cadet de Vaux).

288 grains of	in days	lost grains
Sulphate of soda	61	203
Phosphate of soda	39	91
Carbonate of soda	51	86

Table of Deliquescent Salts (Cadet de Vaux).

288 grains of	in days	absorbed
Acetate of potass	146	700
Muriate of lime	124	684
——— manganese	105	629
Nitrate of manganese	89	527
——— zinc	124	495
——— lime	147	448
Muriate of magnesia	139	441
Nitrate of copper	128	397
Muriate of antimony	124	388
——— alumina	149	342
Nitrate of alumina	147	300
Muriate of zinc	76	294
Nitrate of soda	137	257
——— magnesia	73	207
Acetate of alumina	104	202
Supersulphate of alumina	121	202
Muriate of bismuth	114	174
Superphosphate of lime	93	165
Muriate of copper	119	148

Table of the Weight of the Ultimate Particles or Atoms of Bodies, and of the constitution of compound bodies, according to M. Dalton's theory of definite proportions; drawn up by Dr T. Thomson.

	Weight of an atom.
Oxygen	1·000
Hydrogen	0·132
Carbon	0·751
Azotê	1·803
Phosphorus	2·618
Sulphur	2·000
Boron	0·733
Chlorine	4·498
Iodine	11·160
Potassium	5·000
Sodium	5·882
Barytium	8·731
Strontium	5·900
Calcium	2·620
Magnesium	1·577
Ammonium	1·149
Gold	24·968
Platinum	12·161
Silver	13·714
Mercury	25·000
Palladium	14·204
Copper	8·000
Iron	7·143
Nickel	7·305
Tin	14·705
Lead	12·987
Zinc	4·095
Bismuth	8·994
Antimony	11·249
Tellurium	4·027
Arsenic	6·000
Cobalt	7·326
Manganese	7·115
Uranium	12·000
Molybdenum	6·013
Tungsten	12·121
Cerium	11·487
Chromium	4·720
Titanium	18·010
Rhodium	14·903

	Number of atoms.		Weight of an integrant particle.
Water, composed of	1 *o* +	1 *h*	1·132
Carbonic oxide	1 *o*	1 *c*	1·751
Carbonic acid	2 *o*	1 *c*	2·751
Nitrous oxide	1 *o*	1 *a*	2·803
Nitrous gas	2 *o*	1 *a*	3·803
Nitrous acid	3 *o*	1 *a*	4·803
Nitric acid	5 *o*	1 *a*	6.803
Phosphorous acid	2 *o*	1 *p*	4·618
Phosphoric acid	3 *o*	1 *p*	5·618
Sulphurous acid	2 *o*	1 *s*	4·000
Sulphuric acid	3 *o*	1 *s*	5·000
Oxalic acid	3 *o*	2 *c* + 1 *h*	4·634

	Number of atoms.		Weight of an integrant particle.
Potash	1 *p*	+ 1 *o*	6·000
Peroxide of potash	1 *p*	3 *o*	8·000
Soda	1 *s*	2 *o*	7·882
Peroxide of soda	1 *s*	3 *o*	8·882
Barytes	1 *b*	1 *o*	9·731
Strontia	1 *st*	1 *o*	6.900
Lime	1 *l*	1 *o*	3.620
Magnesia	1 *m*	1 *o*	2·577
Alumina			2·136
Glucina			3·600
Yttria			8·400
Zirconia			5·656
Silica			4·066
Protoxide of gold	1 *g*	+ 1 *o*	25·968
Peroxide of gold	1 *g*	3 *o*	27·968
Protoxide of platinum	1 *p*	1 *o*	13·161
Peroxide of platinum	1 *p*	2 *o*	14·161
Oxide of silver	1 *s*	1 *o*	14·714
Protoxide of mercury	1 *m*	1 *o*	26·000
Peroxide of mercury	1 *m*	2 *o*	27·000
Protoxide of palladium	1 *p*	1 *o*	15·204
Peroxide of palladium	1 *p*	2 *o*	16·204
Protoxide of copper	1 *c*	1 *o*	9·000
Peroxide of copper	1 *c*	2 *o*	10·000
Deutoxide of iron	1 *i*	2 *o*	9·143
Peroxide of iron	1 *i*	3 *o*	10·143
Deutoxide of nickel	1 *n*	2 *o*	9·305
Peroxide of nickel	1 *n*	3 *o*	10·305
Deutoxide of tin	1 *t*	2 *o*	16·705
Tritoxide of tin	1 *t*	3 *o*	17·705
Peroxide of tin	1 *t*	4 *o*	18·705
Protoxide of lead	1 *l*	1 *o*	13·987
Red oxide of lead	2 *l*	3 *o*	28·974
Deutoxide of lead	1 *l*	2 *o*	14·987
Oxide of zinc	1 *z*	1 *o*	5·095
Oxide of bismuth	1 *b*	1 *o*	9·994
Tritoxide of antimony	1 *a*	3 *o*	14·249
White oxide of antimony	1 *a*	4 *o*	15·249
Antimonic acid	1 *a*	6 *o*?	17·249
Oxide of tellurium	1 *t*	1 *o*	5·027
Deutoxide of arsenic	1 *a*	2 *o*	8·000
Arsenic acid	1 *a*	3 *o*	9·000
Deutoxide of cobalt	1 *c*	2 *o*	9·326
Peroxide of cobalt	1 *c*	3 *o*	10·326
Protoxide of manganese	1 *m*	1 *o*	8·115
Deutoxide of manganese	1 *m*	2 *o*	9·115
Tritoxide of manganese	1 *m*	3 *o*	10.115
Peroxide of manganese	1 *m*	4 *o*	11·115
Protoxide of uranium	1 *u*	1 *o*	13·000
Peroxide of uranium	1 *u*	3 *o*	15·000
Deutoxide of molybdenum	1 *m*	2 *o*	8·013
Peroxide of molybdenum	1 *m*	3 *o*	9·013
Deutoxide of tungsten	1 *t*	2 *o*	14·121
Peroxide of tungsten	1 *t*	3 *o*	15·121
Deutoxide of cerium	1 *c*	2 *o*	13·487
Peroxide of cerium	1 *c*	3 *o*	14·487
Green oxide of chromium	1 *c*	2 *o*	6·720

	Number of atoms.		Weight of an integrant particle.
Brown oxide of chromium	1 *c* +	3 *o*	7·720
Chromic acid	1 *c*	4 *o*	8·720
Protoxide of titanium	1 *t*	1 *o*	19·010
Peroxide of titanium	1 *t*	2 *o*	20·010
Protoxide of rhodium	1 *rh*	1 *o*	15·903
Deutoxide of rhodium	1 *rh*	2 *o*	16·903
Peroxide of rhodium	1 *rh*	3 *o*	17·903
Olefiant gas	1 *h*	1 *c*	0·883
Carburetted hydrogen	2 *h*	1 *c*	1·015
Ammonia	1 *h*	1 *a*	1·935
Hydrophosphorous gas	4 *h*	1 *p*	3·146
Phosphuretted hydrogen	3 *h*	1 *p*	3·014 ?
Sulphuretted hydrogen	1 *h*	1 *s*	2·132
Chloride of oxygen	1 *ch*	1 *o*	5·498
Muriatic acid	1 *ch*	2 *h*	4·762
Chloride of sulphur	1 *ch*	1 *o*	6·498
Prochloride of phosphorus	1 *ch*	1 *p*	6·241
Perchloride of phosphorus	2 *ch*	1 *p*	10·996
Chloride of azote	4 *ch*	1 *a*	19·705
Chloride of potassium	1 *ch*	1 *p*	9·498
Chloride of sodium	2 *ch*	1 *s*	14·878
Chloride of ammonium	1 *ch*	1 *am*	5·647
Chloride of barytium	1 *ch*	1 *b*	13·229
Chloride of strontium	1 *ch*	1 *str*	10·398
Chloride of calcium	1 *ch*	1 *c*	7·118
Chloride of magnesium	1 *ch*	1 *m*	6·075
Chloride of silver	1 *ch*	1 *s*	18·212
Prochloride of mercury	1 *ch*	1 *m*	29·498
Perchloride of mercury	2 *ch*	1 *m*	34.996
Prochloride of copper	1 *ch*	1 *c*	12·498
Perchloride of copper	2 *ch*	1 *c*	16·996
Prochloride of iron	2 *ch*	1 *i*	16·139
Perchloride of iron	4 *ch*	1 *i*	25·135
Prochloride of tin	2 *ch*	1 *t*	23·701
Perchloride of tin	4 *ch*	1 *t*	32·697
Chloride of lead	2 *ch*	1 *l*	21·983
Chloride of zinc	1 *ch*	1 *z*	8·593
Chloride of bismuth	1 *ch*	1 *b*	13·493
Chloride of antimony	2 *ch*	1 *a*	20·245
Chloride of arsenic	2 *ch*	1 *a*	14 996
Chloride of manganese	2 *ch*	1 *m*	16·111
Chloride of carbonic oxide	1 *ch*	1 *c. ox*	6·249
Sulphuret of carbon	1 *c*	2 *s*	2·751
Phosphuret of sulphur	1 *p*	1 *s*	4·618
Sulphuret of gold	1 *g*	3 *s*	30·968
Sulphuret of platinum	1 *p*	2 *s*	16·161
Sulphuret of silver	1 *s*	1 *s*	15·714
Prosulphuret of mercury,	1 *m*	1 *s*	27·000
Persulphuret of mercury or cinnabar	1 *m*	2 *s*	29·000
Sulphuret of copper	1 *c*	1 *s*	10·000
Magnetic pyrites	1 *i*	2 *s*	11·143
Cubic pyrites	1 *i*	4 *s*	15 143
Sulphuret of nickel	1 *n*	1 *s*	9·305
Prosulphuret of tin	1 *t*	1 *s*	16·705
Persulphuret of tin or mosaic gold	1 *t*	2 *s*	18·705

	Number of atoms.		Weight of an integrant particle.
Sulphuret of lead	1 *l* +	1 *s*	14·987
Persulphuret of lead	1 *l*	2 *s*	16·987
Sulphuret of zinc	1 *z*	1 *s*	6·095
Sulphuret of bismuth	1 *b*	1 *s*	10·994
Sulphuret of antimony	1 *a*	2 *s*	15.249
Sulphuret of tellurium	1 *t*	2 *s*	8·027
Sulphuret of arsenic or realgar	1 *a*	1 *s*	8·000
Orpiment	1 *a*	2 *s*	10 000
Sulphuret of cobalt	1 *c*	1 *s*?	9·326?
Sulphuret of manganese	1 *m*	1 *s*	9·115
Sulphuret of molybdenum	1 *m*	2 *s*	10·013
Sulphuret of potassium	1 *p*	1 *s*	7·000
Sulphuret of potash	1 *p*	1 *s*	8·000
Sulphuret of sodium	1 *s*	2 *s*	9·882
Carburet of phosphorus	1 *c*	1 *p*	3·369?
Hydrate of potash	1 *p*	1 *w*	7·132
Hydrate of soda	1 *s*	1 *w*	9·014
Hydrate of lime	1 *l*	1 *w*	4·752
Hydrate of barytes	1 *b*	1 *w*	10·863
Hydrate of strontian	1 *st*	1 *w*	8·032
Hydrate of magnesia	2 *m*	1 *w*	6·286
Hydrate of alumina	1 *a*	1 *w*	3·268
Hydrate of glucina	1 *g*	1 *w*	4·732
Hydrate of yttria	1 *y*	3 *w*	11·796
Hydrate of zirconia	1 *z*	1 *w*	6·788
Hydrate of silica	1 *si*	1 *w*	5·198
Hydrosulphuric acid, or acid of 1·85	1 *s*	1 *w*	6·132
2d hydrate of sulphuric acid, or acid of 1·780	1 *s*	2 *w*	7·264
3d hydrate of sulphuric acid, or acid of 1·65	1 *s*	3 *w*	8·396
Hydronitric acid, or acid of 1·620	2 *n*	1 *w*	14·738
2d hydrate of nitric acid, or acid of 1·54	1 *n*	1 *w*	7·935
3d hydrate of nitric acid, or acid of 1·42	1 *n*	2 *w*	9·067
4th hydrate of nitric acid, or acid of 1·350	1 *n*	3 *w*	10·199
Hydrophosphorous acid	2 *p*	1 *w*	5·750
Hydrate of boracic acid	1 *b*	3 *w*	9·106
Hydrate of peroxide of copper	1 *c*	1 *w*	11·132
Hydrate of black oxide of iron	1 *i*	1 *w*	10·275
Hydrate of red oxide of iron	1 *i*	1 *w*	11·275
Hydrate of deutoxide of tin	1 *t*	1 *w*	17·837
Hydrate of peroxide of tin	1 *t*	1 *w*	18·969
Hydrate of deutoxide of nickel	1 *n*	2 *w*	11·569
Hydrate of deutoxide of cobalt	1 *c*	1 *w*	10·458
Hydrate of protoxide of manganese	1 *m*	1 *w*	9·245
Hydrate of oxide of arsenic	1 *a*	1 *w*	9·132
Sulphate of potash	1 *s*	1 *p*	11·000
Supersulphate of potash	2 *s*	1 *p*	16·000
Sulphate of soda	1 *s*	2 *so*	20·764
Sulphate of ammonia	1 *s*	2 *a*	8·870
Sulphate of magnesia	1 *s*	1 *m*	7·577
Sulphate of lime	1 *s*	1 *l*	8·620

	Number of atoms.		Weight of an integrant particle.
Sulphate of barytes	1 *s*	1 *b*	14·731
Sulphate of strontian	1 *s*	1 *str*	11·900
Sulphate of alumina	1 *s*	1 *a*	7·136
Subsulphate of alumina	1 *s*	2 *a*	9·272
Sulphate of yttria	1 *s*	2 *y*	13·400
Sulphate of glucina	1 *s*	1 *g*	8·600
Sulphate of zirconia	1 *s*	1 *z*	10·656
Alum	6 *s*	5 *al* + 1 *p*	46·680
Sulphate of potash and ammonia	2 *s*	1 *p* 2 *a*	19·870
Sulphate of potash and magnesia	3 *s*	1 *p* 2 *m*	26·154
Sulphate of soda and ammonia	5 *s*	2 *so* 8 *a*	56·244
Sulphate of soda and magnesia	4 *s*	2 *so* 3 *m*	43·495
Sulph. of magnesia and ammonia	3 *s*	2 *m* 2 *a*	24·024
Supersulphate of copper	2 *s*	1 *c*	20·000
Sulphate of copper	1 *s*	1 *c*	15·000
Subsulphate of copper	1 *s*	2 *c*	25·000
Supersulphate of iron	2 *s*	1 *i*	19·143
Sulphate of iron	1 *s*	1 *i*	14·143
Subsulphate of iron	2 *s*	3 *i*	37·429
Persupersulphate of iron	3 *s*	1 *i*	25·143
Sulphate of lead	1 *s*	1 *l*	18·987
Sulphate of zinc	1 *s*	1 *z*	10·095
Sulphate of mercury	1 *s*	1 *m*	31·000
Persulphate of mercury	1 *s*	1 *m*	32·000
Sulphate of silver	1 *s*	1 *si*	19·714
Sulphate of bismuth	1 *s*	1 *b*	14·994
Sulphate of nickel	1 *s*	1 *n*	14.305
Sulphate of cobalt	2 *s*	1 *c*	19·326
Sulphate of manganese	2 *s*	1 *m*	19·115
Sulphate of uranium	1 *s*	1 *u*	20·000
Persulphate of platinum	2 *s*	1 *p*	24·161
Nitrate of potash	1 *n*	1 *p*	12·803
Nitrate of soda	2 *n*	1 *s*	21·438
Nitrate of ammonia	1 *n*	1 *a*	8·868
Nitrate of magnesia	1 *n*	1 *m*	9·380
Nitrate of lime	1 *n*	1 *l*	10.423
Nitrate of barytes	1 *n*	1 *b*	16·534
Nitrate of strontian	1 *n*	1 *str*	13·703
Nitrate of amm. and magnesia	4 *n*	3 *m* + 1 *a*	35·878
Nitrate of copper	2 *n*	1 *c*	23·606
Subnitrate of copper	1 *n*	2 *c*	26·803
Nitrate of iron	2 *n*	1 *i*	22·749
Pernitrate of iron	3 *n*	1 *i*	30·552
Nitrate of zinc	1 *n*	1 *z*	11·942
Nitrate of lead	1 *n*	1 *l*	20·790
1st Subnitrate of lead	1 *n*	2 *l*	34·777
2d Subnitrate of lead	1 *n*	3 *l*	48·764
3d Subnitrate of lead	1 *n*	6 *l*	90·725
Nitrate of nickel	3 *n*	1 *nick*	29·714
Subnitrate of nickel	1 *n*	7 *nick*	71·938
Nitrate of silver	1 *n*	1 *s*	21·517
Nitrate of mercury	1 *n*	1 *m*	32·803
Pernitrate of mercury	1 *n*	2 *m*	60·803
Subnitrate of platinum	1 *n*	4 *pl*	63·447
Nitrate of bismuth	1 *n*	1 *b*	16·797
Nitrate of uranium	1 *n*	1 *u*	21·803
Bicarbonate of potass	2 *c*	1 *p*	11·502

	Number of atoms.		Weight of an integrant particle.
Carbonate of potash	1 *c*	1 *p*	8·751
Carbonate of soda	3 *c*	1 *s*	16·135
Subcarbonate of soda	2 *c*	1 *s*	13·384
Bicarbonate of ammonia	2 *c*	1 *a*	7·437
Carbonate of ammonia	1 *c*	1 *a*	4·686
Subcarbonate of ammonia	1 *c*	2 *a*	6·621
Carbonate of lime	1 *c*	1 *l*	6·371
Carbonate of barytes	1 *c*	1 *b*	12·482
Carbonate of strontian	1 *c*	1 *str*	9·651
Bicarbonate of magnesia	2 *c*	1 *m*	8·079
Carbonate of magnesia	1 *c*	1 *m*	5·328
Carbonate of yttria	1 *c*	1 *y*	11·151
Carbonate of zirconia	1 *c*	1 *z*	1·407
Carbonate of glucina	1 *c*	1 *gl?*	6·351 ?
Carbonate of silver	1 *c*	1 *s*	16·369
Percarbonate of mercury	1 *c*	2 *m*	56·751
Percarbonate of copper	1 *c*	1 *c*	12·751
Carbonate of iron	2 *c*	1 *i*	14·645
Carbonate of lead	2 *c*	1 *l*	17·489
Carbonate of nickel	2 *c*	1 *n*	14·807
Carbonate of zinc	1 *c*	1 *z*	7·890
Carbonate of manganese	2 *c*	1 *m*	13.617
Carbonate of cerium	2 *c*	1 *ce*	18·996
Percarbonate of cerium	3 *c*	1 *ce*	21·747
Oxalate of potash	1 *ox*	1 *p*	10·634
Binoxalate of potash	2 *ox*	1 *p*	15·268
Quadroxalate of potash	4 *ox*	1 *p*	24·536
Oxalate of soda	2 *ox*	1 *s*	17·150
Superoxalate of soda	3 *ox*	1 *s*	21·784
Oxalate of ammonia	1 *ox*	1 *a*	6·783
Binoxalate of ammonia	2 *ox*	1 *a*	11·417
Oxalate of magnesia	1 *ox*	1 *m*	7·211
Oxalate of lime	1 *ox*	1 *l*	8·254
Binoxalate of lime	2 *ox*	1 *l*	12·888
Oxalate of barytes	1 *ox*	1 *b*	4·365
Oxalate of strontian	1 *ox*	1 *st*	11·534
Oxalate of alumina	1 *ox*	1 *al*	6·770
Oxalate of yttria	1 *ox*	1 *y*	13·034
Oxalate of glucina	1 *oz*	1 *gl*	14·467
Oxalate of zirconia	1 *ox*	1 *z*	10·290
Oxalate of copper	2 *ox*	1 *c*	19·268
Oxalate of potash and copper	2 *ox*	1 *p* + 1 *c*	29·902
Oxalate of soda and copper	3 *ox*	1 *s* 1 *c*,	32·410
Oxalate of amm. and copper	2 *ox*	1 *a* 1 *c*	26·051
Oxalate of iron	2 *ox*	1 *i*	18·383
Peroxalate of iron	3 *ox*	1 *i*	23·017
Oxalate of nickel	2 *ox*	1 *n*	18·573
Oxalate of cobalt	2 *ox*	1 *c*	18·594
Oxalate of lead	2 *ox*	1 *l*	37·242
Oxalate of zinc	1 *ox*	1 *z*	9·661
Oxalate of mercury	1 *ox*	1 *m*	30·634
Oxalate of silver	1 *ox*	1 *s*	19·348
Oxalate of bismuth	1 *ox*	1 *b*	14.628
Oxalate of manganese	2 *ox*	1 *m*	17·101
Oxalate of uranium	1 *ox*	1 *u*	19·634
Oxalate of cerium	2 *ox*	1 *c*	23·115
Oxalate of platinum	1 *ox*	1 *p*	17·795

Table of Chemical Equivalents by Dr Wollaston.

Hydrogen -	1.32				
Carbon -	7.54				
Oxygen -	10				
Water	11.32	=	10 *ox.*	+	1.32 *hyd.*
Phosphorus -	17.40				
Azote -	17.54				
Sulphur -	20.				
Ammonia -	21.5	=	17.54 *az.*	+	3.96 *hyd.*
Magnesia -	24.6	=	10 *ox.*	+	14.6 *mag.*
Calcium -	25.46				
Carbonic acid -	27.54	=	20 *ox.*	+	7.54 *carb.*
Sodium -	29.1				
Muriatic acid, (dry)	34.1				
Iron, -	34.5				
Lime -	35.46	=	10 *ox.*	+	25.46 *calc.*
Phosphoric acid	37.4	=	20 *ox.*	+	17.4 *phos.*
Nitrous gas -	37.54	=	20 *ox.*	+	17.54 *az.*
Soda -	39.1	=	10 *ox.*	+	29.1 *sod.*
Copper -	40.				
Zinc - -	41.				
Chlorine -	44.1	=	10 *ox.*	+	34.1 *mur. acid.*
Green oxide of iron	44.5	=	10 *ox.*	+	34.5 *ir.*
Muriatic gas -	45.42	=	44.1 *chl.*	+	1.32 *hyd.*
Oxalic acid -	47.0				
Subcarbonate of ammonia -	49.0	=	27.5 *acid*	+	21.5 *am.*
Potassium -	49.1				
Red oxide of iron,	49.5	=	15 *ox.*	+	34.5 *iron*
Sulphuric acid (dry)	50.	=	30 *ox.*	+	20 *sulph.*
Black oxide of copper	50.	=	10 *ox.*	+	40 *copper*
Oxide of zinc -	51	=	10 *ox.*	+	41 *zinc*
Potash -	59.1	=	10 *ox.*	+	49.1 *pot.*
Sulphuric acid sp. gr. 1.85; -	61.32	=	50 *sul. ac.*	+	11.32 *wat.*
Carbonate of lime	63	=	27.54 *carb. ac.*	+	35.46 *lime*
Subcarbonate of soda	66.6	=	27.5 *carb. ac.*	+	39.1 *soda*
Muriate of ammonia	66.9	=	34.1 *acid* + 21.5 *am.*	+	11.32 *wat.*
Nitric acid (dry)	67.54	=	50 *ox.*	+	17.54 *az.*
Strontia -	69				
Muriate of lime	69.6	=	34.1 *acid*	+	35·5 *lime*
Muriate of soda	73.2	=	34.1 *acid*	+	39.1 *soda*
Sulphate of magnesia	74.6	=	50. *acid*	+	24.6 *magn.*
Bicarbonate of ammonia -	76.5	=	27.5 *carb. ac.*	+	49. *subcarb.*
Sulphate of lime	85.5	=	50 *acid*	+	35.5 *lime*
Subcarbonate of potash -	86	=	27.5 *acid*	+	59.1 *potash*

Sulphate of soda	89.1	= 50	*acid*	+ 39.1	*soda*	
Liquid nitric acid sp. gr. 1.50;	90.2	= 67.54	*nit. ac.*	+ 22.64	*wat.*	
Muriate of potash	93.2	= 34.1	*acid*	+ 59.1	*potash*	
Barytes -	97					
Nitrate of lime -	103	= 67.5	*acid*	+ 35.5	*lime*	
Bicarbonate of soda	105.5	= 27.5 *ac.*	+ 66.6 *car. soda*	+ 11.3 *wat.*		
Nitrate of soda -	106.6	= 67.5	*acid*	+ 39.1	*soda*	
Selenite -	108.1	= 85.5	*s. of lime*	+ 22.4	*water*	
Sulphate of potash	109.1	= 50	*acid*	+ 59.1	*potash*	
Sulphate of strontia	119.0	= 50	*acid*	+ 69	*stront.*	
Carbonate of barytes	124.5	= 27.5	*acid*	+ 97	*barytes*	
Bicarbonate of potash -	125.5	= 27.5 *acid*	+ 86. *sub. pot.*	+ 11.3 *wat.*		
Mercury -	125.5					
Nitrate of potash	126.6	= 67.54	*acid*	+ 59.1	*potash*	
Lead -	129.5					
Muriate of barytes	131	= 34	*acid*	+ 97.	*barytes*	
Silver -	135					
Red oxide of mercury -	135.5	= 10	*ox.*	+ 125.5	*merc.*	
Litharge -	139.5	= 10	*ox.*	+ 129.5	*lead*	
Oxide of silver	145	= 10	*ox.*	+ 135	*silver*	
Sulphate of barytes	147.	= 50	*acid*	+ 97	*barytes*	
Binoxalate of potash	153.0	= 94	*acid*	+ 59	*potash*	
Hyperoxymuriate of potash -	153.2	= 93.2	*mur. pot.*	+ 60	*ox.*	
Cryst. muriate of barytes	153.6	= 131	*mur. bar.*	+ 22.6	*wat.*	
Sulphate of magnesia -	153.9	= 74.6	*sul. mag.*	+ 79.3	*water*	
Sulphate of copper	156.6	= 50 *acid*	+ 50 *cop.*	+ 56.6 *water*		
Nitrate of barytes	164.5	= 67.5	*acid*	+ 97	*barytes*	
Carbonate of lead	167.	= 27.5	*acid*	+ 139.5	*lead*	
Corrosive sublimate	170.1	= 34.1 *acid*	+ 10 *ox.*	+ 125.5 *merc.*		
Muriate of lead	173.6	= 34.1	*acid*	+ 139.5	*lead*	
Sulphate of iron	173.8	= 50 *acid*	+ 34.5 *iron*	+ 79.3 *water*		
Phosphate of lead	176.9	= 37.4	*acid*	+ 139.5	*lead*	
Muriate of silver	179.1	= 34.1	*acid*	+ 145	*silver*	
Sulphate of zinc	180.2	= 50 *acid*	+ 51 *zinc*	+ 79.3 *water*		
Oxalate of lead	186.5	= 47	*acid*	+ 139.5	*lead*	
Sulphate of lead	189.5	= 50	*acid*	+ 139.5	*lead*	
Sulphate of soda	202.3	= 50 *acid*	+ 39.1 *soda*	+ 113.2 *water*		
Nitrate of lead	207.0	= 67.5	*acid*	139.5	*lead*	
Protoxide of mercury -	261.	= 10	*ox.*	+ 251.	*merc.*	
Calomel -	296.1	= 34.1. *acid*	+ 10 *ox.*	+ 251 *merc.*		

Composition of some Organic Bodies, according to Berzelius.

	Oxyg.	*Hydr.*	*Carb.*	*Oxyg.*	*Hydr.*	*Carb.*	*Capacity of saturation.*
Benzoic acid	1 *o* +	3 *h* +	5 *c*	20.02	5.27	74.71	6.69
Gallic acid	1 *o*	2 *h*	2 *c*	38.02	5.02	56.96	12.34
Tannin from galls	2 *o*	3 *h*	3 *c*	45.00	4.45	50:55	3.718
Succinic acid	3 *o*	4 *h*	4 *c*	47.923	4.218	47.859	15.9743
Acetic acid	3 *o*	6 *h*	4 *c*	46.934	6.195	46.871	15.63
Sugar of milk	4 *o*	8 *h*	5 *c*	48.348	6.385	45.267	
Sugar	10 *o*	21 *h*	12 *c*	49.083	6.802	44.115	9.98
Potatoe starch	6 *o*	13 *h*	7 *c*	49.583	7.090	43.327	
Gum Arabic	12 *o*	24 *h*	13 *c*	51.456	6.792	41.752	
Citric acid	1 *o*	1 *h*	1 *c*	55.096	3.634	41.270	13.585
Tartaric acid	5 *o*	5 *h*	4 *c*	59.200	3.912	36.888	11.976
Saclactic acid	4 *o*	5 *h*	3 *c*	60.818	5.018	34.164	7.66
Oxalic acid *	6 *o*	1 *h*	4 *c*	66.534	0.244	33.222	22.

* Oxalic acid 3 *o* + 1 *h* + 2 *c* 64.739 2.848 32.413 Dr Thomson.

Composition of some Organic Bodies, according to Gay Lussac and Thenard.

	Carbon.	*Oxygen.*	*Hydrogen.*	*Nitrogen.*
Wax	81.79	5.54	12.67	
Olive oil	77.21	9.43	13.36	
Copal	76.81	10.61	12.58	
Rosin	75.94	13.34	10.72	
Oak wood	52.53	41.78	5.69	
Beech wood	51.45	42.73	5.82	
Fecula	43.55	49.68	6.77	
Sugar	42.47	50.63	6.90	
Gum Arabic	44.23	50.84	6.93	
Sugar of milk	38.825	53.834	7.341	
Acetic acid	50.22	44.15	5.63	
Citric acid	33.81	59.86	6.33	
Tartaric acid	24 05	69.32	6.53	
Mucous acid	33.69	62.67	3.62	
Oxalic acid	26.57	70.69	2.74	
Gelatin	47.881	27.207	7.914	16.998
Albumen	52.883	23.872	7.540	15.705
Fibrin	53.360	19.865	7.021	19.934
Cheese	59.781	11.409	7.429	21.381

Pharmaceutical Calendar for the Climate of Weimar, by Goëtling, shewing the Principal Objects which the Apothecary has to attend to in each Month of the Year.

JANUARY.—The concentration of vinegar by freezing,
Muriate of antimony,
Ethers, dulcified spirits,
Dippel's animal oil to be prepared;
Some gum resins, as assafœtida, galbanum, ammoniac, &c. to be powdered.

FEBRUARY—As in January.

MARCH.—Mezereon bark,
Misletoe of the oak to be gathered;
Conserve of scurvy-grass to be prepared.

APRIL.—Spirit of scurvy-grass,
Syrup of violets to be prepared.

MAY.—Sloe flower water,
Conserve of sorrel;
Plaster of henbane,
Extract of succory, henbane, grass, dandelion, &c.
Oil of beetles (Meloë majalis et proscarabæus),
Spirit of ants, earthworms, &c.

JUNE.—Distilled water of lily of the valley,
Various distilled spiritous waters,
Conserves of various herbs and flowers, as conserve of roses, &c.
Hemlock plaster,
Extracts of hemlock, fumatory, wild lettuce, aconite, &c.

JULY.—Vinegar of roses.
Rose water,
Marjoram butter,
Preserved Cherries, walnuts, currants, &c.
Extract of elaterium,
Honey of roses,
Boiled oil of Hypericum, &c.
Distilled oil of rosemary, mint, parsley, pennyroyal, wild thyme, &c.
Syrup of cherries, raspberries, &c.
Spirit of rosemary.

AUGUST.—Cherry water,
Extract of blessed thistle, thorn apple, &c.
Boiled oil of wormwood, chamomile, &c.
Distilled oil of wormwood, chamomile, peppermint, millefoil, rue, &c.
Rob and syrup of mulberries,

SEPTEMBER.—Quince cinnamon water,
Oxymel of meadow saffron,
Quince cakes,
Syrup of barberries, quince, buckthorn,
Tincture of steel, with quince juice.

OCTOBER.—Tincture of steel, with apple juice.

NOVEMBER and DECEMBER.—As in January.

EXPLANATION OF THE PLATES.

PLATE I.

Fig. 1, 2, 3, Mortars of metal, marble, and earthen ware, with their respective pestles.

Fig. 4. a levigating stone and muller.

a, The table of polished porphyry or other siliceous stone.

b, The muller of the same substance.

Fig. 5, A compound sieve.

a, The lid.

c, The body containing the sieve.

b, The receiver.

Fig. 6. A funnel.

Fig. 7. A hooked glass rod. Several of which may be hung round the edge of the funnel, to prevent the filtering substances from adhering too closely to its sides.

Fig. 8, A compound syphon.

a, *b*, *c*, The syphon.

f, *g*, The mouth-piece.

d, *e*, A board for supporting it.

When we insert the upper orifice *a* into any liquid, and close the lower orifice *c* with the finger; by sucking through *f*, the fluid rises from *a* to *b*, and proceeds by *g* towards *f*; as soon as it has passed g, the finger is to be removed, and the fluid immediately flows through *c*, and continues flowing as long as any remains above the orifice *a*. It is absolutely necessary that the point *g*, where the mouth-piece joins the syphon, be lower than *a*.

Fig. 9, A board perforated with holes for supporting funnels.

Fig. 10, A separatory. The fluids to be separated are introduced through the orifice A, which is then closed with a stopper. The one neck is then to be shut with the finger, and the phial is to be inclined to the other side. As soon as the fluids have separated by means of their specific gravity, the finger is to be removed, and the whole of the heavier fluid will run through the lower neck, before any of the lighter escapes.

PLATE II.

Fig. 11 and 12, Graduated glass measures. 11, A cylindrical one for large quantities.—12, A conical one for small quantities.

Fig. 13, A phial of a particular shape for keeping laudanum.

Fig. 14, External view of Dr Black's furnace.

a, The body.

b, The ash-pit.

c, The chimney.

d, The circular hole for the sand-pot.

e, A door about the centre of the body, to be opened when the furnace is used as a reverberatory. In Dr Black's original furnace, there is no aperture in the side, and, indeed, as its peculiar excellence consists in the power which it gives the

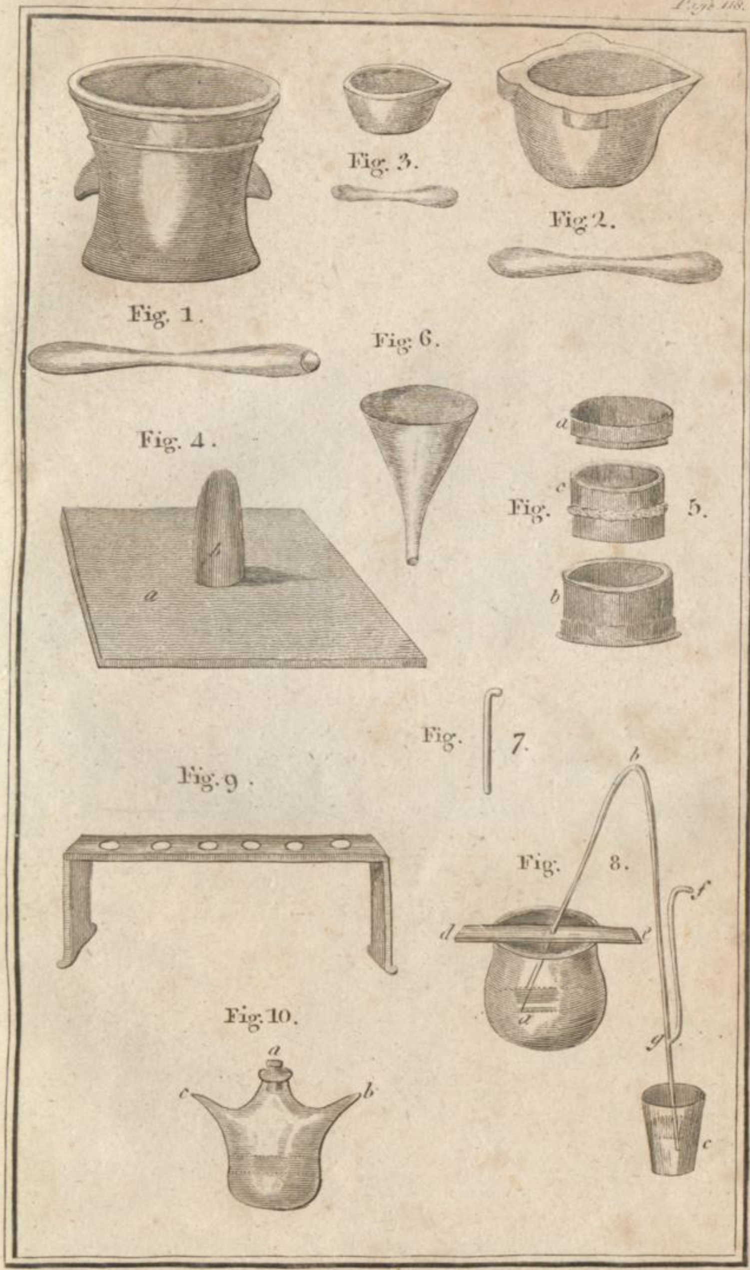


Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
Fig. 5.
Fig. 6.
Fig. 7.
Fig. 8.
Fig. 9.
Fig. 10.

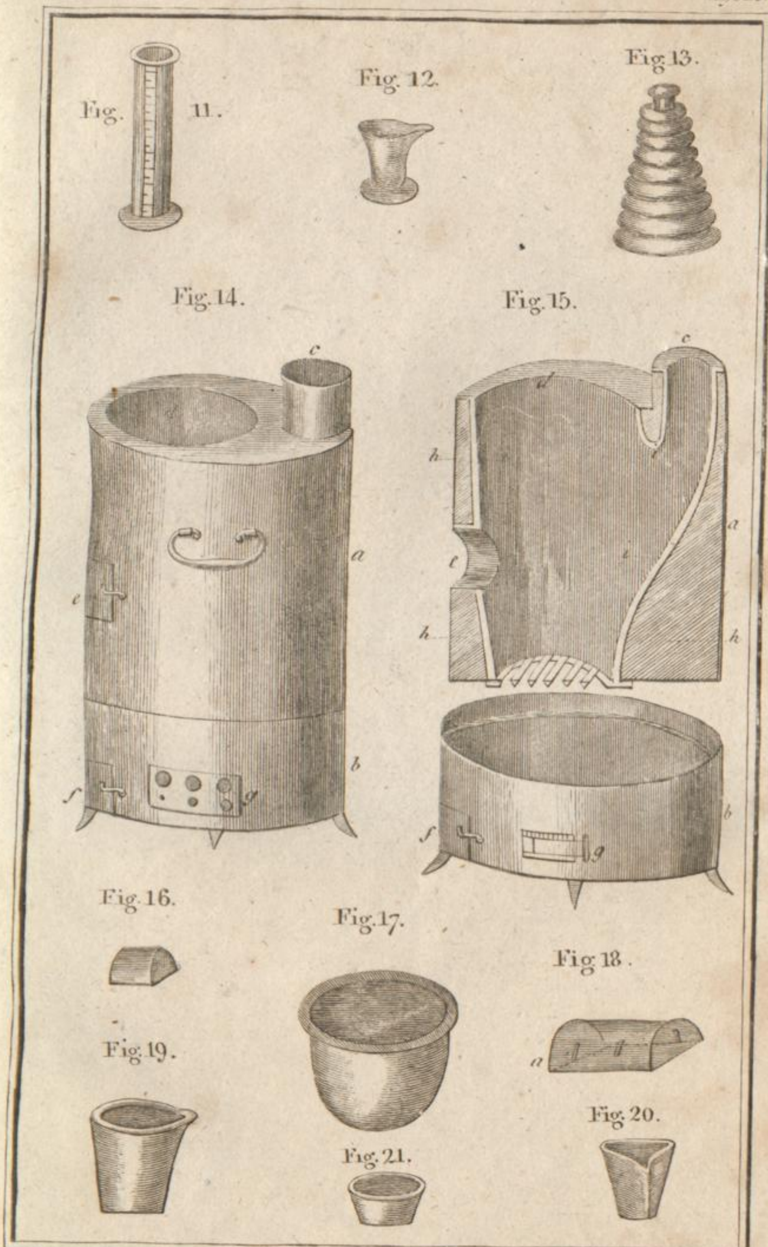


Fig. 11.
Fig. 12.
Fig. 13.
Fig. 14.
Fig. 15.
Fig. 16.
Fig. 17.
Fig. 18.
Fig. 19.
Fig. 20.
Fig. 21.

PLATE III.


Fig. 22.
Fig. 23
Fig. 24.
Fig. 25.
Fig. 26.
Fig. 27.
Fig. 28.
Fig. 29.
Fig. 30.
Fig. 31.
Fig. 32.
Fig. 33.
Fig. 34.
Fig. 35.
Fig. 36.
Fig. 37.

operator of regulating the quantity of air admitted to the fuel, and by that means of regulating the intensity of the fire; every aperture is rather to be considered as an injury than as an improvement. At all times when these apertures are not employed, they must be accurately closed and luted up.

f, The door of the ash-pit.

g, The damping plate for regulating the admission of air, having six holes, fitted with stoppers, increasing in size in a geometrical proportion.

Fig. 15, A vertical section of the body of the same furnace, to shew the manner of luting, and the form and position of the grate.

a——*g*, As in the former figure, except the damping plate which is here closed by a sliding door with a graduated scale.

h, The form which is given to the lute of clay and charcoal which is applied next to the iron.

i, The form given to the lute of sand and clay, with which the former is lined.

e, Is a semicircular aperture left unluted, to serve as a door when necessary. On other occasions, it is filled up with a semi-cylindrical piece of fire-brick, Fig. 16, accurately luted in.

k, The grate fastened on the outside of the body.

Fig. 16, A semi-cylindrical piece of fire-brick, for closing the door *e* of the furnace.

Fig. 17, The sand-pot, which is suspended in the aperture *d* of the furnace, by means of the projecting ring *a b*.

Fig. 18. A muffle, *a a* apertures in its sides for the admission of the heated air.

Fig. 19, A large black lead crucible.

Fig. 20. A small Hessian crucible.

Plate III.

Fig, 21, 22, Tests.

Fig. 23, A small support of clay, to raise the crucible above the grate.

Fig. 24, A pair of crucible tongs.

Fig. 25, A support for raising the muffle, as high as the door *e* of the furnace.

Fig. 26, A ring for suspending a retort within the furnace, when we wish to expose it to the immediate action of the fire. The ring itself, *a*, *b*, is suspended within the aperture *d* of the furnace, by means of the three hooked branches, *c*, *c*, *c*.

Fig. 27, Semicircular rings of plate-iron, for applying round the neck of a retort when suspended within the furnace, in order to close as much as possible the aperture *d*, Fig. 1. The largest pair *a* are first made to rest upon the edge of the aperture *d*, the next pair *b* upon them, and so on until they come in contact with the neck of the retort. The whole are then to be covered with ashes or sand, to prevent the loss of heat, and the escape of vapours, from the burning fuel.

Fig. 28, Circular rings, *a b*, to be applied in the same manner when we wish to evaporate with the naked fire. We must always take care that the fluid rises higher than the portion of the evaporating vessel introduced within the aperture of the ring ; *c*, a circular piece of iron, which, when applied with the rings *a b*, completely closes the aperture *d* of the furnace.

Fig. 29, 30, 31, 32, Evaporating vessels of different shapes.

Fig. 33, A long necked matrass.

Fig. 34, A jar.

Fig. 35, A phial or receiver.

Fig. 36, A cucurbit.

Fig. 37, A cucurbit with its capital.

Plate IV.

Fig. 38, The arrangement of the apparatus for distilling *per decensum*. The substance to be distilled is laid on the metallic plate *a*, which is perforated with holes. The burning fuel is laid upon the upper plate *b*, also of metal, but not perforated. On the application of heat, the vapour descends into the cavity *a*, *c*, where it is condensed.

Fig. 39, A retort and receiver ; *a*, the retort ; *b*, the receiver.

Fig. 40, A retort funnel.

Fig. 41, A metallic still.

c, *d*, *e*, *f*, The body.

a, *b*, *e*, *f*, The lower portion of the body, which hangs within the aperture *d* of the furnace, by the projecting part *a b*.

d, *g*, *c*, The head of the still.

d, *c*, A gutter which goes round the bottom of the head, for conveying any vapours which may be condensed there into the spout *h*, which conveys away the vapour and the fluid condensed in the head into the refrigeratory.

Fig. 42, A refrigeratory.

a, *b*, *c*, *d*, A cylindrical vessel filled with cold water.

e, *f*, A spiral metallic pipe which passes through it. The spout *h* of the still is inserted within the upper orifice *e* ; therefore the vapours which escape from the head of the still enter it, and are condensed in their passage towards *f*, the lower termination of the pipe from which the distilled fluid runs, and is received into proper vessels. As the water in the vessel *a*, *b*, *c*, *d*, continually abstracts caloric from the vapour, it is apt to become too warm to condense it. As soon, therefore, as any steam escapes by the spout *f*, the water must be drawn off by the cock *g*, and its place supplied by cold water.

Fig. 43, A vessel for boiling inflammable fluids.

a, *b*, *c*, *d*, The body of the kettle.

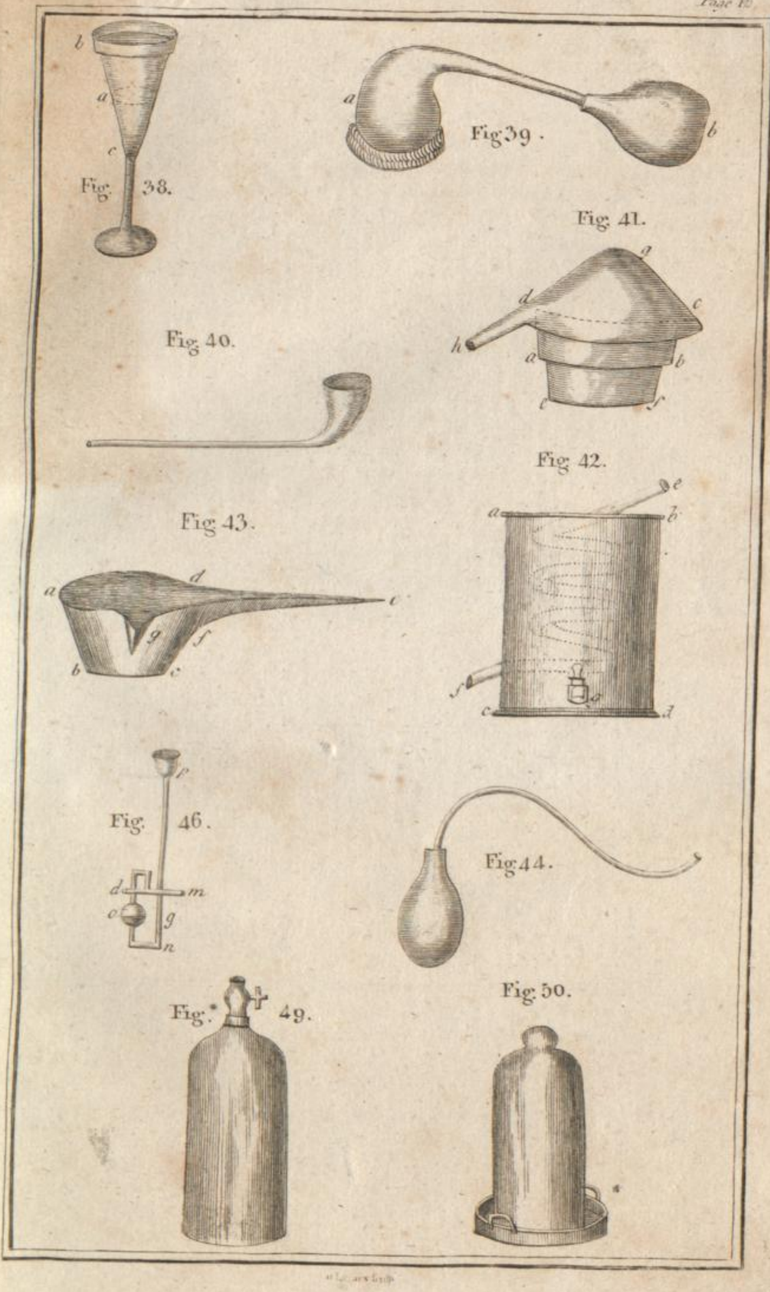


Fig. 38.
Fig. 39.
Fig. 40.
Fig. 41.
Fig. 42.
Fig. 43.
Fig. 44.
Fig. 46.
Fig.* 49.
Fig. 50.

d, e, f, A long spout proceeding from it, for preventing any risk of boiling over.

g, A short spout for pouring out. The vessel should not be filled above *h, f;* and the long spout, *d, e, f,* should be placed so as to be as little heated as possible. When the fluid begins to swell and boil up, both from the great increase of surface, and from part of it running up the cooler spout, *d, e, f,* the ebullition will be checked, and all danger of running over prevented.

Fig. 44, A body with a bent tube.

a, b, The body.

b, c, A sigmoid tube accurately ground to it. When any permanently elastic fluid is generated within the body *a, b,* it escapes by the extremity of the tube, and may be collected by introducing it under a jar filled with water or mercury in the pneumatic cistern. This simple apparatus can only be used conveniently when the production of the gas is slow, or requires the application of heat.

Fig. 45, A Woulfe's apparatus.

a, b, c, d, e, A tubulated retort and receiver.

f,' f,' f," Three three-necked bottles. The first *f,* is commonly filled with water, and the two others with various solutions.

d, g, d,' g,' d," g," d,'" g.'" Bent tubes connecting the different parts of the apparatus, so that when any vapour escapes from the receiver *c, d, e,* it passes along the tube *d, g,* and rises through the fluid contained in the bottle *f,* where it remains in contact with the surface, and under considerable pressure, until the expansion of the vapour, not condensable in *f,* overcomes the column of fluid *h, g,'* in the bottle *f,'* and escapes into the upper part of *f'*. In the same manner the uncondensed vapours proceed to *f,"* and at last to the pneumatic apparatus.

But, as in processes of this kind, diminution of temperature and other causes frequently produce sudden condensations of the gases contained in the different parts of the apparatus, especially in the retort and receiver, any such occurrence would cause the fluids to move through the connecting tubes in a retrograde direction. This accident is prevented, by inserting through the third neck of each bottle a small tube *k, l,* having its lower extremity *l* immersed in the fluid contained in the bottle. By this contrivance no fluid can possibly pass from one bottle into another, because the columns *g, m,* &c. which resist the absorption, are much higher than the columns *h, l,* which oppose the admission of external air; while, on the contrary, no gas can escape through these tubes, because the columns *h, k,* which oppose their escape, are higher than the columns *g, h,* which resist its progress to the next bottle. From their use, these tubes have got the name of tubes of safety.

Another contrivance for the same purpose, the invention of C.

Welter, seems now to be much used in France. It is fixed to the connecting tubes, as at *n*.

Fig. 46. To explain it more fully, we have given a separate view, taken in an oblique direction. When the apparatus is adjusted, a small quantity of water is poured through the funnel *p*, until it rises to about the centre of the ball *o*. Now, on any absorption taking place, the fluid rises in the ball *o*, uutil the column *g n* be annihilated, when a quantity of air will immediately rush in through *p g n o*, &c. and the water will regain its former equilibrium. On the other hand, no gas can escape by this tube, because the whole fluid contained in the ball and tube must previously enter the portion of the tube *n p*, where it would form a column of such a height that its pressure could not be overcome.

Fig. 47. A vertical section of a pneumatic cistern.

a, b, c, d, The whole cavity of the cistern.

e, f, A shelf for holding the jars.

e, b, c, The well for filling the jars.

g, h, The surface of the fluid contained in the cistern, which must always be higher than the surface of the shelf.

Fig. 48, 49, 50, 51, Pneumatic jars of different shapes.

Fig. 48, A jar in the situation in which it is filled with gas.

Fig. 49, A jar fitted with a stop-cock.

Fig. 50, A jar placed upon a tray for removing it from the pneumatic cistern.

Plate V.

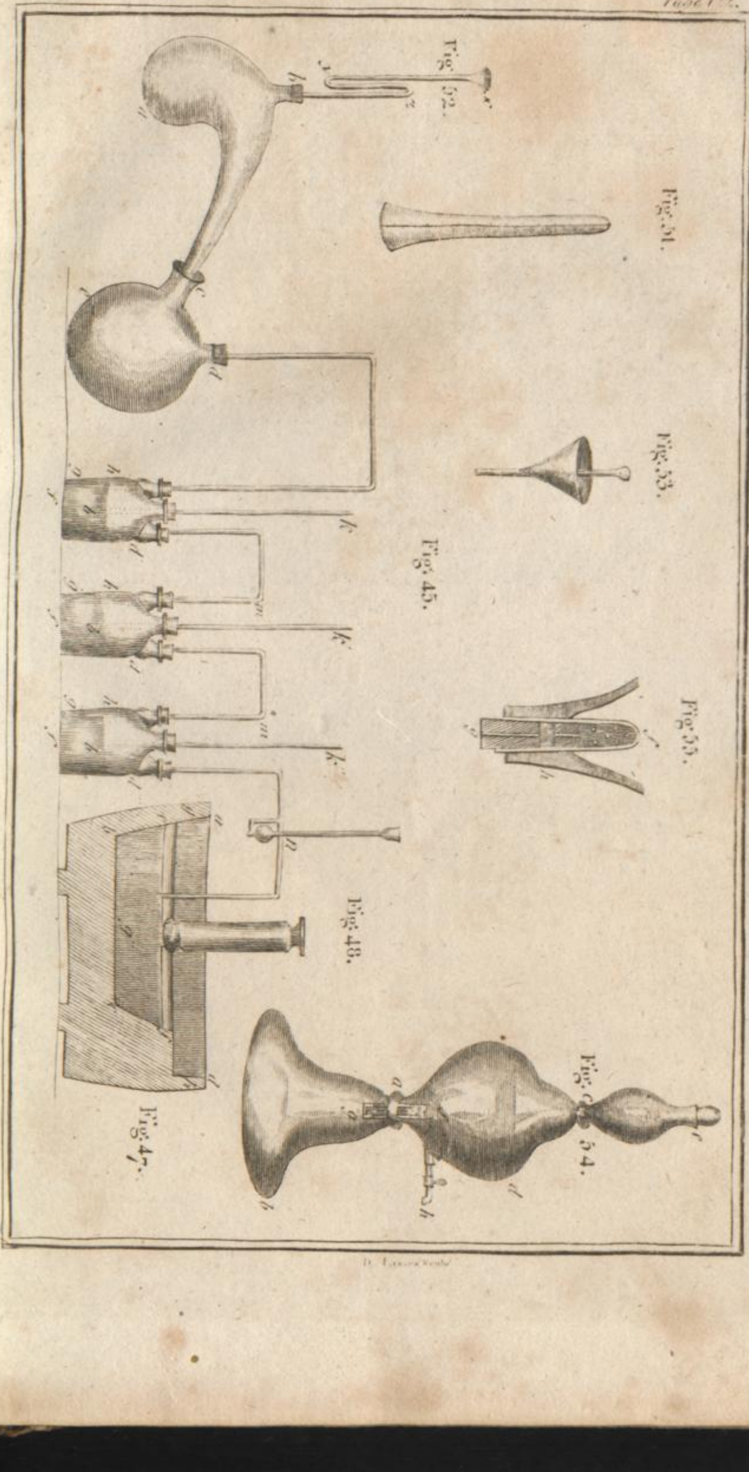
Fig. 51. A graduated jar, commonly called an Eudiometer.

Fig. 52, A hydrostatic funnel, for pouring fluids gradually into air-tight vessels, especially when attended with the formation of gas. It is evident, that any portion of fluid, poured into the funnel *x*, more than sufficient to fill the two first parts of the bent tube up to the level *z*, will escape by the lower extremity *b*. At the same time, no gas can return through this funnel, unless its pressure be able to overcome the resistance of a column of fluid of the height of *x y*.

Fig. 53, Another contrivance for the same purpose. It consists of a common funnel, in the throat of which is inserted a rod with a conical point, which regulates the passage of the fluid through the funnel, according to the firmness with which it is screwed in.

Fig. 54. Nooth's apparatus for promoting the absorption of gaseous fluids by liquids. It consists of three principal pieces; a lower piece *a b*, a middle piece *a c*, and an upper piece *d c e*; all of which are accurately ground to each other. The substances from which the gas is to be extricated are put into the lower piece. The middle piece is filled with the fluid with which the gas is to be combined, and the upper piece is left empty. As soon as a sufficient quantity of gas is formed to overcome the pressure, it passes through the valve *f g*, and rises through the fluid to the upper part of the middle piece. At the same time it forces a quantity of fluid into the upper piece through its lower aperture *d*. As soon as so much of the fluid has been for-

PLATE V.



ced from the middle piece as to bring its surface down to the level of the lower aperture of the upper piece, a portion of gas escapes into the upper piece, and the fluid rises a little in the middle piece. The upper piece is clothed with a conical stopper *e*, which yields, and permits the escape of a portion of gas, as soon as its pressure in the upper piece becomes considerable. *h* is a glass cock for drawing off the fluid.

Fig. 55. The valve of Nooth's apparatus. It consists of an internal tube *g*, of small caliber, but pretty stout in substance, and ground into an external tube *f*, closed at the upper end, but perforated with small holes, to allow the gas to pass. After the internal tube is fitted to the external, a portion of it is cut out, as at *h*, sufficient to receive a small hemisphere of glass, and to allow the hemisphere to rise a little in its chamber, but not to turn over in it. The upper piece of the internal tube is then thrust home into the place where it is to remain, and the glass hemisphere introduced with its plane recumbent on the upper end of the lower piece of the tube, which is ground perfectly flat, as is also the plane of the hemisphere. From this construction it is evident, that by the upward pressure of any gas, the glass hemisphere may be raised so as to allow it to pass, while nothing can pass downwards, for the stronger the pressure from above, the closer does the valve become. We have been more particular in our description of this valve, because it has been very ingeniously applied to distilling apparatuses by Mr Pepys *junior* and Mr Burkit.

PART II.