1770

A
SYSTEM
OF
CHEMISTRY.

IN FOUR VOLUMES.

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A

SYSTEM

OF

CHEMISTRY.

BOOK II. OF PART I. CONTINUED.

CHAP. IV.

OF ACIDS.

THE word ACID, originally synonymous with SOUR, and applied only to bodies distinguished by that taste, has been gradually extended in its signification by chemists, and now comprehends under it all substances possessed of the following properties:

Properties of acids.

1. When applied to the tongue, they excite that sensation which is called *sour* or *acid*.

2. They change the blue colours of vegetables to a red. The vegetable blues employed for this purpose are generally tincture of litmus and syrup of violets or of radishes, which have obtained the name of *reagents* or *tests*. If these colours have been previously converted to a *green* by alkalies, the acids restore them again.

3. They unite with water in almost any proportion.

4. They combine with all the alkalies, and most of the metallic oxides and earths, and form with them those compounds which are called *salts*.

It must be remarked, however, that every acid does not possess all these properties; but all of them possess a sufficient number of them to distinguish them from other substances. And this is the only purpose which artificial definition is meant to answer.

Opinions concerning an acid principle.

The acids are by far the most important class of bodies in chemistry. It was by their means indeed, by studying their properties, and by employing them as instruments in the examination of other bodies, that men of science laid the foundation of chemistry, and brought it to that state in which we find it at present. The nature and composition of acids, therefore, became a very important point of discussion, and occupied the attention of the most eminent cultivators of the science.

Paracelsus believed that there was only one acid principle in nature which communicated taste and solubility to the bodies in which it was combined. Beccher embraced the same opinion; and added to it, that this acid principle was a compound of earth and water, which he considered as two elements. Stahl adopted the theory of Beccher, and endeavoured to prove that his acid principle is sulphuric acid; of which, according to him, all the other acids are mere compounds. But his proofs were only conjectures or vague experiments, from which nothing could be deduced. Nevertheless, his opinion, like every other which he advanced in chemistry, continued to have supporters for a long time, and was even countenanced by Macquer. At last its defects began to be perceived; Bergman and Scheele declared openly against it; and their discoveries, together with those of Lavoisier, demonstrated the falsehood of both parts of the theory, by shewing that sulphuric acid does not exist in the other acids, and that it is not composed of water and earth, but of sulphur and oxygen.

The opinion, however, that acidity is owing to some principle common to all the salts, was not abandoned. Wallerius, Meyer, and Sage, had advanced different theories in succession about the nature of this principle; but as they were founded rather on conjecture and analogy than direct proof, they obtained but few advocates. At last Mr Lavoisier, by a number of ingenious and accurate experiments, proved that several combustible substances when united with oxygen form acids; that a great number of acids contain oxygen; and that when this principle is separated from them, they lose their acid properties. He concluded, therefore, that the acidifying principle is oxygen, and that acids are nothing else but combustible substances combined with oxygen, and differing from one another according to the nature of the combustible base.

Supposed oxygen.

This conclusion, as far as regards the greater number of acids, is certainly true. All the simple combustibles, except hydrogen, are convertible into acids; and these acids are composed of oxygen and the combustible body combined: this is the case also with four of the metals. It must not, however, be admitted without some limitation.

This theory imperfect.

1. When it is said that oxygen is the acidifying principle, it is not meant surely to affirm that oxygen possesses the properties of an acid, which would be contrary to truth; all that can be meant is, that it enters

as a component part into acids, or that acids contain it as an essential ingredient.

2. But, even in this sense, the assertion cannot be admitted: for it is not true that oxygen is an essential ingredient in all acids, or that no body possesses the property of an acid unless it contains oxygen. Sulphurated hydrogen, for instance, possesses all the characters of an acid, yet it contains no oxygen.

3. When it is said that oxygen is the acidifying principle, it cannot be meant surely to affirm that the combination of oxygen with bodies produces in all cases an acid, or that whenever a body is combined with oxygen, the product is an acid; for the contrary is known to every chemist. Hydrogen, for instance, when combined with oxygen, forms not an acid, but water, and the greater number of metallic bodies form only oxides.

All that can be meant, then, when it is said that oxygen is the acidifying principle, is merely that it exists as a component part in the greater number of acids; and that many acids are formed by combustion, or by some equivalent process. The truth is, that the class of acids is altogether arbitrary; formed when the greater number of the bodies arranged under it were unknown, and before any precise notion of what ought to constitute the characteristic marks of an acid had been thought of. New bodies, when they were discovered, if they possessed any properties analogous to the known acids, were referred without scruple to the same class, how much soever they differed from them in other particulars. Hence we find, under the head of acids, bodies which have scarcely a single property in common except that of combining with alkalies and earths.

What substances, for instance, can be more dissimilar than sulphuric, prussic and uric acids? Hence the difficulty of assigning the general characters of the class of acids, and the disputes which have arisen about the propriety of classing certain bodies among acids. If we lay it down as an axiom that oxygen is the acidifying principle, we must either include among acids a great number of bodies which have not the smallest resemblance to those substances which are at present reckoned acids, or exclude from the class several bodies which have the properties of acids in perfection. The class of acids being perfectly arbitrary, there cannot be such a thing as an acidifying principle in the most extensive sense of the word.

Division of acids.

The acids at present known amount to about 30; and all of them, eight excepted, have been discovered within these last 40 years. They may be arranged under two general heads: 1. Acids composed of two ingredients. 2. Acids composed of more than two component parts. Their names and composition, as far as known, are exhibited in the following TABLE:

I. *Acids of two Ingredients.*

Acids.	Component Parts.	
1. Sulphuric 2. Sulphurous	Sulphur	Oxygen
3 Phosphoric 4. Phosphorous	Phosphorus	Oxygen
5 Carbonic	Carbon	Oxygen
6. Nitric 7. Nitrous	Azot	Oxygen
8. Muriatic	Unknown	
9. Oxy-muriatic	Muriatic acid	Oxygen
10. Fluoric 11. Boracic	Unknown	
12. Arsenic	Arsenic	Oxygen
13. Tungstic	Tungsten	Oxygen
14. Molybdic	Molybdenum	Oxygen
15. Chromic	Chromum	Oxygen

II. *Acids of more than two Ingredients.*

Acids.	Component Parts.
1. Acetous	Carbon, Hydrogen, Oxygen
2. Acetic	
3. Oxalic	
4. Malic	
5. Lactic	
6. Tartarous	
7. Mucous	
8. Gallic	
9. Benzoic	
10. Succinic	
11. Camphoric	
12. Suberic	
13. Laccic	
14. Prussic	Carbon, Hydrogen, Azot
15. Sebacic	Carbon, Hydrogen, Azot, Oxygen
16. Zoonic	

The first of these classes may be considered as the most perfect acids. All of them, as far as is known, contain oxygen, and almost all of them are the products of combustion. To them therefore the theory of Lavoisier applies with precision. They cannot be decomposed by means of heat; a property which distinguishes them from the second class of acids, or acids with compound bases, as they are called, all of which are decomposable by heat. In the first class, there are several instances of two acids composed of the same ingredients: thus sulphur and oxygen form both sulphurous and sulphuric acid; phosphorus and oxygen form both phosphorous and phosphoric acids. In these cases one of the acids contains a greater proportion of oxygen than the other. The acid which contains least oxygen is distinguished by the termination *ous*, that which contains most by the termination *ic*. Thus sulphur*ous* acid contains a less proportion of acid than sulphur*ic* acid.

All the acids belonging to the second class are obtained from the vegetable and animal kingdoms. The first twelve (omitting lactic acid have been denominated *vegetable acids*, because they all either exist ready formed in vegetables, or at least may be obtained from vegetable bodies. They are all composed of different proportions of carbon, hydrogen, and oxygen. In them the termination is arbitrary, and has no reference to the proportion of their oxygen. The three last have been called *animal acids*, because they can only be obtained from the animal kingdom. They possess the least of the acid character.

An account of these different acids shall form the subject of the following Sections.

SECT. I.

OF SULPHURIC ACID.

Discovery.

THE ancients were acquainted with some of the compounds into which sulphuric acid enters; *alum*, for instance, and *green vitriol:* but they appear to have been ignorant of the acid itself. It is first mentioned in the works of Basil Valentine, which were published about the end of the 15th century.

It was for a long time obtained by distilling *green vitriol*, a salt composed of sulphuric acid and green oxide of iron; hence it was called *oil of vitriol*, and afterwards *vitriolic acid*. Another method of obtaining it was by burning sulphur under a glass bell; hence it was called also *oleum sulphuris per campanam*. The French chemists in 1787, when they formed a new chemical nomenclature, gave it the name of *sulphuric acid*.

How procured.

At present it is generally procured by burning a mixture of sulphur and nitre in chambers lined with lead. The theory of this process requires no explanation. The nitre supplies a quantity of oxygen to the sulphur, and the air of the atmosphere furnishes the rest. The acid thus obtained is not quite pure, containing a little potass, some lead, and perhaps also nitric and sulphurous acids. These acids may be driven off by applying for some time a gentle heat, and afterwards the sulphuric acid itself may be distilled over pure.

Component parts.

The composition of sulphuric acid was first demonstrated by Lavoisier in 1778. Berthollet * afterwards endeavoured to ascertain the proportion of its component parts; and this has been done more lately by Thenart †. According to the experiments of that gentleman, it is composed of about 56 sulphur
44 oxygen
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100

Its properties.

Sulphuric acid is a liquid somewhat of an oily consistence, transparent and colourless, as water, without

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* *Mem. Par.* 1781, p. 232.

† *Ann. de Chim.* xxxii. 266.

Book II. any smell, and of a very strong acid taste. When applied to animal or vegetable substances, it very soon destroys their texture.

It always contains a quantity of water; part of which, however, may be driven off by the application of a moderate heat. This is called *concentrating the acid.* When as much concentrated as possible, its specific gravity is said to be 2.000; but it can seldom be obtained denser than 1.85.

It changes all vegetable blues to a red except indigo.

According to Erxleben, it boils at 546°; according to Bergman, at 540[*].

When exposed to a sufficient degree of cold, it crystallizes or freezes; and after this has once taken place, it freezes again by the application of a much inferior cold. Morveau froze it at —4°; it assumed the appearance of frozen snow. After the process began, it went on in a cold not nearly so intense. The acid melted slowly at 27.5°; but it froze again at the same temperature, and took five days to melt in the temperature of 43°[†]. Chaptal, who manufactured this acid, once observed a large glass vessel full of it crystallized at the temperature of 48°. These crystals were in groups, and consisted of flat hexahedral prisms, terminated by a six-sided pyramid. They felt hotter than the surrounding bodies, and melted on being handled[‡]. Chaptal has observed, that sulphuric acid, in order to crystallize, must not be too concentrated. This observation has been extended a good deal further by Mr Keir. He found that sulphuric acid, of the specific gravity of

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[*] Bergman, ii. 152.

[†] *Encyc. Method. Chim.* i. 376.

[‡] *Jour. de Phys.* xxxi. 473.

1.780, froze at 45°; but if it was either much more or much less concentrated, it required a much greater cold for congelation[*].

Affinity for water.

Sulphuric acid has a very strong attraction for water. Neumann found, that when exposed to the atmosphere it attracted 6.25 times its own weight. Mr Gould found, that 180 grains of acid, when exposed to the atmosphere, attracted 68 grains of water the first day, 58 the second, 39 the third, 23 the fourth, 18 the fifth, and at last only 5, 4, 3, 4, 3, &c. The 28th day the augmentation was only half a grain[†]. The affinity therefore between sulphuric acid and water, as is the case in general with other substances, becomes weaker the nearer they approach to saturation. He does not specify the specific gravity of his acid; but as it only attracted 3.166 times its own weight, it could not have been very concentrated.

The affinity between sulphuric acid and water becomes still more striking when these bodies are mixed together. If four parts of sulphuric acid and one part of ice, both at the temperature of 32°, be mixed together, the ice melts instantly, and the temperature of the mixture becomes 212°. On the other hand, if four parts of ice and one part of acid, at 32°, be mixed together, the temperature sinks to about —4°. The cause of this change of temperature has been already explained. When four parts of acid and one part of water are mixed together, the temperature of the mixture rises to about 300°[‡]. The density of this compound of acid and water is much greater than the mean. Heat

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[*] *Phil. Trans.* lxxvii. Part ii.

[†] Ibid. 1684.

[‡] Fourcroy, ii. 65.

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is also evolved when other proportions of acid and water are mixed together, though not in so great quantity. Lavoisier and De la Place found, that when 2.625 lbs. troy of sulphuric acid, of the specific gravity 1.87058, were mixed with 1.969 lbs. troy of water, as much caloric was evolved as melted 4.1226 lbs. troy of ice, or as much caloric as the acid and water would have given out had they been heated without mixture to 155.9°*.

Strength at various densities.

We have no reason to suppose that sulphuric acid, at the density of 2.000, is free from all mixture of water; so far from that, we know for certain that it contains a considerable proportion; for when it is combined with other bodies (barytes, for instance, or potass), there is a considerable quantity of water which remains behind, and does not enter into the combination. Now, is it possible to determine how much real acid and how much water are contained in a given quantity of acid of a given specific gravity? Attempts were made to answer this important question by Homberg, by Bergman, by Wenzel, and by Wiegleb; but the differences between their determinations were too great to place any confidence in their accuracy. The subject has lately been resumed, and prosecuted with much industry and skill by Mr Kirwan, whose results may be considered as approaching as nearly to perfect accuracy as the present state of the science admits. His method was as follows: He dissolved 86 grains of potass in water, and saturated it exactly with sulphuric acid of a given specific gravity (we shall suppose of 2.00), and diluted it with water till its specific gravity was 1.013. Forty-five grains of sulphat of potass, dissolved in 1017

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* *Mem. Par.* 1780.

grains of distilled water, have the same specific gravity at the same temperature; from whence it follows, that the proportion of salt in each was equal. But in the last solution the quantity of salt was $\frac{1}{23.6}$ of the whole; therefore the quantity of salt in the first was $\frac{3694}{23.6}$ = 159.52 grs. Now of this weight 86 grains were alkali; the remainder therefore, which amounts to 70.52 grains, must be acid. But the quantity of acid employed was 79 grains; of this there were 8½ grains, which did not enter into the combination, and which must have been pure water: 79 parts of acid, of the specific gravity 2, therefore contain at least 8.5 parts of water; and consequently 100 parts of it contain 10.75 parts of water. It only remains now to consider how much water sulphat of potass contains. Mr Kirwan thinks it contains none, because it loses no weight in any degree of heat below ignition, and even when exposed to a red heat for half an hour it hardly loses a grain. This is certainly sufficient to prove, at least, that it contains very little water; and consequently we may conclude, with Mr Kirwan, that 100 parts of sulphuric acid, of the specific gravity 2.000, are composed pretty nearly of 89.25 of pure acid and 10.75 of water.

Since there is such a strong affinity between sulphuric acid and water, and since the density of the mixture is different from the mean density of the ingredients, it becomes a problem of the greatest importance to determine how much of the strongest sulphuric acid that can be prepared exists in any given quantity of sulphuric acid of inferior specific gravity, and which consequently consists of a determinate quantity of this strong acid diluted with water.

This problem has been solved by Mr Kirwan[*]. He took sulphuric acid of the specific gravity 2.000, which is the strongest that can be procured, for his standard, and the point was to determine how much of this standard acid existed in a given quantity of acid of inferior density.

He concluded, from a number of experiments with sulphuric acid, of the specific gravities 1.8846, 1.8689, 1.8042, 1.7500 (for he could not procure an acid of the specific gravity 2.000 at the temperature of 60°, in which his experiments were performed), that when equal parts of standard acid and water are mixed, the density is increased by $\frac{1}{75}$th part of the whole mixture. Then, by applying a formula given by Mr Poujet[†],

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[*] *Irish Trans.* iv.

[†] Mr Poujet undertook the examination of the specific gravity of alcohol mixed with different quantities of water. He took for his standard alcohol whose specific gravity was 0.8199, at the temperature of 65.75°. He then formed ten mixtures; the first containing nine measures of alcohol and one of water, the second eight measures of alcohol and two of water, and so on till the last contained only one measure of alcohol and nine of water. He took care that each of these measures should contain equal bulks, which he ascertained by weight, observing that a measure of water was to a measure of alcohol as 1 to 0.8199. Thus 10000 grains of water and 8199 of alcohol formed a mixture containing equal bulks of each. From the specific gravity of each of these mixtures he discovered how much they had diminished in bulk in consequence of mixture, by the following method:

Calling A the real specific gravity of any of the mixtures; B its specific gravity found by calculation, supposing no diminution of bulk; n the number of measures composing the whole mass; $n - x$ the number to which it is reduced in consequence of mutual penetration--it is evident, since the increase of density does not diminish the weight of the whole mass, that $n\,B = \overline{n - x} \times A$. Therefore $x = \frac{A - B}{A} \times n$, or he calculated, that the increase of density, on mixing different quantities of standard acid and water, was as in the following TABLE:

(making $n = 1$) $= \frac{A - B}{A}$. $\frac{A - B}{A}$ is therefore the diminution of volume produced by the mixture.

The following TABLE contains the result of Mr Poujet's experiments, calculated according to that formula; the whole volume or n being $= 1$.

Measures of Water.	Measures of Alcohol.	Diminution of the whole volume $= 1$ by experiment.	By calculation.
1	9	0.0109	0.0103
2	8	0.0187	0.0184
3	7	0.0242	0.0242
4	6	0.0268	0.0276
5	5	0.0288	
6	4	0.0266	0.0276
7	3	0.0207	0.0242
8	2	0.0123	0.0184
9	1	0.0044	0.0103

It is evident, from this Table, that the diminution of the bulk of the mixture follows a regular progression. It is greatest when the measures of water and alcohol are equal, and diminishes as it approaches both ends of the series. Mr Poujet accounts for this by conceiving the alcohol to be dissolved in the water, which retains a part of it in its pores, or absorbs it. The quantity absorbed ought to be in the ratio of that of the solvent and of the body dissolved, and each measure of water will retain a quantity of alcohol proportional to the number of measures of alcohol in the mixture. Thus in a mixture formed of nine measures of alcohol and one of water, the water will contain a quantity of alcohol $= 9$; in one of eight measures of alcohol and two of water, the water will contain a quantity of alcohol $= 8$. Therefore the diminution of bulk in each mix-

Number of parts of water.	Number of parts of standard acid.	Augmentation of density.
5	95	0.0252
10	90	0.0479
15	85	0.0679
20	80	0.0856
25	75	0.0699
30	70	0.1119
35	65	0.1213
40	60	0.1279
45	55	0.1319
50	50	0.1333

ture is in a ratio compounded of the measures of alcohol and water which form it; in the Table in the preceding page, as 1×9, 2×8, 3×7, 4×6, &c. And in general, taking the diminution of bulk when the measures of both liquids are equal for a constant quantity, and calling it c, calling the number of measures n, the number of measures of alcohol x, the increase of density or diminution of bulk z; we shall have $c : z :: \frac{n}{2} \times \frac{n}{2} : \overline{n - x} \times x$, and $z = \frac{4c}{n^2} \times \overline{nx - x^2}$, or (making $n = 1$) $= 4cx - 4cx^2$.

The diminution of bulk, calculated according to this formula, make the last column of the Table in this note. They correspond very well with experiment, while the measures of alcohol are more than those of water, but not when the reverse is the case. This Mr Poujet thinks is owing to the attraction which exists between the particles of water, and which, when the water is considerable compared with the alcohol, resists the union of the water with the alcohol.

By the formula $z = \frac{4cnx - 4cx^2}{n^2}$, the quantity of alcohol of the standard may be determined in any mixture where the alcohol exceeds the water.

Let the number of measures, or the whole mass - $= 1$
The measures of alcohol - - - - $= x$
The diminution of bulk at equal measures - - $= c$
The diminution of bulk of a mixture containing x measures of alcohol - - - - - $= 4cx - 4cx^2$
The specific gravity of water - - - $= a$
The specific gravity of the alcohol - - $= b$
The specific gravity of the unknown mixture $= y$

By adding these augmentations to the specific gravity of the above mixture, found by calculation, and taking the mean for the intermediate quantities, he drew up a table of the quantity of acid of the density 2.00 contained in a given weight of acid of inferior density, from 2 to 1.4666. Sulphuric acid of this last density contains just 0.5 of sulphuric acid of 2. The quantity contained in acids of inferior densities was ascertained from actual observation. He found by the first part of the table, that 100 parts of acid, of the specific gravity 1.8472, contained 88.5 parts standard, consequently 400 grains of this acid contain 354 grains standard. He took six portions of this acid, each containing 400 grains, and added to them as much water as made them contain respectively 48, 46, 44, 42, 40, 38 grains standard. The quantity of water to be added, in order to produce this effect, he found by the following method: Suppose $x =$ the quantity of water to be added to 400 parts of acid, that the mixture may contain 48 *per cent.* of standard acid. Then $400 + x : 354 :: 100 : 48$, and consequently $x = 337.5$. After finding the specific gravity of these, the half of each was taken out, and as much water added; and thus the specific gravities, cor-

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Then since the increase of density does not change the weight of the whole, $\overline{1 - x} \times a + bx = \overline{1 - 4cx + 4cx^2} \times y$.

$$\text{Hence } x = 0.5 - \frac{a-b}{8cy} + \sqrt{\frac{a-y}{4cy} + \left(\frac{a-b}{8cy} - 0.5\right)}$$

$$y = \frac{a - ax + bx}{1 - 4cx + 4cx^2}$$

And making $a = 1$, $b = 0.8199$, $c = 0.0288$

$$x = 0.5 - \frac{0.1801}{0.2304y} + \sqrt{\frac{1-y}{0.1152y} + \left(\frac{0.1801}{0.2304y} - 0.5\right)}$$

$$y = \frac{1 - 0.1801x}{1 - 0.1152x + 0.1152x^2}.$$

See *Irish Trans.* iii.

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responding to 24, 23, 22, 21, 20, 19, were found. Then six more portions, of 400 grains each, were taken, of the specific gravity 1.8393, and the proper quantity of water added to make them contain 36, 34, 32, 30, 28, 26 *per cent.* of standard. Their specific gravities were found, the half of them taken out, and as much water added; and thus the specific gravity of 18, 17, 16, 15, 14, and 13 found. Care was taken, after every addition of water; to allow the ingredients sufficient time to unite.

By multiplying the standard acid, as ascertained in this Table, by 0.8929, he obtained the quantity of real acid contained in sulphuric acid of different densities at the temperature of 60°. This may be seen in the following TABLE *.

100 Parts Sp. Gravity.	Real Acid.	100 Parts Sp. Gravity.	Real Acid.
2.0000	89.29	1.7738	73.22
1.9859	88.39	1.7629	72.32
1.9719	87.50	1.7519	71.43
1.9579	86.61	1.7416	70.54+
1.9439	85.71	1.7312	69.64
1.9299	84.82	1.7208	68.75
1.9168	83.93	1.7104	67.86
1.9041	83.04+	1.7000	66.96
1.8914	82.14	1.6899	66.07
1.8787	81.25	1.6800	65.18
1.8660	80.36	1.6701	64.28
1.8542	79.46	1.6602	63.39
1.8424	78.57	1.6503	62.50
1.8306	77.68	1.6407	61.61
1.8188	76.79+	1.6312	60.71
1.8070	75.89	1.6217	59.82
1.7959	75.—	1.6122	58.93
1.7849	74.11	1.6027	58.03

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* Nicholson's *Journal*, iii. 213.

Chap. IV.

100 Parts Sp. Gravity.	Real Acid.	100 Parts Sp. Gravity.	Real Acid.
1.5932	57.14	1.2668	28.57
1.5840	56.25	1.2589	27.68+
1.5748	55.36+	1.2510	26.78
1.5656	54.46	1.2415	25.89
1.5564	53.57	1.2320	25.—
1.5473	52.68	1.2210	24.10
1.5385	51.78	1.2101	23.21
1.5292	50.89	1.2009	22.32
1.5202	50.00	1.1918	21.43+
1.5112	49.11+	1.1836	20.53
1.5022	48.21	1.1746	19.64
1.4933	47.32	1.1678	18.75
1.4844	46.43	1.1614	17.85
1.4755	45.53	1.1531	16.96
1.4666	44.64	1.1398	16.07
1.4427	43.75	1.1309	15.18+
1.4189	42.86+	1.1208	14.28
1.4099	41.96	1.1129	13.39
1.4010	41.07	1.1011	12.50
1.3875	40.18	1.0955	11.60
1.3768	39.28	1.0896	10.71
1.3663	38.39	1.0833	9.80
1.3586	37.50	1.0780	8.93+
1.3473	36.60	1.0725	8.03
1.3360	35.71	1.0666	7.14
1.3254	34.82	1.0610	6.25
1.3149	33.93	1.0555	5.35
1.3102	33.03	1.0492	4.46
1.3056	32.14	1.0450	3.57
1.2951	31.25	1.0396	2.67
1.2847	30.35	1.0343	1.78
1.2757	29.46		

Action on combustibles

Sulphuric acid is not acted on by oxygen; but all the simple combustibles, except azot, decompose it. Hydrogen gas has no effect upon it cold; but when both are passed through a porcelain tube, the decomposition is complete, water is formed, and sulphur deposited*. Phosphorus, especially when assisted by heat, gradually converts it into sulphurous acid, by abstracting part of its oxygen. Charcoal does not act upon it unless assisted by heat; but at a high temperature, it abstracts part of its oxygen, and converts it into sulphurous acid; at a red heat it converts it into sulphur. When sulphur is heated in sulphuric acid, part of it combines and converts the acid into the sulphurous.

And metals.

Sulphuric acid oxidates zinc, iron, and manganese, even without the assistance of heat, especially when diluted. By the assistance of heat it oxidates silver, mercury, copper, antimony, bismuth, arsenic, tin, and tellurium. At a boiling heat it oxidates lead, cobalt, nickel, molybdenum. It does not act upon gold, platinum, tungsten, nor titanium.

When assisted by heat, it decomposes also some of the metallic oxides which contain the greatest quantity of oxygen; as red oxide of lead, black oxide of manganese. It decomposes likewise all the sulphurets and phosphurets which have an alkaline or earthy basis.

Sulphats.

It unites readily with all the alkalies and earths except silica, and with most of the metallic oxides, and forms salts denominated *sulphats*. Thus the combination of sulphuric acid and soda is called *sulphat of soda;* the compound of sulphuric acid and lime, *sulphat of lime*, and so on.

It absorbs a very considerable quantity of nitrous gas, and acquires by that means a purplish colour†.

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[*] Fourcroy, ii. 62.

[†] Priestley, i. 389.

Affinities.

Its affinities are as follows:

Barytes,
Strontian,
Potass,
Soda,
Lime,
Magnesia,
Ammonia,
Glucina,
Yttria,
Alumina,
Zirconia,
Metalic oxides.

This is one of the most important of all the acids, not only to the chemist but to the manufacturer also; being employed to a very great extent in a variety of manufactures, especially in dyeing.

SECT. II.

OF SULPHUROUS ACID.

How formed.

Sulphurous acid may be procured by the following process: Put into a glass retort two parts of sulphuric acid and one part of mercury, and apply the heat of a lamp: The mixture effervesces, and a gas issues from the beak of the retort, and may be received in glass jars filled with mercury, and standing in a mercurial trough. This gas is *sulphurous acid*.

Book II. History.

Though some of the properties of this acid must have been known in the remotest ages, as it is always formed during the slow combustion of sulphur, Stahl was the first chemist who examined it, and pointed out its peculiar nature. He gave it the name of *phlogisticated sulphuric acid*, from the supposition that it is a compound of sulphuric acid and phlogiston. His method of procuring it was to burn sulphur at a low temperature, and expose to its flames cloth dipped in a solution of potass. By this method he obtained a combination of potass and sulphurous acid; for at a low temperature sulphur forms by combustion only sulphurous acid. Scheele pointed out, in 1771, a method of procuring sulphurous acid in quantities *. On Stahl's salt he poured a quantity of tartarous acid, and then applied a gentle heat. The sulphurous acid is in this manner displaced, because its affinity for potass is not so strong as that of tartarous acid; and it comes over into the receiver dissolved in water. Dr Priestley, in 1774, obtained it in the gaseous form, and examined its properties while in a state of purity †. Berthollet published a dissertation on its formation, composition, and uses, in 1782 and 1789‡; and in 1797 appeared a very complete dissertation on its combinations by Fourcroy and Vauquelin§.

Properties.

Sulphurous acid, in the state of gas, is colourless and invisible like common air. It is incapable of maintaining combustion; nor can animals breathe it without death. It has a strong and suffocating odour, pre-

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* Scheele, i. 43.

† *On Air*, ii. 295.

‡ *Mem. Par.* 1782. *Ann. de Chim.* ii. 54.

§ *Ann. de Chim.* xxiv. 229.

cisely the same with that exhaled by sulphur burning with a blue flame: sulphur, by such a combustion, being totally converted into sulphurous acid. Its specific gravity, according to Bergman, is 0.00246[*]; according to Lavoisier, 0.00251[†]. It is therefore somewhat more than twice as heavy as air. One hundred cubic inches of it weigh nearly 63 grains.

Like sulphuric acid, its component parts are sulphur and oxygen; but the proportion of its oxygen is smaller. According to Fourcroy, it is composed of

85	sulphur
15	oxygen
100[‡]	

It is probably a compound of sulphuric acid and sulphur: For it may be formed by heating together sulphuric acid and sulphur; and it is decomposed by almost all substances which act upon sulphuric acid, which should not be the case if sulphuric acid were a compound of sulphurous acid and oxygen, as is commonly supposed.

This acid reddens vegetable blues, and gradually destroys the greater number of them. It exercises this power on a great variety of vegetable and animal colours. Hence the use of the fumes of sulphur in bleaching wool and in whitening linen stained by means of fruits.

Action of heat,

Dr Priestley discovered, that when a strong heat is applied to this acid in close vessels, a quantity of sulphur is precipitated, and the acid is converted into sul-

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[*] Bergman, iii. 343.

[†] Lavoisier's *Chem.* Appendix.

[‡] Fourcroy, ii. 74.

phuric [*]. Berthollet obtained the same result: but Fourcroy and Vauquelin could not succeed [†].

According to Clouet and Monge, when this gas, in a state of condensation, is exposed to the temperature of —18°, it is condensed into a liquid [‡].

Of water,

Water absorbs this acid with avidity. According to Dr Priestley, 1000 grains of water, at the temperature 54.5°, absorb 39.6 grains of this acid. Fourcroy, on the other hand, affirms, that water at 40° absorbs the third of its weight of sulphurous acid gas [§]. Ice absorbs this gas very rapidly, and is instantly melted. Water saturated with this gas, in which state it is known by the name of *liquid sulphurous acid*, or *sulphurous acid*, is of the specific gravity 1.040 [¶]. It may be frozen without parting with any of the acid gas. When water, which has been saturated with this acid at the freezing temperature, is exposed to the heat of 65.25°, it is filled with a vast number of bubbles, which continually increase and rise to the surface. These bubbles are a part of the acid separating from it. It freezes a few degrees below 32° [||].

Of oxygen,

When liquid sulphurous acid is exposed to atmospheric air or to oxygen gas, it gradually combines with oxygen, and is converted into sulphuric acid. This change takes place more completely if the acid be combined with an alkali or earth. When a mixture of sulphurous acid gas and oxygen gas is made to pass thro'

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[*] *On Air*, ii. 330.

[†] Nicholson's *Journal*, i. 313.

[‡] Fourcroy, ii. 74.

[§] Ibid. p. 77.

[¶] Berthollet, *Ann. de Chim.* ii. 56.

[||] Fourcroy and Vauquelin, Nicholson's *Journal*, i. 313.

a red hot porcelain tube, the two bodies combine, and sulphuric acid is formed*.

Combustibles.

Of the simple combustibles, sulphur, phosphorus, and azot, have no action on it whatever; hydrogen gas and charcoal do not alter it while cold, but at a red heat they decompose it completely: water or carbonic acid is formed, and sulphur deposited†.

Sulphurous acid does not seem capable of oxidating or dissolving any of the metals except iron, zinc, and manganese.

Sulphites.

It combines with alkalies, earths, and metallic oxides, and forms salts known by the name of *sulphites*.

Glacial sulphuric acid.

Sulphuric acid absorbs this gas in considerable quantity. It acquires a yellowish brown colour, a penetrating odour, and the property of smoking when exposed to the air. When this mixture is distilled, the first vapour which comes over, and which is a compound of the two acids, crystallizes in long white prisms. This singular compound, formerly known by the name of *glacial sulphuric acid*, smokes in the air; and when the atmosphere is moist, melts with effervescence. When thrown into water, it hisses like a red hot iron. It has the odour of sulphurous acid‡. This curious compound, first mentioned by Kunkel, and afterwards by Bohn and by Neumann, attracted a great deal of the attention of chemists, who attempted to investigate the cause of its singular properties. The general opinion, in consequence of the experiments of Hellot, Wiegel, Meyer, and Gottling, was, that phlogiston, some how or other,

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* Priestley, ii. 332. Fourcroy, ii. 74.

† Fourcroy and Vauquelin.

‡ Fourcroy, ii. 78.

contributed to its production. Dolfusz[*] made a set of experiments on it in 1784; from which he concluded that it was peculiar to sulphat of iron, by the distillation of which it had been usually procured. These experiments were repeated and varied by Morveau[†]; and this philosopher considered it as probable that the glacial acid is merely a sulphuric acid, totally deprived of moisture. Fourcroy has lately demonstrated, that it is a compound of sulphuric and sulphurous acids.

Affinities.

The affinities of sulphurous acid, as far as they have been investigated, are as follows[‡]:

Barytes,
Lime,
Potass,
Soda,
Strontian,
Magnesia,
Ammonia,
Glucina,
Alumina,
Zirconia,
Metallic oxides,
Water.

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[*] Crell's *Annals*, 1785, i. 438.

[†] *Encyc. Method. Chim.* i. 390.

[‡] Fourcroy and Vauquelin, Nicholson's *Journal*, i. 313.

SECT. III.

OF PHOSPHORIC ACID.

Preparation.

PHOSPHORIC ACID may be formed by setting fire to a quantity of phosphorus contained in a vessel filled with oxygen gas. The phosphorus burns with great rapidity, and a great number of white flakes are deposited, which are *phosphoric acid* in a state of purity. It may be obtained too by heating phosphorus under water till it melt, and then causing a stream of oxygen gas to pass through it by means of a tube. In this case the acid as it forms combines with the water; but the liquid may be evaporated off by the application of heat, and then the acid remains behind in a state of purity. It may be procured also by distilling off nitric acid from phosphorus; but the process is expensive, as the quantity of nitric acid required is considerable.

History.

Phosphoric acid remained unknown till after the discovery of phosphorus. Boyle is perhaps the first chemist who mentions it; but Margraff first examined its properties, and demonstrated it to be a peculiar acid. Its properties were afterwards more completely investigated by Bergman, Scheele, Lavoisier, Pearson, Fourcroy and Vauquelin, and several other distinguished chemists.

Lavoisier first proved that it is composed of phosphorus and oxygen. From his experiments it follows, that it is composed of about

39	phosphorus
61	oxygen
100	

Properties.

Phosphoric acid, when pure, is solid, colourless, and transparent. It reddens vegetable blues; it has no smell; its taste is very acid, but it does not destroy the texture of organic bodies.

Action of heat,

When exposed to the open air, it soon attracts moisture, and deliquesces into a thick oily-like liquid, in which state it is usually kept by chemists. When exposed to the fire in a platinum crucible, its water gradually evaporates, and leaves it in the state of a transparent jelly. If the heat be increased it boils and bubbles up, owing to the separation of the remainder of its water accompanied with a small portion of acid. At a red heat it remains in the form of a transparent liquid, and when cooled assumes the form of the purest crystal. In this state it is known by the name of *phosphoric glass*. This glass is merely phosphoric acid totally deprived of water. It has an acid taste, is soluble in water, and deliquesces when exposed to the air.

The specific gravity of this acid, in a state of dryness, is 2.687[*]; in the state of glass, 2.8516[†]; in the state of deliquescence, 1.417[‡].

Water,

This acid is very soluble in water. When in the state of white flakes, it dissolves with a hissing noise similar to that made by red hot iron plunged into water. When in the state of glass it dissolves much more slowly. The heat evolved during the combination of this acid and water is much inferior to that evolved when sulphuric acid enters into a similar combination. Phos-

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[*] Bergman's *Sciagraphia*, p. 20. Engl. Transl.

[†] Hassenfratz, *Ann. de Chim.* xxviii. 11.

[‡] *Encyc. Method. Chim.* i. 221.

phoric acid obtained by deliquescence, when mixed with an equal quantity of distilled water, acquired so little *heat* as to raise the thermometer only one degree, as Mr Sage observed. Mr Lavoisier raised the thermometer from 50° to 63° by mixing phosphoric acid boiled to the consistence of a syrup with an equal quantity of water; and from 50° to 104° when the acid was as thick as turpentine*.

Combustibles,

Oxygen gas has no action on phosphoric acid, whatever be the temperature. Neither is it decomposed or altered by any of the simple combustibles, if we except charcoal †; which, though it has no action on it while cold, at a red heat decomposes it completely; carbonic acid is formed, and phosphorus sublimed. This is the common process for obtaining phosphorus.

Metals.

This acid is incapable of combining with metals; but when in a liquid state, it is capable of oxidating some of them, especially when assisted by heat; at the same time hydrogen gas is emitted. Hence we see that the oxidation is owing to the decomposition of water. Phosphoric acid is capable of oxidating iron, tin, lead, zinc, antimony, bismuth, manganese. When fused with several of these metals, as tin, iron, and zinc, it is converted into phosphorus; a proof that they have a stronger affinity for oxygen.

It does not act upon gold, platinum, silver, copper, mercury, arsenic, cobalt, nickel. It appears, however, to have some action on gold in the *dry way*, as it is called; for when fused with gold-leaf it assumes a purple colour; a proof that the gold has been oxidated.

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* Keir's *Dictionary*.

† And perhaps also hydrogen; but the experiment has not been made.

Book II.

Phosphats. Phosphoric acid combines with alkalies, earths, and metallic oxides, and forms with them salts known by the name of *phosphats*.

Its affinities are as follows:

Affinities.

Barytes,
Strontian,
Lime,
Potass,
Soda,
Ammonia,
Magnesia,
Glucina,
Alumina,
Zirconia,
Metallic oxides,
Silica.

This acid is too expensive to be brought into common use. If it could be procured at a cheap rate, it might be employed with advantage, not only in several important chemical manufactures, but also in medicine, and perhaps even for the purposes of domestic economy.

SECT. IV.

OF PHOSPHOROUS ACID.

History. THE acid obtained by the burning of phosphorus differs according to the rapidity of the combustion; or, which is the same thing, according to the temperature in which the process is conducted. When burnt in oxygen gas, in which case the temperature is the highest possible, the product is *phosphoric* acid, which contains a maximum of oxygen: When allowed to burn gradually, at the common temperature of the air, the product is *phosphorous* acid, which contains a minimum of oxygen. The difference between these two acids had been remarked by Sage, by Proust, and by Morveau; but it was Lavoisier who first, in 1777, demonstrated that they form different compounds with other bodies, and that the difference between them is owing to the different proportions of oxygen which they contain*.

Preparation.

Phosphorous acid is prepared by exposing phosphorus during some weeks to the ordinary temperature of the atmosphere, even in winter; when the phosphorus undergoes a slow combustion, and is gradually changed into a liquid acid. For this purpose, it is usual to put small pieces of phosphorus on the inclined side of a glass funnel, through which the liquor which is formed drops into the bottle placed to receive it. From one ounce of phosphorus about three ounces of acid liquor may be thus prepared. It was called *phlogisticated phosphoric acid* by Morveau, from the supposition that it is a compound of phosphoric acid and phlogiston.

Properties.

Phosphorous acid, thus prepared, is a viscid liquid, of different degrees of consistence, adhering like oil to the sides of the glass vessel in which it is contained. It emits the smell of garlic, especially when heated. Its taste is acid like that of phosphoric acid, and it produces the same effect upon vegetable colours. Its specific gravity has not been determined.

It combines with water in every proportion; but it

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* *Mem. Par.* 1777.

cannot, like phosphoric acid, be obtained in a concrete state.

When heated, part of the water which it contains is at first evaporated; then large bubbles of air rise to the surface, there they break, and emit a dense white smoke, or even take fire if the experiment be performed in an open vessel. The emission of these bubbles of phosphorated hydrogen gas continues for a long time: when the process is finished, the acid which remains is no longer phosphorous, but phosphoric acid. These phenomena would lead one to suspect that phosphorous acid is not, as has been hitherto supposed, a compound of phosphorus and oxygen; but that it is phosphoric acid saturated with phosphorated hydrogen gas.

This acid is converted into phosphoric acid by exposure to air or oxygen gas. The process is exceedingly slow, and the conversion is never complete. It succeeds better when the acid is diluted with a great proportion of water *.

Phosphorous acid is not acted upon by any of the simple combustibles except charcoal, and perhaps also hydrogen. Charcoal decomposes it at a red heat as well as phosphoric acid. The products are carbonic acid and phosphorus.

Its action on metals is exactly similar to that of phosphoric acid, excepting only that the hydrogen gas evolved during the oxidation of the metals has a fetid smell, and holds phosphorus in solution.

It combines with alkalies, earths, and metallic oxides, and forms compounds distinguished by the name of *phosphites*.

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* Fourcroy, ii. 55.

Sulphuric acid produces no change upon it while cold; but at a boiling heat it parts with some of its oxygen, and the phosphorous acid is converted into phosphoric acid. Nitric acid also, when assisted by heat, converts it readily into phosphoric acid. This furnishes us with by far the best process for obtaining phosphoric acid at present known. Mix phosphorous acid, obtained by slow combustion, with one-eighth of its weight of nitric acid of the specific gravity 1.3, and distil. The nitric acid is decomposed, and pure phosphoric acid remains behind. For this process we are indebted to Fourcroy *.

Affinities.

The affinities of phosphorous acid, as ascertained by Bergman, Fourcroy, and Vauquelin, observe the following order:

Lime,
Barytes,
Strontian,
Potass,
Soda,
Ammonia,
Glucina,
Alumina,
Zirconia,
Metallic oxides.

This acid has not hitherto been put to any use.

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* Fourcroy, ii. 86.

SECT. V.

OF CARBONIC ACID.

How procured.

CARBONIC ACID being a compound of carbon and oxygen, may be formed by burning charcoal; but as it exists in great abundance ready formed, it is not necessary to have recourse to that expedient. All that is necessary is to dilute with water a quantity of chalk, which is a compound of carbonic acid and lime, and to pour upon it sulphuric acid. An effervescence ensues, carbonic acid is evolved in the state of gas, and may be received in the usual manner.

As the rapid progress of chemistry during the latter part of the 18th century was in a great measure owing to the discovery of this acid, it may be worth while to trace the history of it somewhat particularly.

History.

Paracelsus and Van Helmont were acquainted with the fact, that air is extricated from solid bodies during certain processes, and the latter gave to air thus produced the name of *gas*. Boyle called these kinds of air *artificial airs*, and suspected that they might be different from the air of the atmosphere. Hales ascertained the quantity of air that could be extricated from a great variety of bodies, and shewed that it formed an essential part of their composition. Dr Black proved, that the substances then called *lime*, *magnesia*, and *alkalies*, are compounds, consisting of a *peculiar species of air*, and pure lime, magnesia, and alkali. To this species of air he gave the name of *fixed air*, because it existed in these bodies in a fixed state. This air or gas was afterwards investigated by Dr Priestley, and a great number of its properties ascertained. From these properties Mr Keir* first concluded that it was an acid; and this opinion was soon confirmed by the experiments of Bergman, Fontana, &c. Dr Priestley at first suspected that this acid entered as an element into the composition of atmospherical air; and Bergman, adopting the same opinion, gave it the name of *aerial acid*. Mr Bewdly called it *mephitic acid*, because it could not be respired without occasioning death; and this name was also adopted by Morveau. Mr Keir called it *calcareous acid;* and at last Mr Lavoisier, after discovering its composition, gave it the name of *carbonic acid gas*.

Composition.

The opinions of chemists concerning the *composition* of carbonic acid have undergone as many revolutions as its name. Dr Priestley and Bergman seem at first to have considered it as an element; and several celebrated chemists maintained that it was the acidifying principle. Afterwards it was discovered to be a compound, and that oxygen gas was one of its component parts. Upon this discovery the prevalent opinion of chemists was, that it consisted of oxygen and phlogiston; and when hydrogen and phlogiston came (according to Mr Kirwan's theory) to signify the same thing, it was of course maintained that carbonic acid was composed of oxygen and hydrogen: and though Mr Lavoisier demonstrated, that it was formed by the combination of carbon and oxygen, this did not prevent the old theory from being maintained; because carbon was itself considered as a compound, into which a very great quan-

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[*] Keir's *Macquer*, art. *Air*.

tity of hydrogen entered. But after Mr Lavoisier had demonstrated, that the weight of the carbonic acid produced was precisely equal to the charcoal and oxygen employed; after Mr Cavendish had discovered that oxygen and hydrogen when combined did not form carbonic acid, but water—it was no longer possible to hesitate that this acid was composed of carbon and oxygen. Accordingly all farther dispute about it seems now at an end. At any rate, as we have already examined the objections that have been made to this conclusion, it would be improper to enter upon them here.

If any thing was still wanting to put this conclusion beyond the reach of doubt, it was to *decompound* carbonic acid, and thus to exhibit its component parts by analysis as well as synthesis. This has been actually done by the ingenious Mr Tennant. Into a tube of glass he introduced a bit of phosphorous and some carbonat of lime. He then sealed the tube hermetically, and applied heat. Phosphat of lime was formed, and a quantity of charcoal deposited. Now phosphat of lime is composed of phosphoric acid and lime; and phosphoric acid is composed of phosphorus and oxygen. The substances introduced into the tube were phosphorus, lime, and carbonic acid; and the substances found in it were phosphorus, lime, oxygen, and charcoal. The carbonic acid, therefore, must have been decomposed, and it must have consisted of oxygen and charcoal. This experiment was repeated by Dr Pearson, who ascertained that the weight of the oxygen and charcoal were together equal to that of the carbonic acid which had been introduced; and in order to shew that it was the carbonic acid which had been decomposed, he introduced pure lime and phosphorus; and instead of obtaining phosphat of lime and carbon, he got nothing but phophuret of lime. These experiments [*] were also confirmed by Messrs Fourcroy, Vauquelin, Sylvestre, and Broigniart [†].

For the investigation of the properties of carbonic acid we are chiefly indebted to the labours of Cavendish [‡], Priestley [§], Bergman [‖], and Lavoisier [¶]. Valuable dissertations on it were also published by Macbride [**], Lane [††], Jacquin [‡‡], Landriani [§§], Fontana, and many other distinguished chemists.

Properties.

Carbonic acid, when in the state of gas, is invisible and elastic like common air. It extinguishes a candle, and is unfit for respiration. It has no smell.

Its specific gravity is about 0.0018 [‖‖]; but this varies according to its dryness or moisture [¶¶].

It reddens the tincture of turnsol, but no other vegetable colour [‡].

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[*] *Ann. de Chim.* xiii. 312.

[†] Count Mussin-Puschkin having boiled a solution of carbonat of potass on purified phosphorus, obtained charcoal. This he considered as an instance of the decomposition of carbonic acid, and as a confirmation of the experiments related in the text. See *Ann. de Chim.* xxv. 105.

[‡] *Phil. Trans.* 1766, lvi. 141.

[§] Priestley, i. 43.

[‖] *Opusc.* i. 1.

[¶] *Mem. Par.* 1776.

[**] *Experimental Essays*, 1764.

[††] Priestley, i. 5.

[‡‡] *Examen. Chem. Doct. Meyer, de Acido Pingui et Blackianæ de Aere Fixo*, 1769.

[§§] Crell's *Annals*, 1785. ii. 139.

[‖‖] Bergman, i. 9.

[¶¶] It is usually about twice as heavy as common air. Hence it may be poured from one vessel into another. When poured from a wide mouthed jar upon a burning candle, it extinguishes it like water.

[‡] Bergman, i. 9.

Atmospheric air is supposed to contain about $\frac{1}{100}$ part of this gas [*].

Carbonic acid gas is dilated by heat, but not otherwise alterated by it.

Water absorbs it gradually when allowed to remain long in contact with it. The rapidity of the absorption, as Mr Lane first discovered, is much increased by agitation. At the temperature of 41° water absorbs its own bulk of this gas. The specific gravity of water saturated with it is 1.0015. This water, at the temperature of 35°, has little taste; but if it be left a few hours in the temperature of 88°, it assumes an agreeable acidity, and a sparkling appearance [†].

Ice absorbs no carbonic acid; and if water containing it be frozen, the whole separates in the act of freezing [‡]. This gas also separates from water at the boiling temperature [§].

By means of artificial pressure, the quantity of this gas absorbed and condensed by water is much increased. Some of the *aerated alkaline water*, prepared in London as a medicine, is said to contain about thrice its volume of carbonic acid gas.

When this liquid carbonic acid is left exposed to the air in an open vessel, the acid soon makes its escape in the form of gas, and leaves the water in a state of purity. This is owing to its affinity for common air;

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[*] At least near the surface of the earth. Lamanon, Mongez, and the other unfortunate philosophers who accompanied La Perouse in his last voyage, have rendered it not improbable that at great heights the quantity of this gas is much smaller. They could detect none in the atmosphere at the summit of the Peak of Teneriffe.—See Lamanon's *Memoir at the end of La Perouse's Voyage.*

[†] Bergman, i. 9.

[‡] Priestley, i. 120.

[§] Ibid.

which is so strong, that air, as Welter observed, is capable of abstracting it from water *. Bergman left a bottle filled with carbonic acid gas uncorked, and found that in a few days it contained nothing but common air.

Carbonic acid is not acted upon by oxygen, nor is it altered by any of the simple combustibles or metals. Charcoal indeed absorbs it, but it gives it out again unchanged. From the experiments of Rouppe and Van Noorden, it appears that this absorption is exceedingly rapid, provided the charcoal be sufficiently freed from air, by allowing it to cool from a red heat in a vacuum. They found that charcoal is capable of absorbing rather more than fourteen times its bulk of carbonic acid gas †.

Phosphorus is insoluble in carbonic acid gas ‡. But phosphorus is capable of decomposing this acid by compound affinity, when assisted by a sufficient heat, as has been demonstrated by Tennant and Pearson. Iron also and zinc, and several other metals, are capable of producing the same effect, as has been discovered by Priestley and Cruickshank. In the first case the phosphorus is partly acidified, partly combined with lime, and charcoal is deposited : in the second, the metals are oxidated, and gaseous oxide of carbon evolved §.

When carbonic acid is mixed with sulphurated, phosphorated or carbonated hydrogen gas, it renders them

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* *Ann. de Chim.* iii. 91. † Ibid. xxxii. 11.

‡ Fourcroy and Vauquelin. Ibid. xxi. 205.

§ In these experiments the phosphorus or the metals are mixed with carbonat of lime. The first has been described in the present Section; the second in the last Chapter, when treating of the gaseous oxide of carbon.

Book II.

less combustible, but produces no farther sensible change.

Carbonats.

This acid is capable of combining with alkalies, and with several of the earths and metallic oxides, and forms with them salts, distinguished by the name of *carbonats*. All the earthy carbonats are insoluble in water. Hence the reason that carbonic acid renders lime water, barytic water, and strontian water turbid. The earth held in solution in these waters combines rapidly with the carbonic acid, which is of course absorbed, if in the state of gas, while the carbonat formed precipitates slowly in the form of a white powder. This occasions the milkiness which immediately ensues. As carbonic acid is the only gas not instantaneously absorbable by water, which renders lime water, or barytic or strontian water, turbid; its presence may be always ascertained by means of these liquids. As it is completely absorbed by them, it may be easily separated by them from other gases with which it may be mixed, and its quantity ascertained by the diminution of volume which the residuum of gas has undergone.

The affinities of carbonic acid, as far as they have been ascertained, observe the following order:

Affinities.

Barytes,
Strontian,
Lime.
Potass,
Soda,
Magnesia,
Ammonia,
Glucina,
Zirconia,
Metallic oxides.

From the experiments of Saussure, it appears that carbonic acid does not combine with alumina *.

Water containing a little soda, and supersaturated with carbonic acid, has been employed with much advantage under the name of *aerated alkaline water*, as a palliative in cases of urinary calculus.

SECT. VI.

OF NITRIC ACID.

Preparation.

NITRIC ACID is generally obtained in large manufactories by distilling a mixture of nitre and clay; but the acid procured by this process is weak and impure. Chemists generally prepare it by distilling three parts of nitre and one of sulphuric acid in a glass retort. This method was first used by Glauber. The neck of the retort must be luted into a receiver, from which there passes a glass tube into a bottle with two mouths, containing a little water, and furnished with a tube of safety †. From the other mouth of this bottle there

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* *Jour. de Phys.* lii. 280.

† A tube of safety is a tube open at its upper end, and having its lower end plunged in water. The water prevents any communication between the external air and the inside of the apparatus. If a vacuum happens to be formed within the vessels, the external air reaches down through the tube and prevents any injury to the vessels. On the other hand, if air is generated in the vessels, it forces the water up the tube, the height of which becomes thus the measure of the elasticity of the air in the vessels. By this contrivance the apparatus is in no danger of being broken, which otherwise might happen.

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passes a tube into a pneumatic apparatus to collect the gas which is evolved during the process. The apparatus is represented in fig. 9. The retort is to be heated gradually almost to redness. The nitric acid comes over and is condensed in the receiver, while the common air of the vessels, and a quantity of oxygen gas which is evolved, especially towards the end of the process, passes into the pneumatic apparatus, and the water in the bottles is impregnated with some acid which is not condensed in the receiver.

The acid, thus obtained, is of a yellow colour, and almost always contains muriatic and sometimes sulphurous acid. These may be removed by distilling it over again with a moderate heat, and changing the receiver after the first portion, which contains all the foreign acids, has passed. It still contains a quantity of nitrous gas, to which it owes its colour and the red fumes which it exhales. This gas may also be expelled by the application of heat. Pure *nitric acid* remains behind, transparent and colourless, like water.

History.

It seems to have been first obtained in a separate state by Raymond Lully, who was born at Majorca in 1235. He procured it by distilling a mixture of nitre and clay. Basil Valentine, who lived in the 15th century, describes the process minutely, and calls the acid *water of nitre*. It was afterwards denominated *aqua fortis* and *spirit of nitre*. The name *nitric acid* was first given it in 1787 by the French chemists.

Nitric acid is one of the most important instruments of analysis which the chemist posseses ; nor is it of inferior consequence when considered in a political or commercial view, as it forms one of the most essential ingredients of gunpowder. Its nature and composition accordingly have long occupied the attention of philosophers. Let us endeavour to trace the various steps by which its component parts were discovered.

As nitre is often produced upon the surface of the earth, and never except in places which have a communication with atmospheric air, it was natural to suppose that air, or some part of the air, entered into the composition of nitric acid. Mayow having observed, that nitre and atmospherical air were both possessed of the property of giving a red colour to the blood, and that air was deprived of this property by combustion and respiration—concluded, that nitre *contained that part of the air which supported combustion, and was necessary for respiration.*

Dr Hales, by applying heat to nitric acid, and what he called *Walton mineral*, obtained a quantity of air possessed of singular properties. When atmospherical air was let into the jar which contained it, a reddish turbid fume appeared, a quantity of air was absorbed, and the remainder became transparent again*. Dr Priestley discovered, that this air could only be obtained from nitric† acid; and therefore called it *nitrous air*. He found, that when this gas was mixed with oxygen gas, nitrous acid was reproduced. Here, then, we find that oxygen is a part of the nitric acid, and consequently that Mayow's affirmation is verified.

Dr Priestley, however, explained this fact in a different manner. According to him, nitrous gas is com-

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* *Veget. Statics*, ii. 284.

† Or nitrous acid; for at the period of Dr Priestley's discovery (1772) they were not accurately distinguished.

posed of nitrous acid and phlogiston. When oxygen is added, it separates this phlogiston, and the acid of course is precipitated. This hypothesis was adopted by Macquer and Fontana; and these three philosophers endeavoured to support it with their usual ingenuity. But there was one difficulty which they were unable to surmount. When the two gases are mixed in proper proportions, almost the whole assumes the form of nitrous acid; and the small residuum ($\frac{1}{34}$th part), in all probability, or rather certainly, depends on some accidental impurity in the oxygen gas. What then becomes of the oxygen and phlogiston? Dr Priestley supposed that they formed carbonic acid gas; but Mr Cavendish proved, that when proper precautions are taken, no such acid appears [*].

Dr Priestley had procured his nitrous gas by dissolving metals in nitric acid; during the solution of which a great deal of nitrous gas escapes. He supposed that nitrous gas contained phlogiston, because the metal was oxidated (and consequently, according to the then received theory, must have lost phlogiston) during its formation. Mr Lavoisier proved, that this supposition was ill-founded, by the following celebrated experiment [†]. To 945 grains of nitric acid (specific gravity 1.316) he added 1104 grains of mercury. During the solution 273.234 cubic inches of nitrous gas were produced. He then distilled the salt (oxide of mercury) which had been formed to dryness. As soon as it became red hot it emitted oxygen gas, and continued to do so till almost the whole of the mercury was revived: The quantity of oxygen emitted was 287.742 cubic inches. All that

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[*] *Phil. Trans.* 1784.

[†] *Mem. Par.* 1776, p. 673.

had happened, therefore, during the solution of the mercury, was the separation of the acid into two parts; nitrous gas which flew off, and oxygen which united with the metal.

Mr Lavoisier concluded, therefore, that the whole of the nitrous gas was derived from the nitric acid; that nitric acid is composed of oxygen and nitrous gas; and that the proportions are nearly 64 parts by weight of nitrous gas, and 36 of oxygen gas.

But there was one difficulty which Mr Lavoisier acknowledged he could not remove. The quantity of oxygen obtained by decomposing nitric acid was often much greater than what was necessary to saturate the nitrous gas. Mr De Morveau attempted to account for this; but without success*. Nitrous gas itself was evidently a compound: but the difficulty was to discover the ingredients. Mr Lavoisier concluded, from an experiment made by decomposing nitre by means of charcoal, that it contained azot; and several of Dr Priestley's experiments led to the same result. But what was the other ingredient?

Mr Cavendish had observed, while he was making experiments on the composition of water, that some nitric acid was formed during the combustion of oxygen and hydrogen gas, and that its quantity was increased by adding a little azot to the two gases before the explosion. Hence he concluded, that the formation of the acid was owing to the accidental presence of azotic gas. To verify this conjecture, he passed an electrical shock through a quantity of common air inclosed in a glass tube: the air was diminished, and some nitric acid

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* *Encyc. Method. Chim. Acide Nitrique.*

Book II.

formed. He repeated the experiment, by mixing together oxygen and azotic gas; and found, that when they bore a certain proportion to each other they were totally convertible into nitric acid. In one experiment the proportion of azot to oxygen (in bulk) was as 416 to 914; in another, as 1920 to 4860 *.

These experiments were immediately repeated by Messrs Van Marum and Van Troostwyk, and with nearly the same result.

The most convenient method of performing them is the following: Take a glass tube, the diameter of which is about the sixth part of an inch, through the cork that shuts one end of which let a small metallic conductor pass with a ball at each end. Fill this tube with mercury, and plunge its open end into a bason of mercury: then put into it a mixture of 0.13 of azotic and 0.87 of oxygen gas, till it occupies three inches of the tube; and introduce a solution of potass till it fill half an inch more. Then, by means of the conductor, make electrical explosions (from a very powerful machine) to pass through the tube till the air is as much diminished as possible. Part of the potass will be found converted into nitre. Mr Cavendish actually saturated the potass with this acid. Mr Van Marum did not, though a good deal more gas had disappeared than in the experiments of Mr Cavendish. This difference evidently depends on the quantity of potass contained in a given weight of the solution. The solution which Mr Van Marum used was no doubt stronger than that which Mr Cavendish employed.

Dr Priestley had observed several years before these

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* *Phil. Trans.* 1783.

experiments were made, that atmospherical air was diminished by the electric spark, and that during the diminution the infusion of turnsole became red; but he concluded merely that he had precipitated the acid of the air. Landriani, who thought, on the contrary, that carbonic acid gas was formed, enounced the alteration of lime-water by it as a proof of his opinion. It was to refute this notion that Mr Cavendish undertook his experiments. He has since that time repeated them with the same success[*].

Composition.

It cannot be doubted, then, that nitric acid is composed of azot and oxygen; consequently nitrous gas is also composed of the same ingredients. And as nitrous gas absorbs oxygen, even from common air, and forms with it nitric acid, it is evident that nitric acid contains more oxygen than nitrous gas. But it is exceedingly difficult to ascertain the exact proportions of the component parts of this acid. Lavoisier concluded, from his experiments on the decomposition of nitre by charcoal, that nitric acid is composed of one part of azot and four parts of oxygen[†]. But Davy has shown, that this decomposition is more complicated than had been supposed; and that Lavoisier's experiments by no means warrant the conclusion which he drew from them[‡]. Cavendish, on the other hand, concluded, from his experiments, that the acid which he formed, by combining together azot and oxygen by means of electricity, is composed of one part of azot and 2.346 of oxygen[§]. With this result the late experiments of Mr Davy correspond very nearly. He formed his standard acid by

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[*] *Phil. Trans.* 1788.

[†] *Mem. de Sav. Etrang.* xi. 226.

[‡] Davy's *Researches*, p. 44.

[§] *Phil. Trans.* lxxviii. 276.

combining together known quantities of nitrous gas and oxygen. According to him, 100 parts of pure nitric acid are composed of

29.5	azot
70.5	oxygen
100.0 *	

This, in all probability, does not differ much from the truth. If there be an error, the proportion of oxygen is under-rated; for Mr Davy's standard acid certainly contained nitrous gas combined with it, the proportion of which it was impossible to ascertain exactly.

Properties.

Nitric acid is liquid, colourless, and transparent; but the affinity between its component parts is so weak, that the action of light is sufficient to drive off a part of its oxygen in the form of gas; and thus, by converting it partly into nitrous gas, to make it assume a yellow colour. Its taste is exceedingly acid and peculiar. It is very corrosive, and tinges the skin of a yellow colour, which does not disappear till the epidermis comes off. It is constantly emitting white fumes which have an acrid disagreeable odour.

It has a strong affinity for water, and has never yet been obtained except mixed with that liquid. When concentrated, it attracts moisture from the atmosphere, but not so powerfully as sulphuric acid. It also produces heat when mixed with water, owing evidently to the concentration of the water.

The specific gravity of the strongest nitric acid that can be procured is, according to Rouelle, 1.583; but

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* Davy's *Researches*, p. 11.

at the temperature of 60°, Mr Kirwan could not procure it stronger than 1.5543.

But as this liquid acid is a compound of two ingredients, namely, pure nitric acid and water, it becomes an object of the greatest consequence to ascertain the proportion of each of these parts. This problem has lately occupied the attention of Mr Kirwan, who has endeavoured to solve it in the following manner.

He dried a quantity of crystallized carbonat of soda in a red heat, and dissolved it in water, in such a proportion that 367 grains of the solution contained 50.05 of alkali. He saturated 367 grains of this solution with 147 grains of nitric acid, the specific gravity of which was 1.2754, and which he ascertained to contain 45.7 *per cent.* of acid, of the specific gravity 1.5543, chosen by him as a standard. The carbonic acid driven off amounted to 14 grains. On adding 939 grains of water, the specific gravity of the solution, at the temperature of 58.5°, was 1.0401. By comparing this with a solution of nitrat of soda, of the same density, precisely in the manner described formerly under sulphuric acid, he found, that the salt contained in it amounted to $\frac{1}{16.901}$ of the whole. There was an excess of acid of about two grains. The weight of the whole was 1439 grains: The quantity of salt consequently was $\frac{1439}{16.901} = 85.142$ grains. The quantity of alkali was $50.05 - 14 = 36.05$. The quantity of standard acid employed was 66.7. The whole of which amounted to 102.75 grains; but as only 85.142 grains entered into the composition of the salt, the remaining 17.608 must have been pure water mixed with the nitric acid. But if 66.7 of standard acid contain 17.608 of water, 100 parts of the same acid must contain 26.38 *.

Strength.

One hundred parts of standard nitric acid, therefore, is composed of 73.62 parts of pure nitric acid and 26.38 of water. But as Mr Kirwan has not proved that nitrat of soda contains no water, perhaps the proportion of water may be greater. He has rendered it probable, however, that nitrat of soda contains very little water.

Mr Kirwan's real acid, then, is nitric acid, of that degree of strength which enters into the composition of nitrat of soda. The proportion of this real acid, contained in nitric acid of different specific gravities, has been given by Mr Kirwan in the following TABLE:

100 Parts Sp. Gravity.	Real Acid.	100 Parts Sp. Gravity.	Real Acid.
1.5543	73.54	1.4373	56.62
1.5295	69.86	1.4324	55.89
1.5183	69.12	1.4275	55.15
1.5070	68.39	1.4222	54.12+
1.4957	67.65	1.4171	53.68
1.4844	66.92	1.4120	52.94
1.4731	66.18	1.4069	52.21
1.4719	65.45	1.4018	51.47
1.4707	64.71	1.3975	50.74
1.4695	63 98+	1.3925	50.00
1.4683	63.24	1.3875	49.27
1.4671	62.51	1.3825	48.53
1.4640	61.77	1.3775	47.80
1.4611	61.03	1.3721	47.06
1.4582	60.30	1.3671	46.33
1.4553	59.56	1.3621	45.59
1.4524	58.83	1.3571	44.86+
1.4471	58.09	1.3521	44.12
1.4422	57.36	1.3468	43.38

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* *Irish Trans.* v.

100 Parts Sp. Gravity.	Real Acid.	100 Parts Sp. Gravity.	Real Acid.
1.3417	42.65	1.2209	27.94
1.3364	41.91	1.2180	27.21 +
1.3315	41.18	1.2152	26.47
1.3264	40.44	1.2033	25.74 +
1.3212	39.71	1.2015	25.00
1.3160	38.97	1.1963	24.26
1.3108	38.34	1.1911	23.53
1.3056	37.50	1.1845	22.79
1.3004	36.77	1.1779	22.06
1.2911	36.03	1.1704	21.32
1.2812	35.30 +	1.1639	20.59
1.2795	34.56	1.1581	19.85
1.2779	33.82	1.1524	19.12
1.2687	33.09	1.1421	18.48
1.2586	32.35	1.1319	17.65 +
1.2500	31.62	1.1284	16.91
1.2464	30.88	1.1241	16.17
1.2419	30.15	1.1165	15.44
1.2374	29.41	1.1111	14.70
1.2291	29.68	2.1040	13.27

Mr Davy considers as pure acid the permanently elastic vapour or gas formed by saturating nitrous gas with oxygen gas. This gas is of a pale yellow colour, and a specific gravity 2.44 times that of air. It is not pure acid, containing undoubtedly a portion of nitrous gas. The following TABLE exhibits the proportion of this acid contained in nitric acid of different densities, according to the experiments of that ingenious chemist *.

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* Davy's *Researches*, p. 41.

100 Parts Nitric Acid, of Sp. Gr.	True Acid	Water.
1.5040	91.55	8.45
1.4475	80.39	19.61
1.4285	71.65	28.35
1.3906	62.96	37.04
1.3551	56.88	43.12
1.3186	52.03	47.97
1.3042	49.04	50.96
1.2831	46.03	53.97
1.2090	45.27	54.73

Action of heat.

When nitric acid is exposed to the action of heat, it boils at the temperature of 248 *, and evaporates completely without alteration; but when made to pass through a red hot porcelain tube, it is decomposed, and converted into oxygen and azotic gas †. When cooled down to —66, it begins to congeal; and when agitated, is converted into a mass of the consistence of butter ‡.

Action on combustibles.

Oxygen gas has no action whatever on nitric acid; but all the simple combustibles decompose it, excepting only azot, and perhaps also the diamond. When poured upon sulphur or phosphorus at a high temperature, it sets them on fire; but at a moderate temperature it converts them slowly into acids, while nitrous gas is exhaled. It inflames charcoal also at a high temperature, and even at the common temperature, provided the charcoal be perfectly dry and minutely divided §. Hydrogen gas produces no change on it at the temperature of the atmosphere; but when passed along with it

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* Bergman, ii. 142.

† Fourcroy, ii. 82.

‡ Fourcroy and Vauquelin, *Ann. de Chim.* xxix. 282.

§ Proust.

through a red hot porcelain tube, it detonates with great violence; water is formed, and azotic gas evolved *.

Inflames oils.

When this acid is poured upon oils, it sets them on fire. This is occasioned by a decomposition both of the acid and oil. The oxygen of the acid combines with the carbon and with the hydrogen of the oils, and at the same time lets go a quantity of caloric. Hence we see that the oxygen which enters into the composition of the nitric acid still contains a great deal of caloric; a fact which is confirmed by a great number of other phenomena. The combustion of oils by this acid was first taken notice of by Borrichius and Slare; but it is probable that Homberg communicated it to Slare. In order to set fire to the fixed oils, it must be mixed with some sulphuric acid; the reason of which seems to be, that these oils contain *water*, which must be previously removed. The sulphuric acid combines with this water, and allows the nitric acid, or rather the oil and nitric acid together, to act. The drying oils do not require any sulphuric acid: they have been boiled, and consequently deprived of all moisture.

Action on metals.

It is capable of oxidating all the metals except gold, platinum †, and titanium. It appears, from the experiments of Scheffer, Bergman, Sage, and Tillet, that nitric acid is capable of dissolving (and consequently of oxidating) a very minute quantity even of gold.

It even sets fire also to zinc, bismuth, and tin, if it

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* Fourcroy, ii. 82.

† Nitre, however, acts upon platinum, as Mr Tennant has proved. *Phil. Trans.* 1797.—Morveau had made the same observation in the *Elemens de Chimie de l'Academie de Dijon.*

be poured on them in fusion, and to filings of iron if they be perfectly dry *.

Nitrats.

Nitric acid combines with alkalies, earths, and the oxides of metals, and forms compounds which are called *nitrats*.

The order of its affinities is as follows:

Affinities.

Barytes,
Potass,
Soda,
Strontian,
Lime,
Magnesia,
Ammonia,
Glucina,
Alumina,
Zirconia,
Metallic oxides.

SECT. VII.

OF NITROUS ACID.

Formation.

NITROUS ACID may be formed by causing nitrous gas to pass through nitric acid. The gas is absorbed, and the acid assumes a yellow colour, and its specific gravity is diminished. In this state it is called *nitrous acid*. It is always in this state that it is obtained by distilling a mixture of sulphuric acid and

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* Proust, Dijon Academicians, and Cornette.

nitre. The acid of commerce is always nitrous acid. The nitric and nitrous acids were first distinguished with accuracy by Scheele. The latter was for some time distinguished by chemists by the name of *phlogisticated nitrous acid,* because it was considered as a compound of nitric acid and phlogiston.

Composition.

The nature of nitrous acid was first investigated by Dr Priestley, who demonstrated, by very decisive experiments, that it is a compound of nitric acid and nitrous gas. This opinion was embraced, or rather it was first fully developed, by Morveau [*]. But the theory of Lavoisier, which supposed the difference between nitric and nitrous acids to depend merely on the first containing a greater proportion of oxygen than the second, for some time drew the attention of chemists from the real nature of nitrous acid. Raymond published a dissertation in 1796, to demonstrate the truth of the theory of Priestley and Morveau; and the same thing has been done still more lately by Messrs Thomson and Davy [†]. At present it is allowed by every one, that nitrous acid is merely nitric acid more or less impregnated with nitrous gas.

This being the case, and nitric acid being capable of absorbing very different proportions of nitrous gas, it is evident that there must be a great variety of nitrous acids, differing from each other in the proportion of nitrous gas which they contain; unless we choose to confine the term *nitrous acid* to the compound formed by saturating nitric acid completely with nitrous gas.

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[*] *Encyc. Method. Chim.* i. 189.

[†] Davy's *Researches*, p. 30.

Book II.

When nitrous gas is placed in contact with nitric acid, the acid absorbs it slowly, and acquires first a pale yellow colour, then a bright yellow: When a considerable portion more of nitrous gas is absorbed, the acid becomes dark orange, then olive, which increases in intensity with the gas absorbed; then it becomes of a bright green; and, lastly, when fully saturated, it becomes blue green. Its volume and its volatility also increase with the quantity of gas absorbed; and when fully saturated, it assumes the form of a dense vapour, of an exceedingly suffocating odour, and difficultly condensible by water. In this state of saturation it is distinguished by Dr Priestley by the name of *nitrous acid vapour*. It is of a dark red colour, and passes through water partly without being absorbed. The quantity of nitrous gas absorbed by nitric acid is very great. Dr Priestley found, that a quantity of acid, equal in bulk to four pennyweights of water, absorbed 130 ounce measures of gas without being saturated *. The component parts of nitrous acid, of different colours and densities, may be seen in the following Table, drawn up by Mr Davy from experiments made by him on purpose, with much precision †.

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* Priestley, i. 383.

† Davy's *Researches*, p. 37.

100 Parts	Sp. Grav.	Component Parts.		
		Nitric Acid	Water	Nitrous Gas
Solid nitric acid	1.504	91.55	8.45	—
Yellow nitrous	1.502	90.5	8.3	2
Bright yellow .	1.500	88.94	8.10	2.96
Dark orange . .	1.480	86.84	7.6	5.56
Light olive . . .	1.479	86.00	7.55	6.45
Dark olive . . .	1.478	85.4	7.5	7.1
Bright green . .	1.476	84.8	7.44	7.76
Blue green . . .	1.475	84.6	7.4	8.00

The colour of nitrous acid depends, in some measure, also on the proportion of water which it contains. When to yellow nitrous acid concentrated, a fourth part by weight of water is added, the colour is changed from red to a fine green; and when equal parts of water are added, it becomes blue*. Dr Priestley observed, that water impregnated with this acid in the state of vapour became first blue, then green, and lastly yellow. A green nitrous acid became orange-coloured while hot, and retained a yellow tinge when cold. A blue acid became yellow on being heated in a tube hermetically sealed. An orange-coloured acid, by long keeping, became green, and afterwards of a deep blue; and when exposed to air, resumed its original colour. When nitrous acid is exposed to heat, the nitrous gas is expelled, and nitric acid remains behind. The gas, however, carries along with it a quantity of acid, especially if the acid be concentrated. But nitrous acid vapour is not altered in the least by exposure to heat†.

It is not altered by oxygen gas, common air, nor by azotic gas.

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* Bergman.

† Fourcroy, ii. 95.

Properties.

The simple combustibles and metals act upon it precisely as on nitric acid. It answers much better than nitric acid for inflaming oils and other similar bodies.

It converts sulphurous and phosphorous acids into sulphuric and phosphoric.

Nitrous acid vapour is absorbed by sulphuric acid, but seemingly without producing any change; for when water is poured into the mixture, the heat produced expels it in the usual form of red fumes*. The only singular circumstance attending this impregnation is, that it disposes the sulphuric acid to crystallize†. This fact, first observed by Dr Priestley in 1777‡, was afterwards confirmed by Mr Cornette.

It is absorbed also rapidly by nitric acid, which assumes the different colours which distinguish nitrous acid, according to the proportion which it imbibes.

Nitrous acid combines with alkalies, earths, and probably also with metallic oxides, and forms salts known by the name of *nitrites;* but as these combinations can-

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* Priestley, iii. 144.

† Ibid. p. 156.

‡ Bernhardt, however, relates, in 1765, that once, when he was distilling a mixture of ten pounds of nitre with an equal quantity of calcined vitriol, which he had put into a retort, to which was fitted an adapter between the retort and the receiver, which contained a quantity of water—he observed a considerable quantity of a white crystalline salt formed in the adapter, while the liquid acid passed as usual into the receiver. This salt was very volatile, smoked strongly when it was exposed to the air, and exhaled a red vapour; it burnt, to a black coal, wood, feathers, or linen, as sulphuric acid does; and where a piece of it fell, it evaporated in form of a blood-red vapour, till the whole of it disappeared. Half an ounce of these crystals dissolved in water with spurting and hissing, like that of a red hot iron dipped in water, and formed a green nitrous acid. Some of this salt being put into a bottle, which was not well stopped, entirely vanished. These crystals were evidently the same with Dr Priestley's. See Keir's *Dictionary*.

not be made directly, the affinities of this acid are unknown.

It is this acid, or this compound of nitric acid and nitrous gas, which is usually employed by chemists in their experiments; and for the greater number of purposes it answers even better than nitric acid.

SECT. VIII.

OF MURIATIC ACID.

Composition unknown.

WE are still unacquainted with the component parts of muriatic acid; but its resemblance to those acids which have been analysed is so striking, that it is at least highly probable that it is composed, like them, of a combustible basis combined with oxygen. Hydrogen has been suspected to constitute that base, probably because it is the only one of the simple combustibles which is not known to be the basis of an acid; but the experiments which have been made in consequence of this supposition are altogether hostile to it*. Berthollet has lately announced, that he thinks he has proved that muriatic acid is a triple compound, composed of azot combined with a little hydrogen and oxygen. His proof is, that muriatic acid is always formed when to

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* Girtanner announced, in 1790, in the *Journal de Physique*, that he had ascertained the basis of muriatic acid to be hydrogen; and in 1796 he published in his Chemistry (p. 154.) the facts upon which this assertion was founded. These *facts* (as he termed them) were examined and refuted by Van Mons and other philosophers (Crell's *Annals*, 1796, i.

Book II. the presence of nitric acid there is joined any circumstance which occasions the decomposition of water *.

Muriatic acid is always obtained from common salt; a substance in which it exists combined with soda. It may be procured by the following process. Put into a retort 100 parts of dry common salt, and pour over it about 70 parts of concentrated sulphuric acid. Apply a moderate heat to the bottom of the retort while its beak is plunged into a trough of mercury. A gas issues from the retort, which may be received in small glass jars previously filled with mercury, and suspended over the beak of the retort. This gas is *muriatic acid.*

Preparation.

History.

Muriatic acid appears to have been known to Basil Valentine; but Glauber was the first who extracted it from common salt by means of sulphuric acid. It was first called *spirit of salt*, afterwards *marine acid*, and now, pretty generally, *muriatic acid* †. It is prepared for commercial purposes, by mixing together one part of common salt and seven or eight parts of clay, and distilling the mixture; or by distilling the usual proportion of common salt and sulphuric acid, and receiving the product in a receiver containing water. By these processes it is obtained combined with water and forming a liquid; the only state in which it was known

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451.) Mr Henry has lately published a set of experiments, in order to determine whether muriatic acid can be decomposed by electricity. These valuable and laborious experiments were conducted with much address, and do the greatest credit, both to the abilities and industry of the author. They have demonstrated that electricity produces no change whatever upon muriatic acid, provided it be in a state of purity. See Nicholson's *Journal*, iv. 209.

* *Jour. de Phys.* lii. 55.

† From *muria.*

till Dr Priestley discovered the method of obtaining it perfectly pure in a gaseous form.

Properties.

Muriatic acid gas is invisible and elastic, like common air. It destroys life and extinguishes flame. A candle, just before it goes out in it, burns with a beautiful green, or rather light blue flame; and the same flame appears when it is first lighted again *. It has a strong pungent smell which excites coughing, and a very acid taste.

Its specific gravity is, according to Mr Kirwan †, 0.002315, which is nearly double that of common air.

It is not in the least altered by exposure to the action of light or heat. It passes unchanged through red hot porcelain tubes.

Water absorbs this gas with great avidity. If a little water be admitted into a jar filled with muriatic acid gas, the gas disappears almost instantaneously. Hence the necessity of making all experiments on it over mercury. Ten grains of water are capable of absorbing ten grains of the gas. The solution thus obtained occupies the space of 13.3 grains of water nearly. Hence its specific gravity is 1.500, and the density of the pure muriatic acid in it is 3.03 ‡. During the ab-

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* Priestley, ii. 293. † *Irish. Trans.* v.

‡ For let D = the density of a mixture; *m* the weight of the denser ingredient; *d* its density; *l* the weight of an equal bulk of water; and *m'*, *d'*, and *l'* the same elements of the rarer: Then $D = \frac{m + m'}{l + l'}$. In the above case, $m + m' = 20$, and $l + l' = 13.3$. Then $D = \frac{20}{13.3} = 1.5$. Now to find the specific gravity of the condensed muriatic acid gas, we have from the above equation $l = \frac{m + m' - l'D}{D} = \frac{5}{1.5} = 3.3$; and $d = \frac{m}{l} = \frac{10}{3.3} = 3.03$.—See *Irish Transactions*, vol. v.

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sorption of the gas, the water becomes hot, and its bulk is increased. Ice also absorbs this gas, and is at the same time liquefied. The quantity of this gas absorbed by water diminishes as the heat of the water increases, and at a boiling heat water will not absorb any of it. When water impregnated with it is heated, the gas is again expelled unaltered. Hence muriatic acid gas may be procured by heating the common muriatic acid of commerce. It was by this process that Dr Priestley first obtained it.

Liquid acid.

As it is only when dissolved in water that muriatic acid can be conveniently used, it is always procured for use in that state, and in that state it is always distinguished by the name of *muriatic acid.* It may be procured in a state of purity by the following process: A hundred parts of dry common salt are put into a glass matrass, to which there is adapted a bent glass tube that passes into a small Wolf's bottle. From this bottle there passes also a glass tube into another larger bottle, containing a quantity of water equal in weight to the common salt employed. When the apparatus is properly secured by luting, 75 parts of sulphuric acid are poured into the common salt through a mouth of the matrass, furnished with a proper stopper. Heat is then applied. The sulphuric acid displaces the muriatic acid, which passes over and is condensed in the water of the large bottle, while any sulphuric acid that may be driven over by the heat is condensed in the smaller

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This calculation, however, is formed upon the supposition that the water suffers no condensation at all—a supposition certainly contradicted by every analogy, and which, as Mr Keir has shewn, the experiments mentioned in Mr Kirwan's first paper are insufficient to prove.

bottle, and thus does not injure the purity of the muriatic acid.

The acid thus obtained is nearly colourless: it has a strong pungent smell similar to the gas, and when exposed to the air is constantly emitting visible white fumes. The muriatic acid of commerce is always of a pale yellow colour, owing to a small quantity of oxymuriatic acid, with which it is impregnated.

As muriatic acid can only be used conveniently when dissolved in water, it is of much consequence to know how much pure acid is contained in a given quantity of liquid muriatic acid of any particular density.

Strength.

Now the specific gravity of the purest muriatic acid that can easily be procured and preserved, is 1.196: it would be needless, therefore, to examine the purity of any muriatic acid of superior density. Mr Kirwan calculated that muriatic acid, of the density of 1.196, contains $\frac{49}{100}$ parts of acid of the density of 1.500, which he took for the standard, or 0.2528 of pure acid: then, by means of experiments, he formed the following TABLE:

100 Parts Sp. Gravity.	Real Acid.	100 Parts Sp. Gravity.	Real Acid.
1.196	25.28	1.1282	16.51
1.191	24.76	1.1244	15.99
1.187	24.25	1.1206	15.48
1.183	23 73	1.1168	14.96
1.179	23.22	1.1120	14.44
1.175	22.70	1.1078	13.93
1.171	22.18	1.1036	13.41
1.167	21.67	1.0984	12.90
1.163	21.15	1.0942	12.38
1.159	20.64	1.0910	11.86
1.155	20.12	1.0868	11.35
1.151	19.60	1.0826	10.83
1.147	19.09	1.0784	10.32
1.1414	18.57	1.0742	9.80
1.1396	18.06	1.0630	8.25
1.1358	17.54	1.0345	5.16
1.1320	17.02	1.0169	2.58

This acid has no action whatever on oxygen gas and the simple combustibles, neither when it is in a gaseous nor when in a liquid state. Charcoal indeed absorbs it, but without any alteration.

It is capable, by the assistance of heat, of oxidating the following metals: Iron, tin, lead, zinc, bismuth, cobalt, nickel, manganese, antimony, arsenic. Several of these, as iron for instance, it oxidates even without the assistance of heat.

At a boiling heat it oxidates silver and copper. It has no action on gold, platinum, mercury, tungsten, molybdenum, tellurium, titanium. Its action on uranium has not been tried. It is a better solvent of metallic oxides in general than any of the other acids.

It combines with the alkalies, earths, and with most of the metallic oxides, and forms salts, known by the name of *muriats*.

Affinities.

The affinities of muriatic acid are as follows:

Barytes,
Potass,
Soda,
Strontian,
Lime,
Ammonia,
Magnesia,
Glucina,
Alumina,
Zirconia,
Metallic oxides.

Effect of electricity.

When electric explosions are made to pass through muriatic acid gas, its bulk is diminished, and hydrogen gas is evolved. At the same time, if the experiment be made over mercury, a quantity of muriat of mercury is formed. These changes continue to take place for a limited time only, after which electricity ceases to produce any farther change. They are always proportional to the moisture of the gas, and have been shown by Mr Henry to be owing to the decomposition of the water held in solution by the gas. The oxygen of that water combines with part of the acid, and forms oxy-muriatic acid, while its hydrogen is set at liberty. Mr Henry has shown that 100 cubic inches of muriatic acid gas, after being made as dry as possible by standing over quicklime or other bodies which absorb moisture, still contain 1.4 grains of water in solution. But this water may be completely decomposed and removed by means of electricity. Here then is a method of depriving this gas altogether of water *. When muriatic acid gas and carbonated hydrogen gas are mixed, electricity decomposes the water, and carbonic acid and hydrogen gas are evolved. After the water is completely decomposed electricity produces no farther effect †.

Destroys putrid miasmata.

Morveau first shewed, that muriatic acid, in the state of gas, neutralizes putrid miasmata, and by that means destroys their bad effects. In 1773, the cathedral of Dijon was so infected by putrid exhalations, that it was deserted altogether after several unsuccessful attempts to purify it. Application was made to Mr Morveau, at that time professor of chemistry at Dijon, to see whether he knew any method of destroying these exhalations. Having poured two pounds of sulphuric acid on six pounds of common salt, contained in a glass capsule, which had been placed on a few live coals in the middle of the church, he withdrew precipitately, and shut all the doors. The muriatic acid gas soon filled the whole cathedral, and could even be perceived at the door. After twelve hours, the doors were thrown open, and a current of air made to pass through to remove the gas. This destroyed completely every putrid odour ‡.

SECT. IX.

OF OXY-MURIATIC ACID.

Formation.

OXY-MURIATIC ACID is composed of muriatic acid and oxgen. It may be procured by the following process: Put into a glass matrass a mixture of three parts

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* Nicholson's *Journal*, iv. 209.

† Henry. Ibid.

‡ *Jour. de Phys.* i. 436.

of common salt, and one part of the black oxide of manganese. From this matrass a bent glass must pass, either into water previously boiled and still warm, or, which is better, into a mercurial trough, and glass jars filled with water or mercury must be inverted over the end of the tube to receive the product. When the apparatus is fully prepared, two parts of concentrated sulphuric acid * are to be poured into the matrass, and the aperture instantly closed. A violent effervescence ensues, and a great quantity of gas issues from the tube. This gas is *oxy-muriatic acid.*

Discovery.

This acid was discovered by Scheele in 1774, during his experiments on manganese. He gave it the name of *dephlogisticated muriatic acid*, from the supposition that it is muriatic acid deprived of phlogiston. The French chemists, after its composition had been ascertained, called it *oxygenated muriatic acid;* which unwieldy appellation Kirwan has happily contracted into *oxy-muriatic.*

The properties of this acid pointed out by Scheele were so peculiar, that it immediately attracted attention, and the most distinguished chemists hastened with emulation to enter upon a field which promised so rich

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* This acid ought to be previously diluted with rather more than its weight of water, otherwise the matrass almost always cracks during the process. It is scarcely necessary to mention, that heat must be applied at least towards the end of the process. I find the most convenient method for filling a number of vessels with oxy-muriatic acid gas is to attach them to each other by means of glass tubes, as in Woulfe's apparatus, and to insert the last tube into a solution of potass. The gas gradually displaces the common air, and fills the vessels, and the potass absorbs that part of the gas which pervades the whole of the vessels, and prevents it from incommoding the operator.

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a harvest of discoveries; Bergman, Pelletier, Bertho[illegible]t, Hermstadt, Morveau, Fourcroy, Scopoli, Westrum, &c. successfully examined its properties, and ascertained its action on other bodies.

Composition.

The true theory of the formation and composition of this acid, which was first given by Berthollet, will appear from the following facts: The *black* oxide of manganese is, during the process, converted into *white* oxide, and must therefore have given out a quantity of oxygen. When oxy-muriatic acid dissolved in water is presented to the light in a vessel half empty, oxygen gas is disengaged and floats above, and the acid is converted into common muriatic acid: consequently oxy-muriatic acid is composed of muriatic acid and oxygen.

Properties.

Oxy-muriatic acid gas is of a yellowish green colour. Its odour is intolerably acrid and suffocating. It cannot be breathed without proving fatal. The death of the ingenious and industrious Pelletier, whose chemical labours have been so useful to the world, was occasioned by his attempting to respire it. A consumption was the consequence of this attempt, which, in a short time, proved fatal. When atmospheric air containing a mixture of it is breathed, it occasions a violent and almost convulsive cough, attended with much pain in the chest. This cough usually continues to return at intervals for a day or two, and is accompanied with a copious expectoration.

Supports flame.

It is capable of supporting combustion in many cases, even more capable than common air. When a burning taper is plunged into it, the flame is diminished, and acquires a very red colour; a great quantity of smoke is emitted, and at the same time the taper consumes much more rapidly than in common air *. The facility with which bodies take fire in this gas, is owing to the ease with which it parts with its oxygen.

This gas is neither altered by exposure to light nor to caloric. It passes unaltered through red hot porcelain tubes †.

Solution in water.

It does not unite readily with water. Scheele found, that after standing 12 hours over water, $\frac{4}{5}$ths of the gas were absorbed: the remainder was common air, which no doubt had been contained in the vessel before the operation. Berthollet surrounded several bottles containing it with ice: as soon as the water in these bottles was saturated, the gas became concrete, and sunk to the bottom of the vessels; but the smallest heat made it rise in bubbles, and endeavour to escape in the form of gas ‡. Westrum observed that it became solid when exposed in large vessels to the temperature of 40°; and that then it exhibited a kind of crystallization §. The specific gravity of water, saturated with this gas at the temperature of 43°, is 1.003 ‖. Water impregnated with this gas is usually distinguished by the name of oxy-muriatic acid. It has a pale greenish-yellow colour, and a suffocating odour like the gas; its taste is not acid, but astringent. It is usually prepared by causing the gas to pass through a succession of Woulfe's bottles, nearly filled with pure water. Light decomposes this acid, as Berthollet discovered, though it has no action on the gas.

It renders vegetable colours *white*, and not red, as

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* Fourcroy, *Ann. de Chim.* iv. 251.

† Fourcroy, ii. 110.

‡ *Jour. de Phys.* 1785.

§ Ibid. xxxvii. 382.

‖ Berthollet, *Jour. de Phys.* 1785.

other acids do; and the colour thus destroyed can neither be restored by acids nor alkalies. It has the same effects on yellow wax. If the quantity of vegetable colours to which it is applied be sufficiently great, it is found reduced to the state of common muriatic acid. Hence it is evident, that it destroys these colours by communicating oxygen. This property has rendered oxy-muriatic acid a very important article in bleaching.

Oxy-muriatic acid is not altered by oxygen gas, nor by azotic gas; but all the other simple combustibles are capable of decomposing it.

Action on combustibles,

Hydrogen gas produces no alteration in this acid gas as long as the mixture continues cold; but when it is made to pass through a red hot porcelain tube, a violent detonation takes place *.

When melted sulphur is plunged into it, inflammation also takes place, and the sulphur is converted into sulphuric acid†; but cold sulphur, though it is partly acidified by this gas, does not take fire in it‡.

When phosphorus is plunged into this gas, it immediately takes fire, burns with great splendour, and is converted into phosphoric acid. This was first described by an anonymous German writer§, and afterwards by Westrum, Schmeisser, Fourcroy, and Vauquelin‖.

When charcoal in fine powder is thrown into this gas heated to about 90°, it also takes fire, according to Westrum; but this experiment has not succeeded in the hands of other chemists. If we believe professor Lampadius, the diamond also, when heated to redness,

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* Fourcroy, ii. 110.

† Ibid.

‡ Westrum, Crell's *Annals*, i. 150. English Transl.

§ Crell's *Beitrage*, vol. i. part 3.

‖ *Ann. de Chim.* iv. 253.

and plunged into oxy-muriatic acid gas, burns in it with great splendour.

Sulphurated, phosphorated, and carbonated hydrogen gas likewise decompose this acid; but none of them, except phosporated hydrogen, produce spontaneous inflammation with it.

On metals,

Oxy-muriatic acid oxidates all the metals without the assistance of heat. Several of them even take fire as soon as they come into contact with the gas, as Westrum first discovered. All that is necessary is to throw a quantity of the metal reduced to a fine powder into a vessel filled with the gas. The inflammation takes place immediately; the metal is oxidated, while the acid, decomposed and reduced to common muriatic acid, combines with the oxide, and forms a muriat. Arsenic burns in oxy-muriatic acid gas with a blue and green flame; bismuth, with a lively bluish flame; nickel, with a white flame, bordering on yellow; cobalt, with a white flame, approaching to blue; zinc, with a lively white flame; tin, with a feeble bluish flame; lead, with a sparkling white flame; copper and iron, with a red flame[*]. Several of the metallic sulphurets, as cinnabar, realgar, sulphuret of antimony take fire when thrown in powder into this gas.

On ammonia.

When oxy-muriatic acid gas and ammoniacal gas are mixed together, a rapid combustion, attended with a white flame, instantly takes place; both the gases are decomposed, water is formed, while azotic gas and muriatic acid are evolved[*]. The same phenomena are apparent, though in a smaller degree, when liquid ammo-

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[*] *Jour. de Phys* xxxvii. 385.

[†] Fourcroy, *Ann. de Chim.* iv. 255.

nia is poured into the acid gas*. The same decomposition takes place though both the acid and alkali be in a liquid state. If four-fifths of a glass tube be filled with oxy-muriatic acid, and the remaining fifth with ammonia, and the tube be then inverted over water, an effervescence ensues, and azotic gas is extricated†. It was by a similar experiment that Berthollet demonstrated the composition of ammonia.

Oxy-muriats.

This acid is capable of combining with fixed alkalies, earths, and several metallic oxides, and of forming salts of a very peculiar nature, distinguished by the name of *oxy-muriats*. As these combinations cannot be made directly with liquid oxy-muriatic acid, it has been hitherto impossible to ascertain the affinities of this acid.

Oxy-muriatic acid gas reddens nitrous gas, and converts it into nitrous acid. It produces no effect upon any of the acids hitherto described, except the sulphurous and phosphorous, which it converts into sulphuric and phosphoric.

Nature of nitro-muriatic acid.

When muriatic acid is mixed with nitric acid, the compound has precisely the smell and the qualities of oxy-muriatic. This mixture of the two acids was formerly called *aqua regia ;* but at present it is usually denominated *nitro-muriatic acid*. It is first mentioned by Isaac Hollandus, and seems to have been known before the muriatic acid itself. It was prepared by pouring nitric acid on common salt. The nitric acid decomposes the salt, and part of it unites with the muriatic acid thus set at liberty. As soon as these two

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* Westrum, Crell's *Annals*, i. 161. English Transl.

† *Jour. de l'Ecole Polytechn.*

acids are mixed they begin to act upon each other. The muriatic acid decomposes part of the nitric, combines with its oxygen, and is thus partly converted into oxy-muriatic acid. Hence the suffocating odour of that acid which the mixture exhales. The nitrous gas, thus set at liberty, is absorbed by the undecomposed nitric acid, and converts it into nitrous acid. When these mutual combinations are completed, the action of the two acids on each other ceases. Thus nitro-muriatic acid is a mixture or combination of nitrous acid, muriatic acid, and oxy-muriatic acid*.

Experiments on the composition of muriatic acid.

Mr Lambe some time ago† announced, that when iron is acted upon by sulphurated hydrogen gas, a substance is produced which possesses all the properties of oxy-muriat of iron (oxy-muriatic acid combined with iron). In a solution of this gas in distilled water, he digested iron-filings, previously purified by repeated washings with distilled water. The bottle was filled with the solution, and corked. The iron was presently acted upon; numerous bubbles arose, which drove the cork out of the bottle; they were strongly inflammable, and probably, therefore, pure hydrogen gas. The liquor gradually lost its odour of sulphurated hydrogen gas, and after some days smelled very much like stagnant rain-water. As the bubbles ceased to be produced, it recovered its transparency. On evaporating a small quantity of this solution in a watch-glass to dryness, a bitter deliquescent salt was left behind. On this salt a little sulphuric acid was dropped, and paper moistened with ammonia was held over the glass; white vapours were immediately formed over the glass; and

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[*] Fourcroy, ii. 107.

[†] *Manchester Memoirs*, v. 194.

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consequently some volatile acid was separated by the sulphuric acid. Mr Lambe evaporated about eight ounce-measures of the same liquor, and, as before, dropped a little sulphuric acid on the residuum; a strong effervescence was excited, very pungent acid fumes arose, which, from their smell, were readily known to be muriatic. The same truth was established beyond a doubt, by holding a bit of paper, moistened with water, which made the vapours visible in the form of a grey smoke; a distinguishing characteristic, as Bergman has observed, of the muriatic acid.—When manganese and mercury were dissolved in sulphurated hydrogen gas, the salts formed gave the same unequivocal marks of the presence of muriatic acid.

This experiment of Mr Lambe has been lately repeated with every possible precaution by Vauquelin, and also by Guyton-Morveau, and Bouillon-Lagrange; but these chemists did not succeed in obtaining a particle of oxy-muriat of iron [*]. We must conclude, then, that in the experiment of Mr Lambe, muriatic acid must have insinuated itself into his solution by some unknown channel. A fact mentioned by Berthollet may perhaps contribute something to explain this insinuation, and may also suggest a valuable hint towards the investigation of the real component parts of this obstinate acid. He converted a quantity of iron into filings with all possible care. The filings, when washed with water, gave no marks of containing muriatic acid; but after being exposed for some days to the air, they furnished, when again washed, evident traces of the presence of muriatic acid [†].

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[*] *Ann. de Chim.* xxxvii. 191.

[†] Ibid. p. 194.

Chap. IV.

Oxy-muriatic acid is one of the most important, and fortunately one of the easiest procured, of all the acids. It is employed with great advantage in bleaching, and in a great variety of chemical processes.

SECT. X.

OF FLUORIC ACID.

Discovery.

THE mineral called *fluor* or *fusible spar* was not properly distinguished from other spars till Margraff published a dissertation on it in the Berlin Transactions for 1768. He first proved, that it contained no sulphuric acid, as had been formerly supposed; he then attempted to decompose it, by mixing together equal quantities of this mineral and sulphuric acid, and distilling them. By this method he obtained a *white sublimate,* which he supposed to be the fluor itself volatilized by the acid. He observed with astonishment, that the glass retort was corroded, and even pierced with holes. Nothing more was known concerning fluor till Scheele published his experiments three years after; by which he proved, that it is composed chiefly of lime and a particular acid, which has been called *fluoric acid.*

The composition of fluoric acid is equally unknown with that of muriatic acid. Mr Henry tried in vain to decompose it by means of electricity. It is always obtained from fluor spar, in which mineral it is found in abundance. For the investigation of the properties of this acid, we are indebted chiefly to Scheele and Priestley.

How obtained.

It may be obtained by putting a quantity of the spar in powder into a leaden retort, pouring over it an equal quantity of sulphuric acid, and then applying a very gentle heat. A gas issues from the beak of the retort, which may be received in the usual manner in glass jars standing over mercury. This gas is *fluoric acid.*

Carries along with it silica.

The acid may be obtained dissolved in water by luting to the retort a receiver containing water. The distillation is to be conducted with a very moderate heat, not only to allow the gas to condense, but also to prevent the fluor itself from subliming. After the process, provided a glass retort has been employed, a crust of white earth is found in the receiver, which has all the properties of silica.

Scheele supposed that the silica produced was formed of fluoric acid and water; and Bergman adopted the same opinion. But Wiegleb and Buccholz showed that the quantity of silica was exactly equal to what the retort lost in weight; and Meyer completed the proof that it was derived from the glass, by the following experiment: He put into each of three equal cylindrical tin vessels a mixture of three ounces of sulphuric acid and one ounce of fluor, which had been pulverized in a mortar of metal. Into the first he put one ounce of pounded glass; into the second, the same quantity of quartz in powder; and into the third, nothing. Above each of the vessels he hung a sponge moistened with water; and having covered them, he exposed them to a moderate heat. The sponge in the first cylinder was covered with the crust in half an hour; the sponge in the second in two hours; but no crust was formed in the third, though it was exposed several days. In consequence of this decisive experiment Bergman gave up his opinion, and wrote an account of Meyer's experiment to Morveau, who was employed in translating his works, to enable him to correct the mistake in his notes.

Soon after the discovery of this acid, difficulties and doubts concerning its existence as a peculiar acid were started by some French chemists, disguised under the name of Boulanger, and afterwards by Mr Achard and Mr Monnet. To remove these objections, Mr Scheele instituted and published a new set of experiments; which not only completely established the peculiar nature of the fluoric acid, but once more displayed the unrivalled abilities of the illustrious discoverer *. It would be needless to enumerate these objections, as they originated entirely from want of precision, and did not produce a single convert.

Its properties.

Fluoric acid gas is invisible and elastic like air; it does not maintain combustion, nor can animals breathe it without death. It has a pungent smell, not unlike that of muriatic acid. It is heavier than common air. It corrodes the skin almost instantly.

Neither caloric nor light produce any alteration on it.

When water is admitted in contact with this gas, it absorbs it rapidly; and if the gas has been obtained by means of glass vessels, it deposites at the same time a quantity of silica.

Dissolved by water.

Water absorbs a considerable proportion of this gas, but the precise quantity has not been determined. The compound is usually termed *fluoric acid* by chemists. It is specifically heavier than water, has an acid taste, reddens vegetable blues, and does not freeze till cooled

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* Scheele, ii. 38. and Crell's *Annals*, 1786, i. 3.

down to 23° [*]. When heated, the acid gas is easily expelled, except the last portions of it, which adhere with great obstinacy.

The most singular property of fluoric acid is the facility with which it corrodes glass and siliceous bodies, especially when hot, and the ease with which it holds silica in solution even when in the state of gas. This affinity for silica is so great, that the thickest glass vessels can only withstand its action for a short time; and the greatest precautions are scarcely sufficient to obtain it entirely free from siliceous earth.

Neither oxygen gas nor any of the simple combustibles produce any change on fluoric acid, either in the gaseous or liquid state.

Fluoric acid gas does not act upon any of the metals, but liquid fluoric acid is capable of oxidating iron, zinc, copper, and arsenic.

It does not act upon gold, platinum, silver, mercury, lead, tin, antimony, cobalt.

Fluats.

It combines with alkalies, earths, and metallic oxides, and forms with them salts which are denominated *fluats*.

It produces no change, as far as is known, upon any of the acids already described.

Its affinities are as follows:

Affinities.

Lime,
Barytes,
Strontian,
Magnesia,
Potass,
Soda,
Ammonia,

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[*] Priestley, ii. 361.

Glucina,
Alumina,
Zirconia,
Silica.

As fluoric acid produces an insoluble compound with lime, it may be employed with great advantage, as Pelletier has observed, to detect the presence of that earth when held in solution. A drop or two of the acid causes a milky cloud or precipitate to appear, if any lime be present. The property which this acid has of corroding glass, has induced several ingenious men to attempt, by means of it, to engrave, or rather etch upon glass. The glass is covered completely with wax, and then that part where the letters or figures are to appear is laid bare by removing the wax. The whole is then exposed for some time to the hot vapours of fluoric acid. This simple process is employed with advantage in writing labels on glass vessels, and in graduating thermometers, and other similar instruments. The discovery is by no means new: It has been shewn by Beckman and Accum, that this acid was employed for that purpose by Henry Swanhard, an artist of Nuremberg, as early as 1670. He seems to have kept his art for some time secret; but the receipt was made public by Pauli in 1725*.

Used to etch on glass.

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* See Beckman's *History of Inventions*, and Accum, Nicholson's *Journal*, iv. 1.—The following advertisement, published by these gentlemen from a German publication of 1725, will give an idea of the method employed by that artist. "Take spiritus nitri per distillationem, put it into a retort, and apply a strong heat. When it has passed over into the receiver, throw into it some powdered *green Bohemian emerald* (which, when heated, shines in the dark), otherwise called *hesphorus*. This being done, place the receiver, containing the mixture, on a heated sand-

SECT. XI.

OF BORACIC ACID.

Origin of borax.

THE word *borax* first occurs in the works of Geber, an Arabian chemist of the 10th century. It is a name given to a species of white salt much used by various artists. Its use in soldering metals appears to have been known to Agricola.

Borax is found mixed with other substances in Thibet. It seems to exist in some lands adjacent to lakes, from which it is extracted by water, and deposited in those lakes; whence in summer, when the water is shallow, it is extracted and carried off in large lumps. Sometimes the water in these lakes is admitted into reservoirs; at the bottom of which, when the water is exhaled by the summer's heat, this salt is found. Hence it is carried to the East Indies, where it is in some measure purified and crystallized: in this state it comes to Europe, and is called *tincal*. In other parts of Thibet,

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bath for about four-and-twenty hours, and it will be fit for the purpose. To use this corrosive acid, take a pane of glass of any kind, clean it well, and free it from grease by washing with a ley, and when dry, trace out upon it, with sulphur and varnish, whatever you choose. Put a border of bees wax round it about one inch high, and then pour the corrosive acid, prepared as before directed, carefully over the whole surface of the glass, and let it stand undisturbed for some time, the longer the better. The glass will become corroded; and all you had traced before will now appear as if raised, or elevated, above the surface of the glass, in a very distinct and pleasing manner." The hesphorus here mentioned was evidently fluor spar.

it seems, by accounts received from China, they dig it out of the ground at the depth of about two yards, where they find it in small crystalline masses, called by the Chinese *mi poun, boui poun*, and *pin pouin;* and the earth or ore is called *pounxa**.

Discovery of boracic acid.

Though borax has been in common use for nearly three centuries, it was only in 1702 that Homberg, by distilling a mixture of borax and green vitriol, discovered the *boracic acid.* He called it *narcotic* or *sedative salt*, from a notion of his that it possessed the properties indicated by these names. In his opinion, it was merely a product of the vitriol which he had used; but Lemery the Younger soon after discovered, that it could likewise be obtained from borax by means of the nitric and muriatic acids. Geoffroy afterwards discovered, that borax contained soda; and at last Baron proved, by a number of experiments, that borax is composed of boracic acid and soda; that it may be reproduced by combining these two substances; and that therefore the boracic acid is not formed during the decomposition of borax, as former chemists had imagined, but is a peculiar substance which pre-existed in that salt.

This conclusion has been called in question by Mr Cadet †; who affirmed, that it was composed of *soda, the vitrifiable earth of copper, another unknown metal, and muriatic acid.* But this assertion has never been confirmed by a single proof; Mr Cadet has only proved, that boracic acid sometimes contains copper; and Beaumé's experiments are sufficient to convince us, that this metal is merely accidentally present, and that it is probably derived from the vessels employed in crystalli-

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* Kirwan's *Min.* ii. 37.

† *Jour. de Phys.* 1782.

zing borax; that boracic acid generally contains a little of the acid employed to separate it from the soda with which it is combined in borax; and that crude borax contains a quantity of earth imperfectly saturated with boracic acid :—All which may be very true; but they are altogether insufficient to prove that boracic acid is not a peculiar substance, since it displays properties different from every other body.

Messrs Exschaquet and Struve have endeavoured, on the other hand, to prove, that the phosphoric and boracic acids are the same. But their experiments merely shew, that these acids resemble one another in several particulars; and though they add considerably to our knowledge of the properties of the phosphoric acid, they are quite inadequate to establish the principle which these chemists had in view; since it is not sufficient to prove the identity of the two acids, to shew us a resemblance in a few particulars, while they differ in many others. Boracic acid must therefore be considered as a distinct substance.

Its preparation.

The easiest method of procuring boracic acid is the following one: Dissolve borax in hot water, and filter the solution; then add sulphuric acid, by little and little, till the liquid has a sensibly acid taste. Lay it aside to cool, and a great number of small shining laminated crystals will form. These are the boracic acid. They are to be washed with cold water, and drained upon brown paper.

Its properties.

Boracic acid, thus procured, is in the form of thin hexagonal scales, of a silvery whiteness, having some resemblance to spermaceti, and the same kind of greasy feel. It has a sourish taste at first, then makes a bitterish cooling impression, and at last leaves an agreeable sweetness. It has no smell; but when sulphuric acid is poured on it, a transient odour of musk is produced*.

It reddens vegetable blues. Its specific gravity is 1.479† while in the form of scales; after it has been fused it is 1.803‡.

It is not altered by light. It is perfectly fixed in the fire. At a red heat it melts, and is converted into a hard transparent glass; which becomes somewhat opaque when exposed to the air, but does not attract moisture.

It is much less soluble in water than any of the acids hitherto described. Boiling water scarcely dissolves 0.02 of boracic acid, and cold water a still smaller quantity. When this solution is distilled in close vessels, part of the acid evaporates along with the water, and crystallises in the receiver. Water, therefore, renders it in some measure volatile, though it is perfectly fixed when in a state of dryness.

Neither oxygen gas, nor the simple combustibles, nor the metals, produce any change upon boracic acid, as far as is at present known.

It is soluble in alcohol; and alcohol containing it burns with a green flame. Paper dipped into a solution of boracic acid burns with a green flame.

Though mixed with fine powder of charcoal, it is nevertheless capable of vitrification; and with soot it melts into a black bitumen-like mass, which is, however, soluble in water, and cannot be easily calcined to ashes, but sublimes in part§.

With the assistance of a distilling heat it dissolves in

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* Reuss *de Sale Sedat.* 1778.

† Kirwan's *Min.* ii. 4.

‡ Hassenfratz, *Ann. de Chim.* xxviii. 11.

§ Keir's *Dictionary.*

oils, especially in mineral oils; and with these it yields fluid and solid products, which give a green colour to spirit of wine.

When boracic acid is rubbed with phosphorus, it does not prevent its inflammation; but an earthy yellow matter is left behind *.

It is hardly capable of oxidating or dissolving any of the metals except iron and zinc, and perhaps copper.

Borats.

Boracic acid combines with alkalies, alkaline earths, and alumina, and most of the metallic oxides, and forms compounds which are called *borats*.

Its affinities are as follows:

Affinities.

Lime,
Barytes,
Strontian,
Magnesia,
Potass,
Soda,
Ammonia,
Glucina,
Alumina,
Zirconia,
Water,
Alcohol.

Composition.

The component parts of this acid are still but imperfectly known. Fabroni has announced that he considers it as a modification of muriatic acid, and that it may be prepared from that acid; but he has not yet published the experiments upon which these opinions are founded †. A very curious set of experiments have been lately made on it by Crell. By digesting oxy-muriatic

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* Keir's *Dictionary*.

† Fourcroy, ii. 128.

acid on it for a very long time, he succeeded in decomposing it, and obtained from it a substance exactly resembling charcoal in its properties; and a volatile acid resembling the muriatic in the greater number of its properties, but differing from it in not precipitating lead from its solution *.

SECT. XII.

OF ARSENIC ACID.

Discovery.

ARSENIC, as we have seen formerly, is capable of combining with two doses of oxygen; and both the compounds which it forms with that body possess acid properties. The first, distinguished by Fourcroy by the name of *arsenious acid,* but more usually denominated *white oxide of arsenic*, has been already described †. The second, called *arsenic acid,* was discovered by Scheele in 1775 ‡, and its most remarkable properties investigated. Pelletier afterwards published a valuable dissertation on it.

Preparation.

Arsenic acid may be produced by simply mixing the white oxide of arsenic with oxy-muriatic acid, and applying a heat sufficient to sublime the muriatic acid. The theory of this operation is evident: the white oxide has a greater affinity for oxygen than muriatic acid has; of course it combines with it, and is thus convert-

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* *Ann. de Chim.* xxxv. 202.—Crell considers this volatile acid as very similar to the *sebacic.*

† See Book I. chap. iii. sect. 14.

‡ Scheele, i. 129.

ed into arsenic acid, and the muriatic acid is easily sublimed by applying heat.

Landriani has informed us, that this acid may be also formed by subliming several times successively the white oxide of arsenic, and taking care every time to renew the air. This process is equally simple; the oxide combines at a high temperature with the oxygen of the atmosphere. It is most commonly prepared by distilling six parts of nitrous acid from one part of white oxide of arsenic, or by heating together one part of nitrous acid and two parts of a solution of white oxide of arsenic in muriatic acid. This last was the process first employed by Scheele.

Properties.

Arsenic acid, thus procured, is a thick mass like honey, incapable of crystallizing, which reddens vegetable blues, and has a specific gravity equal to 3.391. Its taste is acid, caustic, and metallic.

It is very fixed. When heated strongly, it melts and remains transparent, and is converted into a glass, which acts powerfully on the vessel in which the experiment is performed. This glass attracts moisture from the air. When the heat is very strong, the acid gives out a little oxygen gas, and is at the same time partly converted into white oxide.

It is very soluble in water, at the temperature of 60° requiring only two-thirds of its weight of that liquid.

This acid is not acted upon by oxygen gas, nor most probably by azotic gas; but it is decomposed by the other simple combustibles, and likewise by many of the metals, when assisted by heat.

It is poisonous as well as the white oxide of arsenic*.

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* Scheele.

It does not act upon gold, platinum, silver, mercury. It oxidates copper, iron, lead, tin, zinc, bismuth, antimony, cobalt, nickel, manganese, and arsenic, and in a strong heat mercury and silver.

Arseniats.

It combines with alkalies, earths, and several of the metallic oxides, and forms compounds which have been called *arseniats*.

Affinities.

Its affinities are as follows:

Lime,
Barytes,
Strontian,
Magnesia,
Potass,
Soda,
Ammonia,
Glucina,
Alumina,
Zirconia.

Hitherto arsenic acid has been applied to no use; and indeed has scarcely been examined except by Scheele and Pelletier.

SECT. XIII.

OF TUNGSTIC ACID.

Discovery.

THE substance called *tungstic acid* by Scheele and Bergman was discovered by Scheele in 1781. This philosopher obtained it from *tungstat of lime*, by treating it with nitric acid and ammonia alternately. The acid dissolves the lime, and the ammonia combines with the tungstic acid. The ammoniacal solution, when saturated with nitric or muriatic acid, deposites a white powder, which is the *tungstic acid* of Scheele.

Does not deserve the name of acid.

This powder has an acid taste, it reddens vegetable blues, and is soluble in 20 parts of boiling water. The De Luyarts have demonstrated, that this pretended acid is a compound of yellow oxide of tungsten, the alkali employed to dissolve it, and the acid used to precipitate it. Thus, when prepared according to the above described process, it is a compound of yellow oxide, ammonia, and nitric acid. Their conclusions have been more lately confirmed by the experiments of Vauquelin and Hecht. This substance must therefore be erased from the class of acids, and placed among the salts.

Tungstats.

The real acid of tungsten is a yellow powder; the method of procuring which, and its properties, have been already described under the denomination of *Yellow Oxide of Tungsten**. It ought rather, as Vauquelin and Hecht have properly remarked, to be classed among the oxides than the acids; for it is insoluble in water, tasteless, and has no effect on vegetable blues. It agrees with the acids indeed in the property of combining with alkalies and earths, and perhaps also with some metallic oxides, and forming with them salts which have been denominated *tungstats;* but several other metallic oxides, those of lead, silver, and gold, for instance, possess the same property. These oxides therefore may be called acids with as much propriety as the yellow oxide of tungsten.

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* Vol. I. p. 215.

Affinities.

The affinities of this oxide, as far as they have been ascertained, are as follows *:

Lime,
Barytes,
Strontian,
Magnesia,
Potass,
Soda,
Ammonia,
Glucina,
Alumina,
Zirconia.

SECT. XIV.

OF MOLYBDIC ACID.

Discovery.

MOLYBDIC ACID, which is a compound of molybdenum and oxygen, was discovered by Scheele in 1778. It is commonly procured from molybdena, or sulphuret of molybdenum, by distilling off from it nitric acid repeatedly, till both the sulphur and metal are acidified; which is known by the conversion of the whole into a white mass. Hot water carries off the sulphuric acid, and leaves the molybdic in a state of purity.

Properties.

Molybdic acid, thus prepared, is a white powder, of a sharp metallic taste, and a specific gravity of 3.4. When heated in a close vessel, it melts and crystallizes;

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* Luyarts.

but in an open vessel it sublimes in a white smoke, which attaches itself to cold bodies, and assumes the form of brilliant yellow scales.

It is soluble in 960 parts of boiling water. The solution is pale yellow; it has no taste, but reddens litmus paper. The molybdic acid is precipitated from this solution by sulphuric, nitric, and muriatic acids*.

Molybdic acid is not affected by oxygen gas; but it is decomposed by sulphur and charcoal, and several of the metals.

It combines with alkalies, earths, and several metallic oxides, and forms salts known by the name of *molybdats*.

Sulphuric acid dissolves molybdic acid when assisted by heat. The solution is colourless while hot; but when cold it assumes a deep blue colour, which is heightened by saturating the solution with soda. When this sulphuric acid solution is heated strongly, the sulphuric acid is evaporated, and molybdic acid remains. Muriatic acid also dissolves it. The solution is of a pale yellowish green colour; but it becomes blue when saturated with potass. Nitric acid does not dissolve this acid†.

This acid, when combined with potass, forms a colourless salt.

Mixed with filings of tin and muriatic acid, it immediately becomes blue, and precipitates flakes of the same colour, which disappear after some time, if an excess of muriatic acid has been added, and the liquor assumes a brownish colour.

With the solution of nitrat of lead it forms a white precipitate, soluble in nitric acid.

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* Hatchett, *Phil. Trans.* lxxxvi. 323.

† Hatchett, ibid.

When mixed with a little alcohol and nitric acid, it does not change its colour.

With a solution of nitrat of mercury, or of nitrat of silver, it gives a white flaky precipitate.

With the nitrat of copper it forms a greenish precipitate.

With solutions of sulphat of zinc, muriat of bismuth, muriat of antimony, nitrat of nickel, muriats of gold and platinum, it produces white precipitates when these solutions do not contain an excess of acid.

When melted with borax, it gives it a bluish colour.

Paper dipt in this acid becomes in the sun of a beautiful blue colour *.

SECT. XV.

OF CHROMIC ACID.

Discovery.

CHROMIC ACID, discovered lately by Vauquelin, has only been found, in any quantity, in the red lead ore of Siberia, and in chromat of iron. Its properties have been investigated by Vauquelin and Mussin Puschkin.

It may be obtained by boiling the red lead ore with carbonat of soda, decanting off the fluid solution, and saturating it with one of the mineral acids; a red powder precipitates, which is chromic acid.

Properties.

Chromic acid, thus obtained, is a red or orange-yellow powder, of an acrid and strongly metallic taste. It

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* Vauquelin, *Philosophical Magazine*, i. 282.

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is soluble in water, and crystallizes in the form of elongated prisms of a ruby colour.

When heated it gives out oxygen gas, and is converted into green oxide of chromum.

When mixed with filings of tin and the muriatic acid, it becomes at first yellowish brown, and afterwards assumes a beautiful green colour.

When mixed with a little alcohol and nitric acid, it immediately assumes a bluish green colour, which preserves the same shade even after desiccation. Ether alone gives it the same colour.

With a solution of nitrat of mercury, it gives a precipitate of a dark cinnabar colour.

With a solution of nitrat of silver, it gives a precipitate which, the moment it is formed, appears of a beautiful carmine colour, but becomes purple by exposure to the light. This combination, exposed to the heat of the blow-pipe, melts before the charcoal is inflamed. It assumes a blackish and metallic appearance. If it be then pulverised, the powder is still purple; but after the blue flame of the lamp is brought in contact with this matter, it assumes a green colour, and the silver appears in globules disseminated throughout its substance.

With nitrat of copper, it gives a chesnut red precipitate.

With the solutions of sulphat of zinc, muriat of bismuth, muriat of antimony, nitrat of nickel, and muriat of platinum, it produces yellowish precipitates when these solutions do not contain excess of acid. With muriat of gold, it produces a greenish precipitate.

When melted with borax or glass, it communicates to them a beautiful emerald green colour.

Paper impregnated with chromic acid assumes in the light a greenish colour.

When mixed with muriatic acid, the mixture is capable of dissolving gold, like aqua regia; when this mixture of the two acids is distilled, oxy-muriatic acid is disengaged, and the liquor assumes a very beautiful green colour.

Sulphuric acid, while cold, produces no effect upon it; but when warmed, it makes it assume a bluish green colour, probably by favouring the disengagement of oxygen.

When this acid is heated along with charcoal, it is reduced to the metal called *chromum.*

SECT. XVI.

OF ACETOUS ACID.

ACETOUS ACID or vinegar was known many ages before the discovery of any other acid, those only excepted which exist ready formed in vegetables. It is mentioned by Moses, and indeed seems to have been in common use among the Israelites and other eastern nations at a very early period.

It is prepared from wine, from beer, ale, and other similar liquids. These are apt, as every one knows, to turn sour, unless they be kept very well corked. Now sour wine or beer is precisely the same with vinegar.

Preparation of vinegar,

Boerhaave describes the following method of making vinegar, which is said to be still practised in different places.

Take two large oaken vats or hogsheads, and in each of these place a wooden grate or hurdle at the distance of a foot from the bottom. Set the vessel upright, and on the grate place a moderately close layer of green twigs or fresh cuttings of the vine. Then fill up the vessel with the footstalks of grapes, commonly called the *rape*, to the top of the vessel, which must be left quite open.

Having thus prepared the two vessels, pour into them the wine to be converted into vinegar, so as to fill one of them quite up, and the other but half full. Leave them thus for twenty-four hours, and then fill up the half-filled vessel with liquor from that which is quite full, and which will now in its turn be left only half full. Four-and-twenty hours afterwards repeat the same operation; and thus go on, keeping the vessels alternately full and half full during every twenty-four hours till the vinegar be made. On the second or third day there will arise, in the half-filled vessel, a fermentative motion, accompanied with a sensible heat, which will gradually increase from day to day. On the contrary, the fermenting motion is almost imperceptible in the full vessel; and as the two vessels are alternately full and half full, the fermentation is by that means, in some measure, interrupted, and is only renewed every other day in each vessel.

When this motion appears to have entirely ceased, even in the half-filled vessel, it is a sign that the fermentation is finished; and therefore the vinegar is then to be put into casks close stopped, and kept in a cool place.

All that is necessary to convert wine or beer into vinegar is the contact of the external air, a temperature of 80°, and the presence of some substance to act as a ferment. But the theory of this operation belongs to the second part of this work; our business at present is not to investigate the method of making vinegar, but to examine the properties of acetous acid.

And acetous acid.

Vinegar is a liquid of a reddish or yellowish colour, a pleasant sour taste, and an agreeable odour. Its specific gravity varies from 1.0135 to 1.0251, and it differs also in its other properties according to the liquid from which it has been procured. It is very subject to decomposition; but Scheele discovered that if it be made to boil for a few moments, it may be kept afterwards for a long time without alteration. Besides acetous acid and water, vinegar contains several other ingredients, such as mucilage, tartar, a colouring matter, and often also two or more vegetable acids. When distilled at a temperature not exceeding that of boiling water, till about two-thirds of it have passed over, all these impurities are left behind, and the product is pure *acetous acid*.

Its properties;

Acetous acid thus obtained, is a liquid as transparent and colourless as water, of a strong acid taste and an agreeable odour, somewhat different from that of vinegar. It reddens vegetable blues. Its specific gravity is only 1.0005.

It may be preserved without alteration in close vessels. When exposed to a moderate heat, it evaporates completely and without undergoing any change in its properties. When exposed to the action of cold, part of it congeals. The frozen part, which consists almost entirely of water, may be easily separated; and by this method the acid may be obtained in a high degree of concentration. The more concentrated the acid is

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the greater is the cold necessary to produce congelation. Mr Lowitz has ascertained that the acetous acid part itself, how much soever it be concentrated, crystallizes or congeals at the temperature of —22°.

Acetous acid combines with water in every proportion, and indeed can scarcely be obtained except in combination with that liquid.

Acetous acid is not altered by oxygen gas, nor by any of the simple combustibles. Charcoal, according to the discovery of Mr Lowitz, has the property, when mixed with it in the state of powder, of retaining the acid part even at the heat of boiling water, and allowing the watery part to evaporate. It afterwards allows the acid to escape when exposed to a strong heat. By this contrivance Lowitz obtained very highly concentrated acetous acid.

This acid is capable of oxidating iron, zinc, lead, copper, nickel, tin. It does not act upon gold, silver, platinum, mercury, bismuth, cobalt, antimony, arsenic. Its action on tellurium, tungsten, molybdenum, uranium, titanium, and chromum, has not been tried.

Acetites.

It combines with alkalies, earths, and metallic oxides, and forms compounds known by the name of *acetites*.

Its affinities are as follows:

Affinities.

Barytes,
Potass,
Soda,
Strontian,
Lime,
Ammonia,
Magnesia,
Metallic oxides,
Glucina,

Alumina,
Zirconia.

Acetous acid is decomposed by sulphuric and nitric acids. The action of the other acids on it has scarcely been examined. It dissolves boracic acid, and absorbs carbonic acid.

Acetous acid has the property of combining with a great number of vegetable bodies, such as oils, mucilage, and aromatics.

Component parts.

When nitric acid is made to act on acetous acid, it converts it into water and carbonic acid. When acetous acid, combined with a fixed alkali or earth, is exposed to a strong heat, it is almost completely decomposed; water, carbonic acid, and carbonated hydrogen gas are emitted, and the base remains mixed with a quantity of charcoal. From these facts it follows that acetous acid is composed of carbon, hydrogen, and oxygen, into which all these products may be ultimately resolved. But the proportion of these ingredients has not been ascertained with precision.

By distilling 7680 grains of acetite of potass, Dr Higgens obtained the following products*:

Potass, ...	3862.994	grains.
Carbonic acid gas, ...	1473.564	
Carbonated hydrogen gas, . .	1047.6018	
Residuum, consisting of charcoal	78.0000	
Oil, ...	180.0000	
Water, ...	340.0000	
Deficiency†, ...	726.9402	

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[*] Higgens on *Acetous Acid*, p. 26.

[†] For 29.1 grains of oxygen gas had also disappeared from the air of the vessels.

This deficiency Dr Higgens found to be owing to a quantity of water and oil which is carried off by the elastic fluids, and afterwards deposited by them. He calculated it, in the present case, at 700 grains of water and 26.9402 grains of oil. Now, since acetite of potass is composed of acetous acid and potass, and since the whole of the potass remained unaltered, it follows, that the acetous acid was converted into carbonic acid gas, carbonated hydrogen gas, carbon, oil, and water; all of which are composed of oxygen, hydrogen, and carbon.

Now, 1473.564 grains of carbonic acid gas are composed of 1060.966 grains of oxygen, and 415.598 grains of carbon.

1047.6018 grains of carbonated hydrogen gas, from a comparison of the experiments of Dr Higgens and Lavoisier, may be supposed to consist of about 714.6008 grains of carbon, and 333.0010 of hydrogen.

200.9402 grains of oil contain 163.4828 grains of carbon and 43.4574 grains of hydrogen.

1040 grains of water contain 884 grains of oxygen and 156 grains of hydrogen.

Therefore 3817.006 grains of acetous acid are composed of 1944.966 — 29.1 = 1915.866 grains of oxygen, 532.4584 grains of hydrogen, and 1368.6816 grains of carbon. Consequently 100 parts of acetous acid are composed of

50.19 oxygen,
13.94 hydrogen,
35.87 carbon.

100.00

These numbers can only be considered as very imperfect approximations to the truth; for the object of Dr Higgens was not to ascertain the proportions of the ingredients which compose acetous acid; and therefore his experiments were not conducted with that rigid accuracy which would have been necessary for that purpose

Acetous acid is one of the most useful of all the acids, being not only employed as an agreeable seasoner of food, but also in dyeing and several other very important arts.

SECT. XVII.

OF ACETIC ACID.

Preparation.

WHEN acetite of copper, reduced to powder, is put into a retort and distilled, there comes over a liquid at first nearly colourless and almost insipid, and afterwards a highly concentrated acid The distillation is to be continued till the bottom of the retort is red hot. What remains in it then is only a powder of the colour of copper. The acid product, which should be received in a vessel by itself, is tinged green by a little copper which passes along with it; but when distilled over again in a gentle heat, it is obtained perfectly colourless and transparent. The acid thus obtained is exceedingly pungent and concentrated. It was formerly distinguished by the names of *radicál vinegar* and *vinegar of Venus*.

History.

This process was known to the alchymists, and had often been repeated by chemical philosophers; but the product was considered as merely highly concentrated

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acetous acid, till Berthollet published his experiments on it in 1785*. That skilful philosopher demonstrated, that it differs from acetous acid in taste and smell, in its affinities for other bodies, and in the compounds which it forms with them. When it is obtained from acetite of copper by distillation, the powder which remains in the retort consists chiefly of copper in the metallic state. Hence he concluded, that the acetous acid gave out phlogiston to the copper and received from it oxygen. When the existence of phlogiston was disproved, this theory was a little altered. It was concluded, that during the distillation, the acetous acid deprived the oxide of copper of its oxygen and combined with it, and that radical vinegar therefore is acetous acid combined with a new dose of oxygen. For this reason it received the name of *acetic acid.*

This theory was generally admitted by chemists, till Mr Adet published his experiments on acetic acid in 1797 †. He observed, that when acetite of copper is distilled, the products are not only acetic acid and water, but likewise carbonic acid and carbonated hydrogen gas; and that the residuum consists of copper and charcoal. He found that acetous acid did not absorb oxygen when distilled off black oxide of manganese, and that acetic and acetous acids have exactly the same effect upon metals. From these and some other similar experiments, he concluded that acetic and acetous acids do not differ from each other except in concentration.

This conclusion was rather extraordinary, as he did not attempt to account for the very striking difference in the taste and smell of these acids, and as he had

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* *Mem. Par.* 1783.

† *Ann. de Chim.* xxvii. 299.

neither repeated nor refuted the experiments of Berthollet, on which the opinion of the difference between these two acids was founded. The conclusion of Adet was opposed in 1798 by Chaptal, who published a set of experiments on the same subject *. This philosopher has demonstrated, as Berthollet had done before him, that acetic and acetous acids, even when of the same strength, possess very different properties, and have very different effects on other bodies. We must therefore consider them as distinct bodies. From the effect of sulphuric acid upon each, and from the quantity of charcoal which remains in the retort when equal quantities of each saturated with potass is distilled, he concluded that acetous acid contains a smaller proportion of carbon than acetic acid. And this he considers as the cause of the difference in their properties.

Composition.

In 1800 a new set of experiments on the same subject were published by Mr Dabit of Nantes †. This chemist has made the difference between acetous and acetic acids still more evident, and has even rendered it probable that acetic acid contains a greater proportion of oxygen than acetous. A supposition which is so far from being incompatible with the experiments of Chaptal, that it rather confirms them. When Mr Dubit distilled a mixture of acetite of potass and sulphuric acid, the product was acetic acid; but when he subsituted muriatic acid for sulphuric, he obtained acetous acid; but when to this last mixture a little black oxide of manganese was added, he obtained acetic acid. And in none of these cases is there any carbonic acid emitted till towards the end of the distillation.

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* *Ann. de Chim.* xxviii. 113.

† Ibid. xxxviii. 66.

A much easier method of obtaining acetic acid than that commonly used has been lately pointed out by Mr Badollier apothecary at Chartres. All that is necessary is to distil a mixture of equal parts of acetite of lead and sulphat of copper in a glass retort. The acid comes over perfectly pure on the application of a moderate heat *.

Properties.

Acetic acid is transparent and colourless like water. Its smell is intolerably pungent and acrid; and when it is applied to the skin, it reddens and corrodes it in a very short time. It is exceedingly volatile; and when heated in the open air, takes fire so readily, that one would be tempted to suspect the presence of ether in it. It unites with water in any proportion; and when concentrated the mixture evolves a good deal of heat.

This acid is capable of crystallizing: for it cannot be doubted that the crystallized acid described by Lowitz is in reality acetic acid, or at least some analogous modification of the acetous. Indeed Courtenvaux had long before observed, that the last portions of acetic acid, which come over during the distillation, were susceptible of crystallizing in a moderate cold.

Acetats.

The action of the simple combustibles on acetic acid has not been examined. It acts with greater energy on the metals than acetous acid. Like that acid, it combines with alkalies, earths, and metallic oxides, and forms salts, which have received the name of *acetats;* but which have hitherto been but very slightly examined.

This acid, like the acetous, is decomposed by the application of heat, when it is prevented from evaporating

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* *Ann. de Chim.* xxxvii. 111.

by being combined with a base. It is then converted chiefly into water, carbonic acid, and charcoal.

This acid has been used in medicine, both externally and internally, in different parts of the continent.

SECT. XVIII.

OF OXALIC ACID.

Discovery.

WHEN nitric acid is poured upon sugar, and a moderate heat applied, the sugar soon melts, an effervescence ensues, a great quantity of nitrous gas and carbonic acid gas is emitted; and when the effervescence ceases, and the liquid in the retort is allowed to cool, a number of small transparent crystals appear in it. These crystals constitute a peculiar acid, which has received the name of *oxalic acid*, because it exists ready formed, as Scheele has proved, in the *oxalis acetosella*, or wood sorrel. At first, however, it was called the *acid of sugar*, or the *saccharine acid*.

As the earliest and best account of the oxalic acid was published by Bergman, he was for a long time reckoned the discoverer of it; but Mr Ehrhart, one of Scheele's intimate friends, informs us, that the world is indebted for its knowledge of this acid to that illustrious chemist *, and Hermstadt and Westrum assign the discovery to the same author †. The assertions of these gentlemen, who had the best opportunity of obtaining

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* Elwert's *Magazine for Apothecaries*, 1785. part i. p. 54.

† Keir's *Dictionary*.

accurate information, are certainly sufficient to establish the fact, that Scheele was the real discoverer of oxalic acid.

Preparation.

Bergman gives us the following process for obtaining this acid. " Put one ounce of white sugar powdered into a tubulated retort, with three ounces of strong nitric acid, the specific gravity of which is to that of water as 1.567. When the solution is over, during which many fumes of the nitrous acid escape, let a receiver be fitted, and the liquor made to boil, by which abundance of nitrous gas is expelled. When the liquor in the retort acquires a reddish-brown colour, add three ounces more of nitric acid, and continue the boiling till the fumes cease, and the colour of the liquor vanishes. Then let the contents of the retort be emptied into a wide vessel; and, upon cooling, a crystallization will take place of ſlender, quadrilateral prisms, which are often affixed to each other at an angle of 45°. These crystals, collected and dried on blotting paper, will be found to weigh 1 ½ dr. 19 gr. By boiling the remaining lixivium with two ounces of nitric acid in the retort till the red fumes almost disappear, and by repeating the crystallization as before, ½ dr. 13 gr. of solid acid will be obtained. If the process be repeated once more upon the residuum, which has now a glutinous consistence, with the successive additions of small quantities of nitric acid, amounting in all to two ounces, a saline brown deliquescent mass will be formed, weighing half a dram, of which about a half will be lost by a farther purification. The crystals obtained thus at different times may be purified by solution and crystallization, and by digesting the last lixivium with some nitric acid, and evaporation with the heat of the sun."

By the same process Bergman obtained it from gum arabic, alcohol, and honey; Scheele, Hermstadt, Westrum, Hoffman, &c. from a great variety of other vegetable productions; and Berthollet from a great number of animal substances.

It is of great consequence not to use too much nitric acid, otherwise the quantity of oxalic acid will be diminished; and if a very great quantity of nitric acid be used, no oxalic acid will be obtained at all *. On the contrary, if too small a quantity of nitric acid be used, the acid obtained will not be the oxalic, but the tartarous †.

Properties.

Oxalic acid, thus prepared, is in the form of four-sided prisms, whose sides are alternately larger, and they are terminated at the extremities by two-sided summits. They are transparent and colourless, have a very acid taste, and redden vegetable blues.

When this crystallized acid is exposed to heat in an open vessel, there arises a smoke from it, which affects disagreeably the nose and lungs. The residuum is a powder of a much whiter colour than the acid had been. By this process it loses $\frac{3}{10}$ths of its weight, but soon recovers them again on exposure to the air. When distilled, it first loses its water of crystallization, then liquefies and becomes brown; a little phlegm passes over, a white saline crust sublimes, some part of which passes into the receiver; but the greatest part of the acid is destroyed, leaving in the retort a mass $\frac{1}{50}$th of the whole, which has an empyreumatic smell, blackens sulphuric acid, renders nitric acid yellow, and dissolves in muriatic acid without alteration. That part of the acid

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* Bergman.

† Hermstadt.

which sublimes is unaltered. When this acid is distilled a second time, it gives out a white smoke, which, condensing in the receiver, produces a colourless uncrystallizable acid, and a dark coloured matter remains behind*. During all this distillation a vast quantity of elastic vapour makes its escape. From 279 grains of oxalic acid, Bergman obtained 109 cubic inches of gas, half of which was carbonic acid and half carbonated hydrogen. Fontana from an ounce of it obtained 430 cubic inches of gas, one-third of which was carbonic acid, the rest carbonated hydrogen. From these facts, it is evident that oxalic acid is composed of oxygen, hydrogen, and carbon.

The crystals of oxalic acid are soluble in their own weight of boiling water: water at the temperature of 65.7° dissolves half its weight of them. The specific gravity of the solution is 1.0593†. One hundred parts of boiling alcohol dissolve 56 parts of these crystals; but at a mean temperature only 40 parts‡. Liquid oxalic acid has a very acrid taste when it is concentrated, but a very agreeable acid taste when sufficiently diluted with water§.

It changes all vegetable blues except indigo to a red. One grain of crystallized acid, dissolved in 1920 grains of water, reddens the blue paper with which sugar loaves are wrapt: one grain of it, dissolved in 3600 grains of water, reddens paper stained with turnsole‖. According to Morveau, one part of the crystallized acid is sufficient to communicate a sensible acidity to 2633 parts of water¶.

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* Bergman. † Ibid. i. 255. ‡ Ibid. § Ibid. ‖ Ibid.

¶ *Encyc. Method.* art. *Acide Saccharin.*

Its fixity is such, that none of it is sublimed when water containing it in solution is raised to the boiling temperature.

Oxalic acid is not affected by exposure to the air, or to the action of oxygen gas. The effect of the simple combustibles on it has not been tried.

It is capable of oxidating lead, copper, iron, tin, bismuth, nickel, cobalt, zinc, manganese.

It does not act upon gold, silver, platinum, mercury.

Oxalats.

Oxalic acid combines with alkalies, earths, and metallic oxides, and forms salts known by the name of *oxalats*.

Composition.

Muriatic and acetous acids dissolve oxalic acid, but without altering it[*]. Sulphuric acid decomposes it partly by the assistance of heat, and a quantity of charcoal is formed. Nitric acid decomposes it at a boiling heat, and converts it into water and carbonic acid[†]. From this result, and from the products obtained by distilling pure oxalic acid, it follows, that this acid is composed, like the two last, of oxygen, hydrogen, and carbon. Fourcroy informs us, that Vauquelin and he have ascertained that it is composed of

77 oxygen
13 carbon
10 hydrogen

100[‡]

But the experiments upon which this result is founded have not been published; so that it is impossible to judge of their accuracy.

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[*] Bergman.

[†] Fourcroy, vii. 224.

[‡] Ibid.

Affinities.

The affinities of oxalic acid, according to Bergman, are as follows:

Lime,
Barytes,
Strontian,
Magnesia,
Potass,
Soda,
Ammonia,
Alumina,
Metallic oxides,
Water,
Alcohol.

This acid is too expensive to be employed for the purposes of domestic economy; but is extremely useful in chemistry to detect the presence of lime held in solution. For this purpose, either a little of the pure acid, or of the solution of oxalat of ammonia, is dropt into the liquid supposed to contain lime. If any be present, a white powder immediately precipitates. The reason of this is, that oxalat of lime is altogether insoluble, and oxalic acid in consequence is capable of taking lime from every other acid.

SECT. XIX.

OF TARTAROUS ACID.

Discovery.

TARTAR, or CREAM OF TARTAR as it is commonly called when pure, has occupied the attention of chemists for several centuries. Duhamel and Grosse, and after them Margraff and Rouelle the Younger, proved that it was composed of an acid united to potass; but Scheele was the first who obtained this acid in a separate state. He communicated his process for obtaining it to Retzius, who published it in the Stockholm Transactions for 1770. It consisted in boiling tartar with lime, and in decomposing the tartrite of lime thus formed by means of sulphuric acid.

Preparation.

The process employed at present for obtaining tartarous acid, which is the same with that of Scheele, is the following: Dissolve tartar in boiling water, and add to the solution powdered chalk till all effervescence ceases, and the liquid ceases to redden vegetable blues. Let the liquid cool, and then pass it through a filter. A quantity of tartrite of lime (which is an insoluble white powder) remains upon the filter. Put this tartrite, previously well washed, into a glass cucurbite, and pour on it a quantity of sulphuric acid equal to the weight of the chalk employed, which must be diluted with water. Allow it to digest for 12 hours, stirring it occasionally. The sulphuric acid displaces the tartarous; sulphat of lime remains at the bottom, while the tartarous acid is dissolved in the liquid part. Decant off this last, and try whether it contains any sulphuric acid. This is done by dropping in a little acetite of lead; a precipitate appears, which is insoluble in acetous acid if sulphuric acid be present, but soluble if it be absent. If sulphuric acid be present, the liquid must be digested again on some more tartrite of lime; if not, it is to be slowly evaporated, and about one-third part of the weight of the tartar employed is obtained of crystallized tartarous acid.

The form of its crystals is so irregular, that every

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chemist who has treated of this subject has given a different description of them. According to Bergman, they generally consist of divaricating lamellæ[*]; according to Van Packen, they assume oftenest the form of long pointed prisms[†]; Spielman and Corvinus[‡] obtained them in groups, some of them lance-shaped, others needle-formed, others pyramidal. Morveau obtained them needle-form[§]. Their specific gravity is 1.5962[||].

Crystallized tartarous acid does not experience any change in the open air, but heat decomposes it altogether: in the open fire it burns without leaving any other residuum than a spongy charcoal, which generally contains a little lime. When distilled in close vessels, it is converted into carbonic acid gas and carbonated hydrogen gas, a coloured oil, and a reddish acid liquor, which was formerly distinguished by the name of *pyro-tartarous acid*, but which Fourcroy and Vauquelin have lately ascertained to be merely acetous acid impregnated with oil[¶].

Tartarous acid dissolves readily in water. Bergman obtained a solution, the specific gravity of which was 1.230[**]. Morveau observed, however, that crystals formed spontaneously in a solution, the specific gravity of which was 1.084. It is not liable to spontaneous decomposition when dissolved in water, unless the solution be considerably diluted.

Neither its action on oxygen gas nor on simple combustibles has been examined; but it is probable that

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[*] Bergman, iii. 368.

[†] *De Sale Essent. Acidi Tartari.*

[‡] *Analecta de Tartaro.*

[§] *Encyc. Method. Chim.* i. 323.

[||] Hassenfratz, *Ann. de Chim.* xxviii. 11.

[¶] Ibid. xxxv. 131.

[**] Bergman, i. 250.

it is not capable of producing any sensible change on them. It is capable of oxidating iron and zinc, and even mercury; but it does not act upon antimony, bismuth, tin, lead, copper, silver, gold, nor platinum. Its action on the other metallic bodies has not been examined.

Tartrites.

It combines with alkalies, earths, and metallic oxides, and forms salts known by the name of *tartrites*.

The action of the greater part of the other acids on it is unknown. Hermstadt has ascertained, that it may be converted into oxalic acid by distilling it repeatedly with six times its weight of nitric acid. By this process he obtained 560 parts of oxalic acid from 360 parts of tartarous acid *.

Composition.

From this result, and from the products obtained when tartarous acid is distilled, it is evident that it is composed of oxygen, carbon, and hydrogen. Fourcroy inform us, that Vauquelin and he have ascertained that these ingredients are combined in it in the following proportions †:

70.5	oxygen
19.0	carbon
10.5	hydrogen
100.0	

Affinities.

The affinities of this acid follow the same order as those of oxalic acid.

Tartarous acid, in a state of purity, has scarcely been put to any use; but some of the compounds into which it enters are much employed in medicine. This acid has the property of combining in two different pro-

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* Crell's *N. End. in d. Chem.* 1782, p. 76.

† Fourcroy, vii. 261.

portions with a great number of bases. With potass, for instance, in one proportion, it forms a salt pretty soluble in water, called *tartrite of potass;* but when added in a greater proportion, it forms tartar, a salt very imperfectly soluble in water. By this property, the presence of tartarous acid, in any acid solution, may easily be detected. All that is necessary is to drop in slowly a little solution of potass: if tartarous acid be present, tartar immediately precipitates in the form of a white gritty powder.

SECT. XX.

OF CITRIC ACID.

Discovery.

CHEMISTS have always considered the juice of oranges and lemons as an acid. This juice contains a quantity of mucilage and water, which render the acid impure, and subject to spontaneous decomposition. Mr Georgius took the following method to separate the mucilage. He filled a bottle entirely with lemon-juice, corked it, and placed it in a cellar: in four years the liquid was become as limpid as water, a quantity of mucilage had fallen to the bottom in the form of flakes, and a thick crust had formed under the cork. He exposed this acid to a cold of 23°, which froze a great part of the water, and left behind a strong and pretty pure acid *. It was Scheele, however, that first point-

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* *Stockholm Transactions*, 1774.

ed out a method of obtaining this acid perfectly pure, and who demonstrated that it possesses peculiar properties.

Preparation.

His process, which is still followed, is this: Saturate lemon juice, while boiling, with powdered chalk. A white powder falls to the bottom, which is lime combined with citric acid. Separate this powder, and wash it with warm water till the water passes off colourless. Then pour upon it as much sulphuric acid as will saturate the chalk employed, having previously diluted it with six times its weight of water. Boil mixture for some minutes, and pass it through a filter to separate the sulphat of lime. The liquid is then to be evaporated to the consistence of a syrup, and set aside to cool. A number of crystals form in it: these are *citric acid*[*].

Mr Scheele advises the use of an excess of sulphuric acid, in order to insure the separation of all the lime; but, according to Dizé, this excess is necessary for another purpose[†]. A quantity of mucilage still adheres to the citric acid in its combination with lime, and sulphuric acid is necessary to decompose this mucilage; which, as Fourcroy and Vauquelin have proved, it is capable of doing. His proof of the presence of mucilage is, that when the solution of citric acid in water, which he had obtained, was sufficiently concentrated by evaporation, it assumed a brown colour, and even became black towards the end of the evaporation. The crystals also were black. By repeated solutions and evaporations, this black matter was separated, and found to be charcoal. Hence he concluded that mucilage had

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[*] Scheele, ii. 203.

[†] Nicholson's *Journal*, ii. 34.

been present; for mucilage is composed of carbon, hydrogen, and oxygen; sulphuric acid causes the hydrogen and oxygen to combine and form water, and charcoal remains behind. It is not certain, however, as Mr Nicholson remarks very justly [*], that the sulphuric acid may not act upon the citric acid itself, and that the charcoal may not proceed from the decomposition of it: at least the experiments of Mr Dizé are insufficient to prove the contrary. In that case, the smaller the excess of sulphuric acid used the better.

Proust, who has published a memoir on the preparation of citric acid in the *Journal de Physique* for 1801 [†], has observed, that this is actually the case. When too much sulphuric acid is employed, it acts upon the citric acid, chars it, and prevents it from crystallizing. This error is remedied by adding a little chalk. This chemist has ascertained, that 4 parts of chalk require for saturation 94 parts of lemon juice. The citrat of lime obtained amounts to 7½ parts. To decompose this, 20 parts of sulphuric acid, of the specific gravity 1.15, are necessary.

Properties.

The crystals of citric acid are rhomboidal prisms, the sides of which are inclined to each other at angles of about 120 and 60 degrees, terminated at each end by four trapezoidal faces, which include the solid angles [‡]. They are not altered by exposure to the air. Their taste is exceedingly acid, and even excites pain; but when the acid is properly diluted with water, its acidity is exceedingly pleasant.

When exposed to the open fire, it first melts, then

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[*] Nicholson's *Journal*, ii. 43.

[†] *Jour. de Phys.* lii. 366.

[‡] Dize, Nicholson's *Journal*, ii. 43.

swells up and exhales an acrid vapour, and leaves behind it a small quantity of charcoal. When distilled in close vessels, it partly evaporates without decomposition, and is partly converted into acetous acid, carbonic acid, and carbonated hydrogen gas, which pass over; and charcoal, which remains in the retort.

Citric acid is exceedingly soluble in water. According to Vauquelin, 100 parts of it require only 75 parts of water. Boiling water dissolves twice its weight of it *. This solution may be kept a long time in close vessels; however, it at last putrifies, and is decomposed.

Neither oxygen gas nor the simple combustibles produce any effect upon it. It is capable of oxidating iron, zinc, tin. It does not act upon gold, silver, platinum, mercury, bismuth, antimony, arsenic.

Citrats.

It combines with alkalies, earths, and metallic oxides, and forms salts known by the name of *citrats*.

Composition.

The action of none of the acids on it has been examined, if we except that of the sulphuric and nitric. Sulphuric acid, when concentrated, converts it into acetous acid †. Scheele said that he could not convert it into oxalic acid by means of nitric acid, as he had done several other acids: but Westrum affirms, that this conversion may be effected; and thinks that Scheele had probably failed from having used too large a quantity of nitric acid, by which he had proceeded beyond the conversion into oxalic acid, and had changed the citric acid into vinegar; and in support of his opinion, he quotes his own experiments; from which it appeared that, by treating 60 grains of citron acid with different

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* Dizc.

† Fourcroy, vii. 206.

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quantities of nitric acid, his products were very different. Thus with 200 grains of nitric acid he got 30 grains of oxalic acid; with 300 grains of nitric acid he obtained only 15 grains of the oxalic acid; and with 600 grains of nitric acid no vestige appeared of the oxalic acid. On distilling the products of these experiments, especially of the last, he obtained vinegar mixed with nitric acid. The experiments of Westrum have been confirmed by Fourcroy and Vauquelin; who, by treating citric acid with a great quantity of nitric acid, converted it into oxalic and acetous acids. The proportion of the first was much smaller than that of the second.

From these experiments it is evident that its component parts are oxygen, hydrogen, and carbon; but the proportions of them have not been ascertained.

Its affinities are as follows:

Affinities.

Lime,
Barytes,
Strontian,
Magnesia,
Potass,
Soda,
Ammonia,
Alumina,
Zirconia.

The use of this acid, as a seasoner of food, and in preparing an agreeable cooling drink called *lemonade*, is well known.

SECT. XXI.

OF MALIC ACID.

Discovery.

If nitric acid be distilled with an equal quantity of sugar, till the mixture assumes a brown colour (which is a sign that all the nitric acid has been abstracted from it), this substance will be found of an acid taste; and after all the oxalic acid which may have been formed is separated by lime-water, there remains another acid, which may be obtained by the following process: Saturate it with lime, and filter the solution; then pour upon it a quantity of alcohol, and a coagulation takes place. This coagulum is the acid combined with lime. Separate it by filtration, and edulcorate it with fresh alcohol; then dissolve it in distilled water, and pour in acetite of lead till no more precipitation ensues. The precipitate is the acid combined with lead, from which it may be separated by diluted sulphuric acid*.

Preparation.

This acid, which was discovered by Scheele in 1785, has received the name of *malic acid*, because it may be obtained in abundance from the juice of apples, in which it exists ready formed. Scheele has given us the following process for extracting it. Saturate the juice of apples with potass, and add to the solution acetite of lead till no more precipitation ensues. Wash the precipitate carefully with a sufficient quantity of water; then pour upon it diluted sulphuric acid till the mix-

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* *Swedish Trans.* and Crell's *Annals* for 1785.

ture has a perfectly acid taste, without any of that sweetness which is perceptible as long as any lead remains dissolved in it; then separate the sulphat of lead, which has precipitated, by filtration, and there remains behind pure malic acid [*].

Vauquelin has lately ascertained that it may be extracted, with greater advantage, from the juice of the *sempervivum tectorum*, or common house-leek, where it exists abundantly, combined with lime. The process which he found to answer best is the following: To the juice of the house-leek add acetite of lead as long as any precipitate takes place. Wash the precipitate, and decompose it by means of diluted sulphuric acid in the manner directed by Scheele [†].

Properties.

Malic acid, thus obtained, is a liquid of a reddish brown colour and a very acid taste. When evaporated it becomes thick and viscid like a mucilage or syrup, but it does not crystallize. When exposed to a dry atmosphere in thin layers, it dries altogether, and assumes the appearance of varnish.

When heated in the open fire it becomes black, swells up, exhales an acrid fume, and leaves behind it a very voluminous coal. When distilled the products are an acid water, a little carbonated hydrogen gas, and a large proportion of carbonic acid [‡].

It is very soluble in water. It gradually decomposes spontaneously, by undergoing a kind of fermentation in the vessels in which it is kept.

Sulphuric acid chars it, and nitric acid converts it

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[*] *Swedish Trans.* and Crell's *Annals* for 1785.

[†] *Ann. de Chim.* xxxiv. 127.

[‡] Fourcroy, vii. 199.

into oxalic acid*. Hence it is evident that it is composed of oxygen, hydrogen, and carbon, though the proportions of these substances have not been ascertained.

Malats.

Malic acid combines with alkalies, earths, and metallic oxides, and forms salts known by the name of *malats*.

Its affinities have not yet been ascertained.

Difference from citric acid.

This acid bears a strong resemblance to the citric, but differs from it in the following particulars:

1. The citric acid shoots into fine crystals, but this acid does not crystallize.

2. The salt formed from the citric acid with lime is almost insoluble in boiling water; whereas the salt made with malic acid and the same basis is readily soluble by boiling water.

3. Malic acid precipitates mercury, lead, and silver, from the nitrous acid, and also the solution of gold when diluted with water; whereas citric acid does not alter any of these solutions.

3. Malic acid seems to have a less affinity than citric acid for lime; for when a solution of lime in the former acid is boiled one minute with a salt formed from volatile alkali and citric acid, a decomposition takes place, and the latter acid combines with the lime and is precipitated.

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* Scheele and Hermstadt.

SECT. XXII.

OF LACTIC ACID.

Discovery.

If milk be kept for some time it becomes sour. The acid which then appears in it was first examined by Scheele, and found by him to have peculiar properties. It is called *lactic* acid. In the whey of milk this acid is mixed with a little curd, some phosphat of lime, sugar of milk, and mucilage. All these must be separated before the acid can be examined. Scheele accomplished this by the following process.

Preparation.

Evaporate a quantity of sour whey to an eighth part, and then filtrate it: this separates the cheesy part. Saturate the liquid with lime-water, and the phosphat of lime precipitates. Filtrate again, and dilute the liquid with three times its own bulk of water; then let fall into it oxalic acid, drop by drop, to precipitate the lime which it has dissolved from the lime-water; then add a very small quantity of lime-water, to see whether too much oxalic acid has been added. If there has, oxalat of lime immediately precipitates. Evaporate the solution to the consistence of honey, pour in a sufficient quantity of alcohol, and filtrate again; the acid passes through dissolved in the alcohol, but the sugar of milk and every other substance remains behind. Add to the solution a small quantity of water, and distil with a small heat, the alcohol passes over, and leaves behind the lactic acid dissolved in water*.

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* Scheele, *Stockholm Trans.* 1780.

Properties.

This acid is incapable of crystallizing: when evaporated to dryness, it deliquesces again in the air[*].

When distilled, water comes over first, then a weak acid resembling the tartarous, then an empyreumatic oil mixed with more of the same acid, and lastly carbonic acid and carbonated hydrogen gas—there remains behind a small quantity of coal[†].

Lactats.

The combinations which this acid forms with alkalies, earths, and metallic oxides, are called *lactats.*

All that is known concerning these salts are the following facts ascertained by Scheele. When saturated with fixed alkalies, it gave salts which were deliquescent and soluble in spirit of wine. It formed deliquescent salts with ammonia, with barytes, with lime, and alumina; but with magnesia it formed small crystals, which however at length deliquesced. This acid had no effect on bismuth, cobalt, antimony, tin, mercury, silver, and gold. It dissolved zinc and iron; and it produced with these metals hydrogen gas. Zinc was the only metal with which it crystallized. Copper rendered this acid first slightly blue, then green, and lastly a deep blue; but no crystals were formed. Digested upon lead, it became sweet, but did not crystallize.

The affinities of lactic acid are, according to Bergman, the same with those of acetous acid.

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[*] Scheele, *Stockholm Trans.* 1780.

[†] Ibid.

SECT. XXIII.

OF GALLIC ACID.

Discovery.

THERE is an excrescence known by the name of *nut gall*, which grows on some species of oaks. This substance contains a peculiar acid, called from that circumstance *gallic acid*, the properties of which were first examined with attention by the commissioners of the academy of Dijon; and the result of their experiments was published in 1777, in the third volume of their Elements of Chemistry. In these experiments, however, they employed the infusion of galls, in which the acid is combined with the tanning principle*. It was reserved for Scheele to obtain it in a state of purity.

Preparation.

He observed, in an infusion of galls made with cold water, a sediment, which proved on examination to have a crystalline form and an acid taste. By letting an infusion of galls remain a long time exposed to the air, and removing now and then the mouldy skin which formed on its surface, a large quantity of this sediment was obtained; which being edulcorated with cold water, redissolved in hot water, filtrated and evaporated very slowly, yielded an acid salt in crystals as fine as sand†.

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* A substance lately discovered by the French chemists, to be afterwards described. It exists also in oak-bark, and every other body which may be substituted for that bark in the operation of tanning.

† *Stockholm Trans.* 1786.

Deyeux has proposed a much speedier method of obtaining gallic acid *; but it does not succeed without a good deal of precaution. It consists in exposing pounded nut-galls in a large glass retort to a heat cautiously and slowly raised. A number of brilliant white crystalline plates are sublimed, which possess all the properties of gallic acid. Care must be taken not to apply too great a heat, and to stop the process before any oil begins to come over, otherwise the crystals will be redissolved, and the whole labour lost.

Properties.

Gallic acid thus obtained has the form of transparent plates or octahedrons. Its taste is acid, and somewhat austere or astringent; and when heated, it has a peculiar and rather unpleasant aromatic odour.

When exposed to the action of heat, it is sublimed without alteration: but a strong heat decomposes it in part, and converts it into an acid water, carbonated hydrogen gas, carbonic acid gas, oil, and charcoal. When distilled, a quantity of oxygen gas is disengaged, an acid liquor is found in the receiver, with some gallie acid not decomposed, and there remains in the rctort a quantity of charcoal. If what has passed into the receiver be again distilled, more oxygen gas is obtained, some gallic acid still sublimes, and a quantity of charcoal remains in the retort. By repeated distillations the whole of the acid may be decomposed. This decomposition may be more easily accomplished by distilling repeatedly a solution of gallic acid in water. The products are oxygen gas, charcoal, and an acid liquor.

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* This method was in fact discovered by Scheele, but Deyeux repeated it, and pointed out the proper precautions.—See Crell's *Annals*, i. 29. Eng. Trans.

Book II.

From these experiments Mr Deyeux, who performed them, has concluded, that gallic acid is composed of oxygen, and a much larger proportion of carbon than enters into the composition of carbonic acid. But this conclusion is not warranted by the analysis; for Mr Deyeux did not find that the quantity of oxygen gas and carbon obtained was equal to that of the gallic acid decomposed: and in the acid liquor which came over, there evidently existed a quantity of water, which doubtless was formed during the distillation. Scheele, by treating gallic acid with nitric acid in the usual manner, converted it into oxalic acid. Now it is certain, that oxalic acid contains hydrogen as well as carbon. It cannot be doubted, then, that gallic acid is composed of oxygen, hydrogen, and carbon, in proportions not yet ascertained. But Mr Deyeux has proved, that the quantity of carbon is very great, compared with that of the hydrogen.

Gallic acid is not altered by exposure to the air. It is soluble in 1$\frac{1}{2}$ parts of boiling water, and in 12 parts of water at the temperature of the atmosphere. Alcohol dissolves one-fourth of its weight of this acid at the temperature of the atmosphere. When boiling hot, it dissolves a quantity equal to its own weight.

Neither oxygen gas nor the simple combustibles produce any alteration on it.

Gallats.

Gallic acid combines with alkalies, earths, and metallic oxides, and forms compounds known by the name of *gallats*.

Its affinities have not yet been determined; but oxide of iron seems to have a stronger affinity for it than for any other substance; for gallic acid is capable of taking it from every other acid. In consequence of this property, the infusion of galls is employed to detect the presence of iron in any liquid. As soon as it is poured in, if iron be present, a black or purple colour is produced.

Strong affinity for metallic oxides.

It has a very strong affinity for metallic oxides, and is capable of combining with them in almost every situation. As the greater number of its compounds are insoluble, it for the most part occasions a precipitate when poured into a solution containing a metal; and this precipitate differs in colour, according to the metal which occasions it. Hence this acid, or at least the infusion of nut-galls, is very much used by chemists to detect the presence of metals when held in solution. The formation of a precipitate, with infusion of nut galls, is even considered as a property almost peculiar to metallic oxides. The alkalies are destitute of it, and so are the earths, except glucina, zirconia, and yttria. It ought to be remarked, however, that all the metals are by no means precipitated from their solutions by gallic acid. The following must be excepted:

1. Plantinum,
2. Tin,
3. Zinc,
4. Cobalt,
5. Manganese,
6. Arsenic.

Most of those which are precipitated lose at the same time, as Proust has proved, a part or the whole of their oxygen; and it is to this loss that their precipitation is to be ascribed. The following Table exhibits a view of the colours of the precipitates of different metals by means of this acid:

Gold, ...	Brown.
Silver, ...	Brown.
Mercury, ...	Orange yellow.
Copper, ...	Brown.

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Iron, ...	Black.
Bismuth, ...	Yellow.
Lead, ...	White.

Molybdic acid acquires a dark yellow colour, but does not precipitate *.

SECT. XXIV.

OF MUCOUS OR SACCHOLACTIC ACID.

Preparation.

MUCOUS ACID may be obtained by the following process: Upon one part of gum arabic, or other similar gum, previously put into a retort, pour two parts of nitric acid. Apply a slight heat for a short time, till a little nitrous gas and carbonic acid gas have come over; then allow the mixture to cool. A white powder gradually precipitates, which may be easily separated by filtration. This powder is *mucous acid* †.

Discovery.

This acid was discovered by Scheele in 1780. After having obtained oxalic acid from sugar, he wished to examine whether the sugar of milk would furnish the same product. Upon four ounces of pure sugar of milk, finely powdered, he poured 12 ounces of diluted nitric acid, and put the mixture in a large glass retort, which he placed in a sand bath. A violent effervescence ensuing, he was obliged to remove the retort from the sand-bath till the commotion ceased. He then continued the distillation till the mixture became yellow.

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* Scheele, Crell's *Annals*, i. 28. Eng. Tr.

† Fourcroy, vii. 146.

Chap. IV.

As no crystals appeared in the liquor remaining in the retort after standing two days, he repeated the distillation as before, with the addition of eight ounces of nitric acid, and continued the operation till the yellow colour, which had disappeared on addition of the nitrous acid, returned. The liquor in the retort contained a white powder, and when cold was observed to be thick. Eight ounces of water were added to dilute this liquor, which was then filtrated, by which the white powder was separated; which being edulcorated and dried, weighed 7½ dr. The filtrated solution was evaporated to the consistence of a syrup, and again subjected to distillation, with four ounces of nitric acid as before; after which, the liquor, when cold, was observed to contain many small, oblong, sour crystals, together with some white powder. This powder being separated, the liquor was again distilled with more nitric acid as before; by which means the liquor was rendered capable of yielding crystals again; and by one distillation more, with more nitrous acid, the whole of the liquor was converted into crystals. These crystals, added together, weighed five drams; and were found, upon trial, to have the properties of the oxalic acid.

Mr Scheele next examined the properties of the white powder, and found it to be an acid of a peculiar nature; he therefore called it the *acid of sugar of milk* *. It was afterwards called *saccholactic* acid by the French chemists. Fourcroy has lately given it the name of *mucous acid*, because it is obtained by treating gum arabic, and other mucilaginous substances, with nitric acid. This last name deserves the preference, not only

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* Scheele, ii. 69.

because it is shorter, but because it indicates more precisely the origin of the acid.

Mr Hermstadt of Berlin had made similar experiments on sugar of milk at the same time with Scheele, and with similar results; but he concluded, that the white powder which he obtained was nothing else than oxalat of lime with excess of acid, as indeed Scheele himself did at first. After he became asquainted with Scheele's conclusions, he published a paper in defence of his own opinion; but his proofs are very far from establishing it, or even rendering its truth probable *. He acknowledges himself, that he has not been able to decompose this supposed salt: he allows that it possesses properties distinct from the oxalic acid; but he ascribes this difference to the lime which it contains; yet all the lime which he could discover in 240 grains of this salt was only 20 grains; and if the alkali which he employed was a carbonat (as it probably was), these 20 must be reduced to 11. Now Morveau has shewn, that oxalic acid, containing the same quantity of lime, exhibits very different properties. Besides, this acid, whatever it is, when united with lime, is separated by the oxalic, and must therefore be different from it; as it would be absurd to suppose that an acid could displace itself †. The mucous acid must therefore be considered as a distinct acid, since it possesses peculiar properties.

Properties.

Mucous acid, thus obtained, is under the form of a white gritty powder, with a slightly acid taste.

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* Crell's *Annals*, 1784, ii. 509.

† Morveau, *Encyc. Method.* i. 291.

Heat decomposes it. When distilled, there comes over an acid liquor which crystallizes in needles on cooling, a red coloured acrid oil, carbonic acid gas, and carbonated hydrogen gas. There remains in the retort a large proportion of charcoal.

Mucous acid, according to Scheele, is soluble in 60 parts of its weight of boiling water; but Messrs Hermstadt [*] and Morveau [†] found, that boiling water only dissolved $\frac{1}{80}$th part: it deposited about $\frac{1}{4}$th part on cooling in the form of crystals [‡].

The solution has an acid taste, and reddens the infusion of turnsole [§]. Its specific gravity, at the temperature of 53.7°, is 1.0015 [||].

Mucites.

The compounds which it forms with earths, alkalies, and metallic oxides, are denominated *mucites*. These salts are but very imperfectly known, no chemist having examined them except Scheele. The facts which he ascertained are the following:

With potass it forms a salt soluble in eight parts of boiling water, which crystallizes on cooling. The mucite of soda also crystallizes, and is soluble in five parts of water. Mucite of ammonia loses its base by a moderate heat, while the acid remains behind. The compounds which it forms with the earths are nearly insoluble in water. It scarcely acts upon any of the metals, but it combines with their oxides: it forms salts almost insoluble in water. When poured into the nitrats of silver, mercury, or lead, it occasions a white

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[*] *Phys. Chem.*

[†] *Encyc. Method.* i. 290.

[‡] Scheele.

[§] Id.

[||] Morveau, Ibid.

Book II. precipitate. It produces no change in the sulphats of iron, copper, zinc, manganese, nor in the muriats of tin and mercury *.

SECT. XXV.

OF BENZOIC ACID.

Discovery. BENZOIN, or BENJAMIN as it is sometimes called, is a kind of resin brought from the East Indies; obtained, according to Dr Dryander, from the styrax benzoe, a tree which grows in the island of Sumatra. This substance consists partly of a peculiar acid, described as long ago as 1608 by Blaise de Vigenere, in his Treatise on Fire and Salt, under the name of *flowers of benzoin,* because it was obtained by sublimation; but it is now denominated *benzoic acid.*

Preparation. The usual method of obtaining this acid is to put a quantity of benzoin, coarsely powdered, into an earthen pot, to cover the mouth of the pot with a cone of thick paper, and then to apply a very moderate sand heat. The benzoic acid is sublimed, and attaches itself to the paper. But Scheele has published a different process, which is far preferable †. This process is as follows: Upon four parts of unslaked lime pour twelve parts of water, and after the ebullition is over add 96 parts more of water; then put 12 parts of finely pounded benzoin into a tinned pan, pour upon it first about six

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* Scheele, ii. 76.

† Ibid. i. 124.

parts of the above milk of lime, mix them well together, and thus successively add the rest of the mixture of lime and water. If it be poured in all at once, the benzoin, instead of mixing with it, will coagulate, and run together into a mass. This mixture ought to be boiled over a gentle fire for half an hour with constant agitation; then take it from the fire, let it stand quiet for an hour, in order that it may settle; pour off the supernatant limpid liquor into a glass vessel. Upon the remainder in the pan pour 96 parts of pure water; boil them together for half an hour, then take it from the fire, and let it settle; add the supernatant liquor to the former; pour upon the residuum some more water, boil it as aforesaid, and repeat the same process once more. At last put all the residuums upon a filter, and pour hot water several times upon it. During this process, the calcareous earth combines with the acid of benzoin, and separates it from the resinous particles of this substance. A small quantity of the resin is dissolved by the lime-water, whence it acquires a yellow colour. All these clear yellow leys and decoctions are to be mixed together, and boiled down to 24 parts, which are then to be strained into another glass vessel.

After they are grown cold, muriatic acid is to be added, with constant stirring, till there be no further precipitation, or till the mass tastes a little sourish. The benzoic acid, which was before held in solution by the lime, precipitates in the form of a fine powder.

Properties.

Benzoic acid, thus obtained, is a fine light whitish powder, which is not brittle, but has rather a kind of ductility. Its taste is acrid, hot, and somewhat bitter. Its odour is slight, but peculiar and aromatic. Its specific gravity is 0.667[*]. It hardly affects the infusion of violets, but it reddens that of turnsole, especially when hot[†].

Heat volatilizes this acid, and makes it give out a strong odour, which excites coughing. When exposed to the heat of the blow-pipe in a silver spoon, it melts, becomes as fluid as water, and evaporates without taking fire. It only burns when in contact with flame, and then it leaves no residuum behind. When thrown upon burning coals, it rises in a white smoke. When allowed to cool after being melted, it hardens, and a radiated crust forms on its surface[‡]. When distilled in close vessels, the greater part of it sublimes unaltered, but some of it is decomposed. This portion is converted almost entirely into oil and carbonated hydrogen gas.

This acid is not altered by exposure to the air. Cold water dissolves no sensible quantity of it; but it is soluble enough in hot water: 480 grains of boiling water dissolve 20 grains of it; 19 of these are deposited, when the water cools, in long, slender, flat, feather-like crystals[§].

It is not affected by oxygen gas, nor by any of the simple combustibles. It does not seem capable of oxidating any of the metals[‖].

Benzoats.

It combines with alkalies, earths, and metallic oxides, and forms salts known by the name of *benzoats.*

Concentrated sulphuric acid dissolves it without heat

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[*] Hassenfratz, *Ann. de Chim.* xxviii. 11.

[†] Morveau, *Encyc. Method. Chim.* i. 44.

[‡] Lichtenstein.

[§] Id.

[‖] Trommsdorf.

or any other change, except becoming somewhat brown: when water is poured into the solution, the benzoic acid separates and coagulates on the surface without any alteration *. Nitric acid presents precisely the same phenomena, and also the sulphurous and nitrous acids. Neither the muriatic, the oxy-muriatic, nor the phosphoric acids dissolve it. The acetous, formic, and sebacic acids, when hot, dissolve it precisely as water does; but it crystallizes again when these acids cool †.

Alcohol dissolves it copiously, and lets it fall on the addition of water ‡.

Affinities.

Its affinities, from the experiments of Trommsdorf, appear to be as follows:

White oxide of arsenic,
Potass,
Soda,
Ammonia,
Barytes,
Lime,
Magnesia,
Alumina.

This acid is sometimes used as a medicine, but much less frequently than formerly.

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* Lichtenstein. † Id. ‡ Id.

SECT. XXVI.

OF SUCCINIC ACID.

Discovery.

AMBER is a well-known brown, transparent, inflammable body, pretty hard, and susceptible of polish, found at some depth in the earth, and on the sea-coast of several countries. It was in high estimation among the ancients both as an ornament and a medicine.—When this substance is distilled, a volatile salt is obtained, which is mentioned by Agricola under the name of *salt of amber ;* but its nature was long unknown. Boyle was the first who discovered that it was an acid[*]. From *succinum*, the Latin name of amber, this acid has received the appellation of *succinic acid.*

Preparation.

It is obtained by the following process: Fill a retort half way with powdered amber, and cover the powder with a quantity of dry sand ; lute on a receiver, and distil in a sand-bath without employing too much heat. There passes over first an insipid phlegm ; then a weak acid, which, according to Scheele, is the acetous[†]; then the succinic acid attaches itself to the neck of the retort ; and if the distillation be continued, there comes over at last a thick brown oil, which has an acid taste.

The succinic acid is at first mixed with a quantity of

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[*] Boyle abridged by Shaw, iii. 369.

[†] Bergman's Notes on Scheffer.

oil. It may be made tolerably pure by dissolving it in hot water, and putting upon the filter a little cotton, previously moistened with oil of amber: this substance retains most of the oil, and allows the solution to pass clear. The acid is then to be crystallized by a gentle evaporation; and this process is to be repeated till the acid be sufficiently pure. Guyton Morveau has discovered that it may be made quite pure by distilling off it a sufficient quantity of nitric acid, taking care not to employ a heat strong enough to sublime the succinic acid [*].

Properties.

The crystals of succinic acid are transparent, white, shining, and of a foliated triangular, prismatic form: they have an acid taste, but are not corrosive: they redden tincture of turnsole, but have little effect on that of violets.

They sublime when exposed to a considerable heat, but not at the heat of a water-bath. In a sand-bath they melt, and then sublime and condense in the upper part of the vessel; but the coal which remains shews that they are partly decomposed [†].

One part of this acid dissolves in 96 parts of water at the temperature of 50°, according to Spielman [‡]; in 24 parts at the temperature of 52°; and in 2 parts of water at the temperature of 212°, according to Stockar de Neuforn [§]; but the greatest part crystallizes as the water cools. According to Roux, however, it still retains more of the acid than cold water is capable of dissolving [||].

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[*] *Ann. de Chim.* xxix. 165.

[†] Pott.

[‡] *Inst. Chem.* § xii.

[§] *De Succino.*

[||] Morveau, *Encyc. Method. Chim.* i. 72.

Two hundred and forty grains of boiling alcohol dissolve 177 of this acid; but crystals again shoot as the solution cools*.

Succinats.

The compounds which this acid forms with alkalies, acids, and metallic oxides, have received the name of *succinats*. Scarcely any of them have been examined with attention.

When combined with soda, it crystallizes in four and six sided prisms. When this salt is distilled in a retort, the succinic acid is completely decomposed. There passes over into the receiver an acid liquor, which is the acetous much diluted, and a quantity of brown oil. At the same time carbonic acid gas, and carbonated hydrogen gas, are disengaged, and there remains in the retort soda and charcoal †. Hence it follows that this acid, like the others of the same class, is decomposed by heat, and that it is composed of oxygen, hydrogen, and carbon.

The affinities of succinic acid, according to Morveau, are as follows:

Affinities.

Barytes,
Lime,
Potass,
Soda,
Ammonia,
Magnesia,
Alumina,
Metallic oxides.

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* Wenzel.

† Morveau, *Ann. de Chim.* xxix. 165.

SECT. XXVII.

OF CAMPHORIC ACID.

Discovery.

CAMPHOR is a well-known white crystalline substance, of a strong taste and smell, obtained from a species of laurel in the East Indies. It is so volatile, that it cannot be melted in open vessels, and so inflammable, that it burns even on the surface of water.

When camphor is set on fire in contact with oxygen gas, it burns with a very brilliant flame; much caloric is disengaged, water is formed, the inner surface of the vessel is covered with a black matter, which is undoubtedly charcoal, and a quantity of carbonic acid gas is also produced*. Hence it follows, that it is composed of hydrogen and carbon, at least principally.

Mr Kosegarten, by distilling nitric acid off camphor eight times successively, obtained an acid in crystals†, to which the name of *camphoric acid* has been given.

His experiments have been repeated by Mr Bouillon La Grange. The process for obtaining camphoric acid, as described by this chemist, is as follows: Put into a retort one part of camphor and eight parts of nitric acid of the specific gravity 1.33. Distil with a sand heat. A great deal of nitrous gas and carbonic acid gas is emitted, and a little camphor sublimes. This process must be repeated three times on the same cam-

Preparation.

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* Bouillon La Grange, *Ann. de Chim.* xxiii. 153.

† Kosegarten *de Camphora*, &c. 1785.

phor; so that 24 parts in all of nitric acid are necessary. After the third distillation, when the retort is allowed to cool, a number of crystals make their appearance in it. These are *camphoric acid.* They amount to somewhat less than the half of the camphor employed.

Properties.

Comphoric acid thus obtained is in snow-white crystals, of the form of parallelopipedons [*].

These crystals effloresce in the air [†].

Camphoric acid has a slightly acid bitter taste, and a smell like that of saffron.

It reddens vegetable colours.

It is soluble in 200 parts of cold water, according to Kosegarten; in 96 parts of water at the temperature of 60°, according to Bouillon La Grange. Boiling water dissolves $\frac{1}{12}$th of its weight [‡].

According to Kosegarten, it is insoluble in alcohol; according to Bouillon La Grange, alcohol dissolves it, and when the solution is left in contact with the air of the atmosphere, the acid crystallizes. It is not precipitated from its solution in alcohol by the addition of water [§].

When this acid is placed on ignited coals, it emits a dense aromatic fume, and is entirely dissipated. By a gentler heat, it melts, and is sublimed. If it be put into a heated porcelain tube, and oxygen gas be passed through it, the acid does not undergo any change, but is sublimed.

By mere distillation, it first melts and then sublimes; by which process its properties are in some respect

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[*] Kosegarten.

[†] La Grange.

[‡] Kosegarten.

[§] Bouillon La Grange, *Ann. de Chim.* xxvii. 40.

changed. It no longer reddens the tincture of turnsole, but acquires a strong aromatic smell; its taste becomes less penetrating, and it is no longer soluble either in water or the sulphuric and muriatic acids. Heated nitric acid turns it yellow and dissolves it. Alcohol likewise dissolves it; and if this solution be left in contact with the air of the atmosphere, it crystallizes.

Camphoric acid does not produce any change in sulphur; alcohol and the mineral acids totally dissolve it; and so likewise do the volatile and the fat oils.

Camphoric acid does not precipitate lime from lime-water. It produces no change on the solution of indigo in sulphuric acid.

Camphorats.

It forms combinations with the alkalies, earths, and metallic oxides, which are called *camphorats*.

Affinities.

Its affinities, as far as acertained by Bouillon La Grange, are as follows[*].

Lime,
Potass,
Soda,
Barytes,
Ammonia,
Alumina,
Magnesia.

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[*] *Ann. de Chim.* xxvii. 21.

SECT. XXVIII.

OF SUBERIC ACID.

Discovery.

CORK, a substance too well known to require any description, is the bark of a tree which bears the same name. By means of nitric acid, Brugnatelli converted it into an acid[*], which has been called the *suberic acid*, from *Suber*, the Latin name of the cork tree. Several chemists affirmed that this acid was the oxalic, because it possesses several properties in common with it. These assertions induced Bouillon La Grange to undertake a set of experiments on suberic acid. These experiments, which have been published in the 23d volume of the *Annales de Chimie*, completely establish the peculiar nature of suberic acid, by shewing that it possesses properties different from those of any other acid.

Preparation.

Suberic acid may be formed by pouring six parts of nitric acid of the specific gravity 1.261 on one part of cork grated down, or simply broken down into small pieces, and distilling the mixture with a gentle heat as long as red vapours continue to escape. As the distillation advances, a yellow matter like wax makes its appearance on the surface of the liquid. While the matter contained in the retort is hot, it is to be poured into a glass vessel, placed upon a sand-bath over a gentle fire, and constantly stirred with a glass rod. By this means it becomes gradually thick. As soon as white vapours,

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[*] Crell's *Annals*, 1787.

exciting a tickling in the throat, begin to disengage themselves, the vessel is removed from the bath, and the mass continually stirred till it is almost cold.

By this means an orange-coloured mass is obtained of the consistence of honey, of a strong and sharp odour while hot, but having a peculiar aromatic smell when cold.

On this mass twice its weight of boiling water is to be poured, and heat applied till it becomes liquid; and then that part of it which is insoluble in water is to be separated by filtration. The filtered liquor becomes muddy; on cooling it deposits a powdery sediment, and a thin pellicle forms on its surface. The sediment is to be separated by filtration, and the liquor reduced to a dry mass by evaporating in a gentle heat. This mass is *suberic acid.* It is still a little coloured, owing to some accidental mixture, from which it may be purified either by saturating it with potass and precipitating it by means of an acid, or by boiling it along with charcoal powder.

Properties.

Suberic acid thus obtained is not crystallizable, but when precipitated from potass by an acid it assumes the form of a powder; when obtained by evaporation it forms thin irregular pellicles.

Its taste is acid and slightly bitter; and when dissolved in a small quantity of boiling water it acts upon the throat, and excites coughing.

It reddens vegetable blues; and when dropped into a solution of indigo in sulphuric acid (*liquid blue*, as it is called in this country), it changes the colour of the solution, and renders it green.

Water at the temperature of 60° or even 70° dissolves only $\frac{1}{57.6}$ part of its weight of suberic acid; and if the acid be very pure, only $\frac{1}{144}$th part: boiling water, on the contrary, dissolves half its weight of it.

When exposed to the air, it attracts moisture, especially if it be impure.

When exposed to the light of day, it becomes at last brown; and this effect is produced much sooner by the direct rays of the sun.

When heated in a matrass, the acid sublimes, and the inside of the glass is surrounded with zones of different colours. If the sublimation be stopped at the proper time, the acid is obtained on the sides of the vessel in small points formed of concentric circles. When exposed to the heat of the blow-pipe on a spoon of platinum, it first melts, then becomes pulverulent, and at last sublimes entirely with a smell resembling that of sebacic acid.

It is not altered by oxygen gas:—the other acids do not dissolve it completely. Alcohol developes an aromatic odour, and an ether may be obtained by means of this acid.

It converts the blue colour of nitrat of copper to a green; the sulphat of copper also to a green; green sulphat of iron to a deep yellow; and sulphat of zinc to a golden yellow.

It has no action either on platinum, gold, or nickel; but it oxidates silver, mercury, copper, lead, tin, iron, bismuth, arsenic, cobalt, zinc, antimony, manganese, and molybdenum.

Suberats. With alkalies, earths, and metallic oxides, it forms compounds known by the name of *suberats*.

It affinities are as follows:

Affinities.

Barytes,
Potass,

Soda,
Lime,
Ammonia,
Magnesia,
Alumina [*].

SECT. XXIX.

OF LACCIC ACID.

Discovery.

About the year 1786, Dr Anderson of Madras mentioned, in a letter to the governor and council of that place, that nests of insects, resembling small cowry shells, had been brought to him from the woods by the natives, who eat them with avidity. These supposed nests he soon afterwards discovered to be the coverings of the females of an undescribed species of coccus, which he shortly found means to progagate with great facility on several of the trees and shrubs growing in his neighbourhood [†].

On examining this substance, which he called *white lac*, he observed in it a very considerable resemblance to bees wax; he noticed also, that the animal which secretes it provides itself by some means or other with

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[*] *Ann. de Chim.* xxiii. 42.

[†] The Chinese collect a kind of wax, which they call *pe-la*, from a coccus, deposited for the purpose of breeding on several shrubs, and manage it exactly as the Mexicans manage the cochineal insect. It was the knowledge of this that induced Dr Anderson to attempt to propagate his insect.

a small quantity of honey, resembling that produced by our bees; and in one of his letters he complains, that the children whom he employed to gather it were tempted by its sweetness to eat so much of it as materially to reduce the produce of his crop. Small quantities of this matter were sent into Europe in 1789, both in its natural state and melted into cakes; and in 1793 Dr Pearson, at the request of Sir Joseph Banks, undertook a chemical examination of its qualities, and his experiments were published in the Philosophical Transactions for 1794.

A piece of white lac, from 3 to 15 grains in weight, is probably produced by each insect. These pieces are of a grey colour, opaque, rough, and roundish. When white lac was purified by being strained through muslin, it was of a brown colour, brittle, hard, and had a bitterish taste. It melted in alcohol, and in water of the temperature of 145°. In many of its properties it resembles bees wax, though it differs in others; and Dr Pearson supposes that both substances are composed of the same ingredients, but in different proportions.

Two thousand grains of white lac were exposed in such a degree of heat as was just sufficient to melt them. As they grew soft and fluid, there oozed out 550 grains of a reddish watery liquid, which smelled like newly baken bread *. To this liquid Dr Pearson has given the name of *laccic acid* †.

It possesses the following properties:

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* The same liquid appears on pressing the crude lac between the fingers; and we are told, that when newly gathered it is replete with juice.

† Pearson's *Trans. of the Chemical Nomenclature.*

Properties of laccic acid.

It turns paper stained with turnsole to a red colour.

After being filtered, it has a slightly saltish taste with bitterness, but is not at all sour.

When heated, it smells precisely like newly baken hot bread.

On standing, it grows somewhat turbid, and deposits a small quantity of sediment.

Its specific gravity at the temperature of 60° is 1.025.

A little of it having been evaporated till it grew very turbid, afforded on standing small needle-shaped crystals in mucilaginous matter.

Two hundred and fifty grains of it were poured into a very small retort and distilled. As the liquor grew warm, mucilage-like clouds appeared; but as the heat increased they disappeared again. At the temperature of 200° the liquor distilled over very fast: A small quantity of extractive matter remained behind. The distilled liquor while hot smelled like newly baken bread, and was perfectly transparent and yellowish. A shred of paper stained with turnsole, which had been put into the receiver, was not reddened; nor did another which had been immersed in a solution of sulphat of iron, and also placed in the receiver, turn to a blue colour upon being moistened with the solution of potass *.

About one hundred grains of this distilled liquid being evaporated till it grew turbid, after being set by for a night, afforded acicular crystals, which under a lens appeared in a group not unlike the umbel of parsley. The whole of them did not amount to the quarter of a grain. They tasted only bitterish.

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* A proof that the acid was not the prussic.

Another 100 grains being evaporated to dryness in a very low temperature, a blackish matter was left behind, which did not entirely disappear on heating the spoon containing it very hot in the naked fire; but on heating oxalic acid to a much less degree, it evaporated and left not a trace behind.

Carbonat of lime dissolved in this distilled liquid with effervescence. The solution tasted bitterish, did not turn paper stained with turnsole red, and on adding to it carbonat of potass a copious precipitation ensued. A little of this solution of lime and of alkali being evaporated to dryness, and the residuum made red hot, nothing remained but carbonat of lime and carbonat of potass.

This liquid did not render nitrat of lime turbid, but it produced turbidness in nitrat and muriat of barytes.

To five hundred grains of the reddish-coloured liquor obtained by melting white lac, carbonat of soda was added till the effervescence ceased, and the mixture was neutralised; for which purpose three grains of the carbonat were necessary. During this combination a quantity of mucilaginous matter, with a little carbonat of lime, was precipitated. The saturated solution being filtrated and evaporated to the due degree, afforded on standing deliquescent crystals, which on exposure to fire left only a residuum of carbonat of soda.

Lime-water being added to this reddish-coloured liquor produced a light purple turbid appearance; and on standing there were clouds just perceptible.

Sulphuret of lime occasioned a white precipitation, but no sulphurated hydrogen gas was perceptible by the smell.

Tincture of galls produced a green precipitation.

Sulphat of iron produced a purplish colour, but no precipitation; nor was any precipitate formed by the addition first of a little vinegar, and then of a little potass, to the mixture.

Acetite of lead occasioned a reddish precipitation, which redissolved on adding a little nitric acid.

Nitrat of mercury produced a whitish turbid liquor.

Oxalic acid produced immediately the precipitation of white acicular crystals, owing probably to the presence of a little lime in the liquid.

Tartrite of potass produced a precipitation not unlike what takes place on adding tartarous acid to tartrite of potass; but it did not dissolve again on adding potass.

Such were the properties of this acid discovered by Dr Pearson. They are sufficient to distinguish it from all the acids hitherto examined *.

SECT. XXX.

OF PRUSSIC ACID.

As the PRUSSIC ACID is one of the most important instruments which the chemist possesses, and as it has perhaps occupied more of the attention of the most distinguished cultivators of the science than any of the other acids, it will be proper to trace somewhat particularly the gradual discovery of its nature and properties.

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* *Phil. Trans.* 1794, p. 383.

Discovery of prussian blue.

About the beginning of the 18th century, Diesbach, a chemist of Berlin, wishing to precipitate a solution of cochineal mixed with a little alum and sulphat of iron, borrowed from Dippel some potass, from which that chemist had *distilled* several times his *animal oil.* On pouring in the potass, Diesbach was surprised to see, instead of the red precipitate which he had expected, a beautiful blue powder falling to the bottom of the vessel. By reflecting on the materials which he had employed, he easily discovered the method of procuring the blue powder at pleasure*. This powder was called *Prussian blue*, from the place where it was discovered. It was announced in the Berlin Memoirs for 1710†; but the process was concealed, because it had become a lucrative article of commerce. A method of preparing it, however, was published by Woodward in the Philosophical Transactions for 1724, which he said he had got from one of his friends in Germany. This method was as follows: Detonate together 4 ounces of nitre and as much tartar, in order to procure an extemporaneous alkali; then add 4 ounces of dried bullock's blood, mix the ingredients well together, and put them into a crucible covered with a lid, in which there is a small hole; calcine with a moderate fire till the blood emits no more smoke or flame capable of blackening any white body exposed to it: increase the fire towards the end, so that the whole matter contained in the crucible shall be moderately but sensibly red. In this state throw it into two pints of water, and boil it for half an hour. Decant off this water, and continue to pour on

Preparation.

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* Stahl's *Three Hundred Experiments*, p. 281.

† *Miscellanea Berol.* vol. i.

more till it come off insipid. Add all these liquids together, and boil them down to two pints. Dissolve two ounces of sulphat of iron and eight ounces of alum in two pints of boiling water; mix this with the former liquor while both are hot. An effervescence takes place, and a powder is precipitated of a green colour mixed with blue. Separate this precipitate by filtration, and pour muriatic acid upon it till it becomes of a beautiful blue; then wash it with water and dry it*.

Different explanations were given of the nature of this precipitate by different chemists. All of them acknowledged that it contained iron, but to account for the colour was the difficult point. Brown, and Geoffroy, and Neumann, discovered in succession, that a great many other animal substances besides blood communicated to alkalies the property of forming prussian blue; but the theories by which they attempted to account for its formation were altogether nugatory. At last a very important step was made in the investigation of this compound by Macquer, who published a dissertation on it in the year 1752†.

Annalysed by Macquer.

This celebrated chemist ascertained the following facts: 1. When alkali is added to a solution of iron in any acid, the iron is precipitated of a yellow colour, and soluble in acids; but if iron be precipitated from an acid by an alkali prepared by calcination with blood (which has been called a *prussian alkali*), it is of a green colour. 2. Acids dissolve only a part of this precipitate, and leave behind an insoluble powder which is of an intense blue colour. The green precipitate therefore is composed of two different substances, one of

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* *Phil. Trans.* xxxiii. 15.

† *Mem. Par.* 1752.

which is prussian blue. 3. The other is the brown or yellow oxide of iron ; and the green colour is owing to the mixture of the blue and yellow substances. 4. When heat is applied to this prussian blue, its blue colour is destroyed, and it becomes exactly similar to common oxide of iron. It is composed therefore of iron and some other substance, which heat has the property of driving off. 5. If it be boiled with a pure alkali, it loses its blue colour also, and at the same time the alkali acquires the property of precipitating of a blue colour solutions of iron in acids, or it has become precisely the same with the prussian alkali. 6. Prussian blue, therefore, is composed of iron and something which a pure alkali can separate from it, something which has a greater affinity for alkali than for iron. 7. By boiling a quantity of alkali with prussian blue, it may be completely saturated with this something, which may be called *colouring matter*. 8. No acid can separate this colouring matter from iron after it is once united with it. 9. When iron dissolved in an acid is mixed with an alkali saturated with the colouring matter, a double decomposition takes place, the acid unites with the alkali, and the colouring matter with the iron, and forms prussian blue. 10. The reason that, in the common method of preparing prussian blue, a quantity of yellow oxide is precipitated, is, that there is not a sufficient quantity of colouring matter (for the alkali is never saturated with it) to saturate all the iron displaced by the alkali ; a part of it therefore is mixed with prussian blue. Muriatic acid dissolves this oxide, carries it off, and leaves the blue in a state of purity.—Such were the conclusions which Macquer drew from his experiments ; experiments which not only discovered the composition of prussian blue, but threw a ray of light on the nature of affinities, which has contributed much towards the advancement of that important branch of chemistry.

The nature of the colouring matter, however, was still unknown. Macquer supposed it to be phlogiston; and this opinion was for some time acceded to by almost all chemists. Hence the alkali saturated with it received the name of *phlogisticated alkali.*

The dissertation of Macquer drew the attention of chemists to prussian blue in a peculiar manner: but for some time they satisfied themselves with ascertaining the different bodies which might be employed to *phlogisticate* the alkali, without attempting to ascertain what this phlogistication was. At length, in 1772, Morveau announced his suspicion that the colouring matter was not mere phlogiston, but probably an acid. This seems to have led succeeding chemists to direct their attention towards an examination of its properties. Sage affirmed that it was phosphoric acid; but this opinion was refuted by Lavoisier *. Bergman also announced his suspicions that it was an acid, but an unknown one †. Deyeux and Parmentier, Bergman, Erxleben, Delius, and Scopoli, submitted prussian blue to distillation, and obtained a quantity of ammonia. Fontana ascertained that prussian blue detonated with nitre. Landriani obtained, by distillation, a little acid liquid and oil, and a great quantity of azotic gas and carbonated hydrogen gas. Such was the knowledge of chemists respecting the nature of this colouring matter, when Scheele all at once removed the veil, and explained its properties and

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* *Mem. Par.* 1777, p. 77.

† Notes on Scheffer, § 164.

composition. This he performed in two dissertations on prussian blue, published in the Stockholm Transactions for 1782 and 1783 *.

He observed that the prussian alkali, after being exposed for some time to the air, lost the property of forming prussian blue; the colouring matter must therefore have left it.

Discovery of prussic acid.

He put a small quantity of it into a large glass globe, corked it up, and kept it some time; but no change was produced either in the air or the prussian alkali. Something must therefore displace the colouring matter when the alkali is exposed to the open air, which is not present in a glass vessel. Was it carbonic acid gas? To ascertain this, he put a quantity of prussian alkali into a glass globe filled with that gas, and in 24 hours the alkali was incapable of producing prussian blue. It is therefore carbonic acid gas which displaces the colouring matter. He repeated this experiment with this difference, that he hung in the globe a bit of paper which had been previously dipped into a solution of sulphat of iron, and on which he had let fall two drops of an alkaline lixivium in order to precipitate the iron. This paper was taken out in two hours, and became covered with a fine blue on adding a little muriatic acid. Carbonic acid, then, has the property of separating the colouring matter from alkali without decomposing it.

He found also that other acids produce the same effect. Hence he concluded that the colouring matter might be obtained in a separate state. Accordingly he made a great many attempts to procure it in that state, and at last hit upon the following method, which succeeds perfectly.

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* Scheele, ii. 141.

Preparation.

Mix together ten parts of prussian blue in powder, five parts of the red oxide of mercury, and thirty parts of water, and boil the mixture for some minutes in a glass vessel. The blue colour disappears, and the mixture becomes yellowish green. Pour it upon a filter; and after all the liquid part has passed, pour ten parts of hot water through the filter to wash the residuum completely. The oxide of mercury decomposes prussian blue, separates its colouring matter, and forms with it a salt soluble in water. The liquid therefore which has passed through the filter contains the colouring matter combined with mercury. The other component parts of the prussian blue, being insoluble, do not pass through the filter. Pour this mercurial liquid upon 2½ parts of clean iron filings, quite free from rust. Add at the same time one part of concentrated sulphuric acid, and shake the mixture. The iron filings are dissolved, and the mercury formerly held in solution is precipitated in the metallic state. The cause of this sudden change is obvious: The iron de-oxidates the mercury, and is at the same instant dissolved by the sulphuric acid, which has a stronger affinity for it than the colouring matter has. There remains in solution therefore only sulphat of iron and the colouring matter.

Now the colouring matter being volatile, which the sulphat of iron is not, it was easy to obtain it apart by distillation. Accordingly he distilled the mixture in a gentle heat: the colouring matter came over by the time that one-fourth of the liquor had passed into the receiver. It was mixed, however, with a small quantity of sulphuric acid; from which he separated it by distilling a second time over a quantity of carbonat of lime. The sulphuric acid combines with the lime and remains behind, which the colouring matter cannot do, because carbonic acid has a stronger affinity for lime than it has. Thus he obtained the colouring matter in a state of purity.

Composition.

It remained now to discover its component parts. He formed a very pure prussian blue, which he distilled, and increased the fire till the vessel became red. The small quantity of water which he had put into the receiver contained a portion of the blue colouring matter and of ammonia; and the air of the receiver consisted of azot, carbonic acid gas, and the colouring matter. He concluded, from this and other experiments, that the colouring matter is a compound of ammonia and oil. But when he attempted to verify this theory by combining together ammonia and oil, he could not succeed in forming colouring matter. This obliged him to change his opinion; and at last he concluded that the colouring matter is a compound of ammonia and charcoal. He mixed together equal quantities of pounded charcoal and potass, put the mixture into a crucible, and kept it red hot for a quarter of an hour: he then added a quantity of sal ammoniac in small pieces, which he pushed to the bottom of the melted mixture, kept it in the fire for two minutes till it had ceased to give out vapours of ammonia, and then threw it into a quantity of water. The solution possessed all the properties of the prussian alkali. Thus Mr Scheele succeeded in forming the colouring matter.

This colouring matter was called *prussic acid* by Morveau in the first volume of the chemical part of the *Encyclopedie Methodique;* an appellation which is now generally received, and which therefore it will be proper to employ in the remaining part of this Section.

These admirable experiments of Scheele were repeated and carried still farther by Berthollet in 1787; who applied to the explanation of the composition of the colouring matter the light which had resulted from his previous experiments on the component parts of ammonia. This illustrious chemist, scarcely inferior to Scheele in ingenuity and address, ascertained, in the first place, that the phlogisticated alkali is a triple salt, composed of prussic acid, the alkali, and oxide of iron; that it may be obtained in octahedral crystals; and that when mixed with sulphuric acid, and exposed to the light, it lets fall a precipitate of prussian blue. His next object was to ascertain the component parts of prussic acid. When oxy-muriatic acid is poured into prussic acid, obtained by Scheele's process, it loses its oxygen, and is converted into common muriatic acid. At the same time, the prussic acid becomes more odorous and more volatile, less capable of combining with alkalies, and precipitates iron from its solutions, not blue, but *green*. Thus prussic acid, by combining with oxygen, acquires new properties, and is converted into a new substance, which may be called *oxy-prussic acid*. If more oxy-muriatic acid gas be made to pass into prussic acid, and it be exposed to the light, the prussic acid separates from the water with which it was combined, and precipitates to the bottom in the form of an aromatic oil; which heat converts into a vapour insoluble in water, and incapable of combining with iron. When the green precipitate, composed of oxy-prussic acid and iron, is mixed with a pure fixed alkali, the oxy-prussic acid is decomposed, and converted into carbonat of ammonia.

From these experiments, Berthollet concluded, that prussic acid does not contain ammonia ready formed; but that it is a triple compound of carbon, hydrogen, and azot, in proportions which he was not able to ascertain. This conclusion has been still farther verified by Mr Clouet, who found that when ammoniacal gas is made to pass through a red hot porcelain tube containing charcoal, a quantity of prussic acid is formed*. This experiment does not succeed unless a pretty strong heat be applied to the tube †.

Fourcroy and several other chemists believe, that the prussic acid contains also a portion of oxygen in its composition, resting chiefly upon an experiment of Vauquelin ‡. This is certainly possible, though it has not been proved; and the experiments of Berthollet render it somewhat unlikely.

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* *Ann. de Chim.* xi. 30.

† *Jour. de l'Ecole Polytechn.* I. iii. 436.

‡ Vauquelin's experiments were as follows:

Exper. I. Put into a retort 100 parts of the muriat of ammonia, 50 parts of lime, and 25 parts of charcoal in fine powder; adapt to the retort a receiver containing a slight solution of the sulphat of iron, and immerse into it the beak of the retort; then apply a brisk heat, and continue the action of the fire until nothing more is disengaged.

Exper. II. Put into a retort 100 parts of the muriat of ammonia, 50 parts of semi-vitreous oxide of lead, and 25 parts of charcoal; adapt a receiver containing a solution of sulphat of iron, and proceed as before. Stir well the liquors contained in the receivers, and expose them to the air for several days, in order that the combination between the oxide of iron and the prussic acid may be perfect, and that the prussiat of iron may absorb as much oxygen as is necessary for its passing to the state of blue prussiat, and for its being proof against acids: then pour into these liquors equal quantities of sulphuric acid well diluted with water, and you will have prussian blue, the quantities of which will be as one to six; that is to say, the prussian blue of the experiment in which Vauquelin employed oxide of lead, was six times more abundant than that of the experiment in which he employed only lime to disengage the ammonia.

Having thus traced the gradual progress of philosophers in ascertaining the nature of the prussic acid, it only remains to give an account of its properties, which were first examined by the indefatigable Scheele.

Properties.

Prussic acid obtained by Scheele's process is a colourless liquid like water. It has a strong odour, resembling that of the flowers of the peach, or of bitter almonds. Its tase is sweetish, acrid, and hot, and apt to excite cough. It does not alter the colour of vegetable blues.

It is exceedingly volatile, and evidently capable of assuming the gaseous form; though it has never been obtained apart, nor examined in that state. At a high temperature (when united to a base) it is decomposed and converted into ammonia, carbonic acid, and carbonated hydrogen gas.

It unites difficultly with alkalies and earths, and is separated from them much more easily than from metallic oxides. Mere exposure to the light of the sun, or to a heat of 110°, is sufficient for that purpose. These combinations are decomposed also by all the acids.

It has no action on metals, but it unites with their oxides, and forms with them salts, which are almost all insoluble, if we except prussiats of mercury and manganese. These compounds are not decomposed by acids. Yet the prussic acid is not capable of taking the metallic oxides from the other acids.

Prussic acid has a great tendency to enter into triple compounds, combining at once with an alkali and a metallic oxide; and these compounds are much more permanent and difficult to decompose than its single combinations.

Affinities.

The affinities of this acid, as far as they have been ascertained, are as follows:

- Barytes[*],
- Strontian,
- Potass,
- Soda,
- Lime,
- Magnesia,
- Ammonia.

It does not seem capable of combining with alumina.

Detects metals.

This acid is of great importance to the chemist, in consequence of the property which it has of forming insoluble compounds with metallic oxides, and almost with metallic oxides alone. This puts it in our power to ascertain the presence of a metallic body held in solution. When the prussic acid is dropt in, a precipitate appears if a metal be present. The colour of this precipitate indicates the metal, and the quantity of it enables us to ascertain the quantity of metal contained in the solution. It is used especially to indicate the presence of iron, which it does by the blue colour that the solution assumes; and to free solutions from iron, which it does by precipitating the iron in the form of prussian blue.

It is evident, however, that the pure prussic acid cannot be employed for these purposes, because it is incapable of taking metallic oxides from other acids. It is always employed combined with an alkaline or earthy basis. In that state it decomposes all metallic salts by a compound affinity. The base most commonly employed is potass or lime; and indeed it is most usually

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[*] Henry, Nicholson's *Journal*, iii. 171.

employed in the state of a triple salt, composed of prussic acid, potass, and oxide of iron, which is preferred, because it is not apt to be decomposed by the action of the atmosphere. The method of preparing this salt, and the precautions necessary in employing it, will be given in a subsequent part of this Work.

Action on metallic oxides.

Of all the metallic solutions tried by Scheele, pure prussic acid occasioned only a precipitate in three, namely,

1. Nitrat of silver precipitated white.
2. Nitrat of mercury . . . . . . black.
3. Carbonat of iron . . . . green becoming blue.

It has no action on the oxides of

1. Platinum.
2. Iron.
3. Tin.
4. Lead.
5. Bismuth.
6. Antimony.
7. Manganese.
8. Arsenic acid.
9. Molybdic acid.

10. Gold precipitated by the alkaline carbonats is rendered white by this acid.

11. It disengages carbonic acid from the oxide of silver, precipitated by the same alkalies; but the oxide remains white.

12. It dissolves red oxide of mercury, and forms with it a salt, which may be obtained in crystals.

13. Oxide of copper precipitated by carbonat of potass effervesces in it, and acquires a slight orange-yellow colour.

14. Oxide of iron precipitated from the sulphat of iron by carbonat of potass, effervesces in it, and becomes blue.

15. Oxide of cobalt precipitated by the same alkali, gives in it some marks of effervescence, and becomes yellowish brown *.

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* Scheele, ii. 169.

The compounds which prussic acid makes with zirconia[*] and yttria[†], seem also to be insoluble; for these earths are precipitated from their solutions by prussiat of potass; a circumstance in which they differ from all the other earths and alkalies, and which indicates a coincidence between them and the metallic oxides.

SECT. XXXI.

OF SEBACIC ACID.

Discovery.

CHEMISTS had long suspected that an acid could be obtained from tallow, on account of the acrid nature of the fumes which it emits at a high temperature; but it was M. Grutzmacher who first demonstrated this acid in a dissertation *De Ossium Medulla*, published in 1748[‡]. M. Rhodes mentioned it in 1753, and Segner published a dissertation on it in 1754, and Crell examined its properties very fully in two dissertations published in the Philosophical Transactions for 1780 and 1782. It was called at first *acid of fat*, and afterwards *sebacic acid*.

Preparation.

It may be procured by the following process: Mix quick-lime with melted tallow, and keep the mixture for some time in a melting heat. Then let it cool, and wash it in a great quantity of water. Evaporate this water, and there will be obtained a brown salt, which is impure sebat of lime. Heat this pretty strongly in a crucible, dissolve it in water, filter it, separate the ex-

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[*] Klaproth.

[†] Vauquelin, *Ann. de Chim.* xxxvi. 158.

[‡] Leonhardi.

cess of lime by means of carbonic acid, then evaporate. Pure crystallized sebat of lime is obtained. Mix this salt with sulphuric acid and distil with a moderate heat. *Sebacic* acid comes over.

Properties.

Sebacic acid, thus obtained, is a liquid of an acid, sharp, bitterish taste. When concentrated, it exhales a white smoke, which has a strong disagreeable peculiar odour, and irritates the eyes and the throat. It reddens tincture of turnsole.

Heat causes it to assume a yellowish colour. When distilled, it yields a brownish liquid, and when distilled to dryness, it leaves a little charcoal. When passed through a red hot tube, it is decomposed and converted into water, carbonic acid, carbonated hydrogen gas, and charcoal *.

It combines with alkalies, earths, and metallic oxides, and forms salts called *sebats*.

It oxidates silver, mercury, copper, iron, lead, tin, zinc, antimony, manganese.

It does not act upon bismuth, cobalt, nickel. When mixed with nitric acid it dissolves gold.

Affinities.

Its affinities, according to Morveau, are as follows:

Barytes,
Potass,
Soda,
Lime,
Magnesia,
Ammonia,
Alumina,
Metallic oxides.

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* Fourcroy, ix. 291.

SECT. XXXII.

OF ZOONIC ACID.

Discovery.

Mr Berthollet has obtained a peculiar acid by distilling vegetable and animal substances, to which he has given the name of the *zoonic acid*[*]. He procured it by distilling the gluten of wheat, the yest of beer, bones, and woollen rags; and concludes, therefore, that it may be produced by the distillation of all animal substances.

Preparation.

To obtain this acid pure, he mixed lime with the distilled liquid, after having separated the oil, which it always contains (for the product of the distillation of animal substances is chiefly oil and carbonat of ammonia). He boiled this mixture till the carbonat of ammonia was exhaled: he then filtered it, added a little more lime, and boiled it again till the smell of the ammonia had gone off entirely. The liquor, which now contained only zoonat of lime, he filtered again, and then added a little water impregnated with carbonic acid, in order to precipitate any lime which might happen to be dissolved in the liquid without being combined with the zoonic acid.

After concentrating the zoonat of lime, he mixed it with phosphoric acid, and distilled it in a retort. At a heat nearly equal to that of boiling water, the zoonic acid passes over in a state of purity.

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[*] *Ann. de Chim.* xxvi. 86.

Chap. IV.
Properties.

The zoonic acid has an odour like that of meat when frying, and it is actually formed during that process. It has an austere taste.

It gives a red colour to paper tinged with turnsole.

With alkalies and earths it produces salts, which do not appear capable of crystallizing.

It forms a white precipitate in the solutions of acetite of lead, and nitrat of mercury.

Part of the zoonic acid seems to be destroyed by the action of heat during the distillation of the zoonat of lime with phosphoric acid: for the liquor, which is in ebullition, becomes brown, and grows black at the end of the operation: hence Mr Berthollet concludes that the zoonic acid contains carbon. The zoonat of silver, when kept, becomes gradually brown; hence he concludes that the acid contains hydrogen.

Nothing more is at present known concerning this acid. Trommsdorf supposes it the same with the sebacic; but this has not been proved, nor even rendered probable.

SECT. XXXIII.

GENERAL REMARKS.

From the preceding account of the acids, it is evident that these bodies are exceedingly different from each other, and that bodies of the most opposite nature have been arranged under the same class. This has made it a very difficult matter to assign the characteristic marks of acids in general, or those properties which constitute the essence of an acid, and render it necessary to place a body in this class rather than in any other. Accordingly we find that chemists have differed very considerably about these characteristics.

All acids form salts.

They all agree in this particular, that acids are capable of combining with alkalies, earths, and metallic oxides, and of forming with them compounds known by the name of salts. No substance which wants this property is considered as an acid. But this property alone is not sufficient to distinguish acids from other bodies; because many substances possess it which have been unanimously excluded from the class of acids; the greater number of metallic oxides, for instance, and the gaseous oxide of azot. It is true indeed that the salts which these last bodies form with alkalies and earths have not been much examined; but it is no less certain that they exist.

Action on vegetable blues.

All the acids convert vegetable blues to red, if we except the prussic; but they differ exceedingly in the extent to which they possess this property. The greater number convert almost all vegetable blues (except indigo) to red; while some, the carbonic for instance, only act upon the most delicate, as the tincture of turnsole. The cause of this change of colour has not been ascertained. In many cases it seems to be in consequence of the saturation of an alkaline or earthy substance which was previously combined with the colouring matter. This is the case evidently with respect to litmus. If this held always, the conversion of vegetable blues into red would be merely a consequence of the affinities between acids and alkaline bodies, and of the superior affinity which they have for them.

Taste.

All the acids have an acid or sour taste, except five; namely, the oxy-muriatic, the benzoic, the laccic, the prussic, and the zoonic. In all these the other characters of acids are likewise exceedingly feeble. The strength of the acid taste differs exceedingly in those which have it. In some, as the sulphuric, it is intolerably strong; in others, as the boracic and the succinic, it is barely perceptible; while in others, as those which have a metallic basis, it is overpowered by an acrid metallic savour.

Solubility in water,

All the acids are soluble in water; but in this respect also they differ exceedingly from each other. Six of them are so soluble in water that they have never been obtained except in combination with that liquid. These are,

1. Sulphuric,
2. Nitric,
3. Acetous,
4. Prussic,
5. Sebacic,
6. Zoonic.

The rest may be obtained either in the state of gas, or in a solid or crystallized form. Five of them are gases, which are readily absorbed by water to a certain amount, after which the water being saturated refuses to absorb any more. The weight of each absorbed by 100 parts of water may be seen in the following TABLE.

1. Muriatic	100.00
2. Sulphurous	3.96
3. Carbonic	0.18
4. Oxy-muriatic	unknown
5. Fluoric	unknown

The weight of the remaining acids, when solid or crystallized, soluble in 100 parts of water, is exhibited in the following TABLE.

Phosphoric	Very soluble, proportion not determined.
Acetic	
Tartarous	
Malic	
Lactic	

Arsenic	152 parts
Citric	133
Oxalic	50
Gallic	8.4
Boracic	1.6
Mucous	1.0
Succinic	1.0
Suberic	0.7
Camphoric	0.5
Benzoic	0.2
Molybdic	0.1

In alcohol.

All the acids are more or less soluble in alcohol, except phosphoric acid and the metallic acids. The sulphuric, nitric, and oxy-muriatic, as we shall see afterwards, have the property of decomposing alcohol.

Divisible into,

The acids differ from each other exceedingly in the changes which they undergo when exposed to the action of heat. Some of them are incombustible; others, on the contrary, are combustible.

1. Incombustible, or mineral;

The incombustible acids have received the name of *mineral acids*, because they are obtained most abundantly from the mineral kingdom. They are the acids which have been described in the first 15 Sections of this Chapter. All of them, as far as is known, contain a combustible basis combined with oxygen. The greater number of them can only be produced by combustion or some equivalent process. Two of them, namely, nitric and oxy-muriatic acids, are capable of supporting combustion, and it is not unlikely that this is the case also with arsenic acid.

2. Combustible, or

The combustible acids include all that have been described in the preceding Sections, except the first 15. They are almost all either the products of vegetation, Vegetable

or obtained by peculiar processes from animal and vegetable substances. For that reason they have been denominated vegetable and animal acids. The vegetable acids are the following:

1. Acetous,
2. Acetic,
3. Oxalic,
4. Tartarous,
5. Citric,
6. Malic,
7. Gallic,
8. Mucous,
9. Benzoic,
10. Succinic,
11. Camphoric,
12. Suberic,
13. Laccic.

And animal.

The animal acids are only four in number; namely,

1. Lactic,
2. Prussic,
3. Sebacic,
4. Zoonic.

And perhaps the sebacic might also be reckoned among the vegetable acids, for it may be obtained from vegetable fats as well as animal.

These acids are of a more complex nature than the mineral acids. The vegetable acids are all composed of oxygen, hydrogen, and carbon. Hence the reason that several of them may be converted into others by the action of nitric acid. This acid alters the proportion of their ingredients, either by abstracting part of their carbon and hydrogen, or by communicating oxygen; or by both together. But it is impossible to explain precisely what these changes actually amount to, without being acquainted with the component parts of every vegetable acid, the manner in which these acids are combined, and the affinities which exist between each of their ingredients. This, however, is very far from being the case at present. Though a vast number of experiments have been made on purpose to throw light on this very point, the difficulties which were to be encountered have been so great, that no accurate results have yet been obtained. All that is known at

Book II. present is an approximation towards the component parts of three acids. This may be seen in the following TABLE.

Acids.	Oxygen.	Carbon.	Hydrogen.
Acetous	50.19	35.87	11.94
Oxalic	77	13	10
Tartarous	70.5	18	10.5

It was some time ago supposed by chemists, that each of these acids was composed of a peculiar compound base or radical combined with oxygen. The radical was supposed to be a combination of carbon and hydrogen; but no proof whatever has been given of the truth of this opinion, nor has the smallest evidence been produced that any such radicals exist. It is much more probable that all the ingredients of the acids are combined together and constitute a triple combination.

Two of the animal acids, namely the prussic and zoonic, besides hydrogen and carbon, contain also azot. Whether this be the case also with the sebacic has not been ascertained. In all probability lactic acid contains none; for it resembles vegetable acids in every respect.

Besides the acids which have been described in this Chapter, there are several others which have been purposely omitted. All of them belong to the class of animal acids. These are,

Other acids. 1. FORMIC ACID, or ACID OF ANTS, obtained by distilling that species of ant called by Linnæus *formica rufa*; or by infusing these animals in water. It is exceedingly probable, from the experiments of Deyeux, that this acid is the acetous.

2. BOMBYC ACID, or the ACID OF THE SILKWORM. Mr Boissier de Sauvages observed that the juice of the silkworm, in the disease called in France *muscadine*, was acid; and Chaussier remarked that the silkworm, after being converted into a butterfly, gives out a liquor which turns vegetable blues to a red. He found that during the time that the animal was forming its cocoon, the acid was deposited in a reservoir near the anus. By means of a pair of scissars he collected some which reddened blue paper, united with alkalies with effervescence, and even attacked the scissars. He afterwards collected it by infusing the chrysalids in alcohol, which dissolved the acid, but left the impurities untouched. The properties of this acid have not been examined. We do not therefore know at present whether it be the same with some of the acids already dedescribed.

3. URIC ACID. } These acids not being applied
4. AMNIOTIC ACID. } to any use by chemists, the description of them will come in with more propriety under the Class of ANIMAL BODIES.

CHAP. V.

OF COMPOUND COMBUSTIBLES.

Number of compound combustibles.

THE compound combustibles are almost all composed of carbon and hydrogen, or of carbon, hydrogen, and oxygen. They are a very numerous class of bodies, comprehending the greater number of animal and vegetable substances, and of the products obtained from these substances. But the present state of chemistry does not permit us to take the term in that comprehensive sense: The investigation of vegetable and animal bodies is too incomplete; their properties are too imperfectly known to allow us to introduce them into the first principles of the science; and the utility of the greater number of them as chemical instruments is too inconsiderable to warrant any such introduction, even if their properties were completely investigated. For these reasons, it will be proper to treat in this Chapter of those compound combustibles only which are employed in chemistry as instruments of investigation, reserving the remainder for the Second Part of this Work. These may be reduced under four classes; namely,

1. Fixed oils,
2. Volatile oils,
3. Alcohol,
4. Ether.

These shall form the subject of the following Sections.

SECT. I.

OF FIXED OILS.

Discovery.

OIL, which is of such extensive utility in the arts, was known at a very remote period. It is mentioned in Genesis, and during the time of Abraham was even used in lamps*. The olive was very early cultivated, and oil extracted from it in Egypt. Cecrops brought it from Sais, a town in Lower Egypt, where it had been cultivated from time immemorial, and taught the Athenians to extract oil from it. In this manner the use of oil became known in Europe†. But the Greeks seem to have been ignorant of the method of procuring light by means of lamps till after the siege of Troy; at least Homer never mentions them, and constantly describes his heroes as lighted by torches of wood. There are two classes of oils exceedingly different from each other; namely, *fixed oils* and *volatile oils*.

FIXED OILS, which form the subject of this Section, are distinguished by the following characters:

Characters.

1. Liquid, or easily become so when exposed to a gentle heat.
2. An unctuous feel.
3. Very combustible.
4. A mild taste.
5. Boiling point not under 600°.
6. Insoluble in water and alcohol.
7. Leave a greasy stain upon paper.

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[*] Gen. xv. 17.

[†] Herodot. lib. ii. 59. and 62.

Preparation.

These oils, which are called also *fat* or *expressed* oils, are numerous, and are obtained, partly from animals and partly from vegetables, by simple expression. As instances, may be mentioned whale oil or train oil, obtained from the blubber of the whale; olive oil, obtained from the fruit of the olive; linseed oil and almond oil, obtained from linseed and almond kernels. Fixed oils may also be extracted from poppy seeds, hemp seeds, beech mast, and many other vegetable substances.

It deserves attention, that the only part of vegetables in which fixed oils are found is the seeds of bicotyledinous plants [*]. In animals they are most usually deposited in the liver, though they are found also in the eggs of fowls.

All these oils differ from each other in several particulars, but they also possess many particulars in common. Whether the oily principle in all the fixed oils is the same, and whether they owe their differences to accidental ingredients, is not yet completely ascertained, as no proper analysis has hitherto been made; but it is exceedingly probable, as all the oils hitherto tried have been found to yield the same products. In the present state of our knowledge, it would be useless to give a particular description of all the fixed oils, as the differences between them have not even been accurately ascertained.

Composition.

Fixed oils are considered at present as composed of hydrogen and carbon. Lavoisier analysed olive oil by burning a given portion of it in oxygen gas, by means of the apparatus represented by fig. 10. which will be

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[*] Fourcroy, vii. 319.

described in a subsequent Section. During the combustion there was consumed

Of oil	15.79 grains troy
Of oxygen gas . . .	50.86
Total . .	66.65

The products were carbonic acid and water. The carbonic acid obtained amounted to 44.50 grains; the weight of the water could not be accurately ascertained: but as the whole of the substances consumed were converted into carbonic acid gas and water, it is evident that if the weight of the carbonic acid be subtracted from the weight of these substances, there must remain precisely the weight of the water. Mr Lavoisier accordingly concluded, by calculation, that the weight of the water was 22.15 grains. Now the quantity of oxygen in 44.50 grains of carbonic acid gas is 32.04 grains, and the oxygen in 22.15 grains of water is 18.82 grains; both of which taken together amount to 50.86 grains, precisely the weight of the oxygen gas employed.

The quantity of charcoal in 44.50 grains of carbonic acid gas is 12.47 grains; and the quantity of hydrogen in 22.15 grains of water is 3.32 grains; both of which, when taken together, amount to 15.79 grains, which is the weight of the oil consumed.

It follows, therefore, from this analysis, that 15.79 grains of olive oil are composed of

12.47 carbon
3.32 hydrogen.

Olive oil therefore is composed of about

79 carbon
21 hydrogen
100 *

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* *Mem. Par.* 1784, and *Jour. de Phys.* for 1787, July.

This, however, can only be considered as a very imperfect approximation towards the truth.

Properties.

Fixed oil is usually a liquid with a certain degree of viscidity, adhering to the sides of the glass vessels in which it is contained, and forming striæ*. It is never perfectly transparent, having always a certain degree of colour; most usually it is yellowish or greenish. Its taste is sweet, or nearly insipid. When fresh, it has little or no smell. Its specific gravity varies from 0.9403 (the specific gravity of linseed oil) to 0.9153 (the specific gravity of olive oil).

Fixed oil is insoluble in water. When the two liquids are agitated together, the water loses its transparency, and acquires the white colour and consistency of milk. This mixture is known by the name of *emulsion.* When allowed to remain at rest, the oil soon separates, and swims upon the surface of the water.

Fixed oil does not evaporate till it be heated to about 600°. At that temperature it boils, and may be distilled over; but it is always somewhat altered by the process. Some water and sebacic acid seem to be formed, a little charcoal remains in the retort, and the oil obtained is lighter, more fluid, and has a stronger taste than before. Oil, thus distilled, was formerly distinguished by the name of *philosophical oil.*

Fixed oil, when in the state of vapour, takes fire on the approach of an ignited body, and burns with a yellowish white flame. It is upon this principle that candles and lamps burn. The tallow or oil is first converted into the state of vapour in the wick; it then takes fire, and supplies a sufficient quantity of heat to

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* Sometimes it is nearly solid, or of the consistence of butter.

convert more oil into vapour; and this process goes on while any oil remains. The wick is necessary to present a sufficiently small quantity of oil at once for the heat to act upon. If the heat were sufficiently great to keep the whole oil at the temperature of 600°, no wick would be necessary, as is obvious from oil catching fire spontaneously when it has been raised to that temperature.

When exposed to the action of cold, fixed oils lose their fluidity, and are converted into ice; but this change varies exceedingly in different oils.

Action of air.

When fixed oils are exposed to the open air or to oxygen gas, they undergo different changes according to the nature of the oil.

Drying oils.

1. Some of them dry altogether, without losing their transparency, when thin layers of them are exposed to the atmosphere. These are distinguished by the name of *drying oils*, and are employed by painters. Linseed-oil, nut oil, poppy oil, and hempseed oil, possess this property; but linseed oil is almost the only one of these liquids employed in this country as a drying oil. The cause of this peculiarity has not been completely investigated. But it is well known that these oils possess the drying quality at first but imperfectly. Before they can be employed by painters, they must be boiled with a little litharge. During this operation the litharge is partly reduced to the metallic state. Hence it has been conjectured that drying oils owe their peculiar properties to the action of oxygen; which is supposed either to constitute one of their component parts, or to convert them into drying oils by diminishing their hydrogen.

Fat oils.

2. Other fixed oils, when exposed to the atmosphere, gradually become thick, opaque, and white, and as-

sume an appearance very much resembling wax or tallow. These have been distinguished by the term *fat oils*. Olive oil, oil of sweet almonds, of rapeseed, and of ben, belong to this class.

When oil is poured upon water, so as to form a thin layer on its surface, and is in that manner exposed to the atmosphere, these changes are produced much sooner. Berthollet, who first examined these phenomena with attention, ascribed them to the action of light: but Sennebier observed that no such change was produced on the oil though ever so long exposed to the light, provided atmospherical air was excluded; but that it took place on the admission of oxygen gas, whether the oil was exposed to the light or not *. It cannot be doubted, then, that it is owing to the action of oxygen. It is supposed at present to be the consequence of the simple absorption of oxygen and its combination with the oils.

Rancidity.

3. Both these classes of oils, when exposed in considerable quantity to the action of the atmosphere, undergo another change, well known under the name of *rancidity*. But the fat oils become rancid much more readily than the drying oils. Rancid oils are thick, have usually a brown colour, convert vegetable blues to red, and have the smell and taste of sebacic acid. During the change which they undergo, some drops of water also appear on their surface. The rancidity of oils then is owing to the formation of a quantity of sebacic acid in them. This, together with the water, is evidently the consequence of a partial decomposition †.

Fixed oils readily dissolve sulphur when assisted by

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* *Ann. de Chim.* xi. 89.

† Fourcroy, vii. 328.

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heat. The solution assumes a reddish colour. When distilled, there comes over a great quantity of sulphurated hydrogen gas. When the solution is allowed to cool, the sulphur is deposited in crystals. By this process Pelletier obtained sulphur in regular octahedrons.

They likewise dissolve a small proportion of phosphorus when assisted by heat. These oily phosphurets emit the odour of phosphorated hydrogen, and yield, when distilled, a portion of that gas. When rubbed in the open air, or when spread upon the surface of other bodies, they appear luminous in consequence of the combustion of the phosphorus. When hot oils saturated with phosphorus are allowed to cool, the phosphorus crystallizes in octahedrons, as Pelletier ascertained.

Charcoal has no sensible action on fixed oils; but when they are filtered through charcoal powder, they are rendered purer, the charcoal retaining their impurities. Neither hydrogen nor azotic gas have any action on fixed oils.

Fixed oils have scarcely any action upon metals; but they combine with several metallic oxides, and form compounds known by the name of *plasters*.

They combine likewise with alkalies and earths, and form with them compounds called *soaps*. The fat oils enter into these combinations much more readily than the drying oils.

Fixed oils absorb nitrous gas in considerable quantity, and at the same time become much thicker and specifically heavier than before *.

Sulphuric acid decomposes fixed oils, at least when concentrated. It renders them first thick and of a

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* Priestley, i. 378.

brown colour; then water is formed, charcoal precipitated, and an acid formed *. Nitric acid renders them thick and viscid. When nitrous acid is poured upon the drying oils, it inflames them without addition; but it does not produce that effect upon the fat oils, unless it be mixed with a portion of sulphuric acid.

The affinities of fixed oils are as follows:

Affinities.

Lime,
Barytes,
Fixed alkalies,
Magnesia,
Ammonia,
Oxide of mercury,
Other metallic oxides,
Alumina.

The importance of fixed oils is well known. Some of them are employed as seasoners of food; some are burnt in lamps; some form the basis of soap; not to mention their utility in painting, and the many other important purposes which they serve.

SECT. II.

OF VOLATILE OILS.

VOLATILE OILS, called also *essential oils*, are distinguished by the following properties:

Characters.

1 Liquid; often almost as liquid as water; sometimes viscid.

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* Fourcroy, vii. 330.

2. Very combustible.
3. An acrid taste and a strong fragrant odour.
4. Boiling point not higher than 212°.
5. Soluble in alcohol; and imperfectly in water.
6. Evaporate without leaving any stain on paper.

By this last test it is easy to discover whether they have been adulterated with any of the fixed oils. Let a drop of the volatile oil fall upon a sheet of writing paper, and then apply a gentle heat to it. If it evaporates without leaving any stain upon the paper, the oil is pure; but if it leaves a stain, it has been contaminated with some fixed oil or other.

Preparation.

Volatile oils are almost all obtained from vegetables, and they exist in every part of plants; the root, the bark, the wood, the leaves, the flower, and even the fruit, though they are never found in the substance of the cotyledons; whereas the fixed oils, on the contrary, are almost always contained in these bodies *.

When the volatile oils are contained in great abundance in plants, they are sometimes obtained by simple expression. This is the case with the oil of oranges, of lemons, and of bergamotte; but in general they can only be obtained by distillation. The part of the plant containing the oil is put into a still with a quantity of water, which is distilled off by the application of a moderate heat. The oil comes over along with the water, and swims upon its surface in the receiver. By this process are obtained the oil of peppermint, thyme, lavender, and a great many others, which are prepared and employed by the perfumer. Others are procured by the distillation of resinous bodies. This is the case in par-

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* Fourcroy, vii. 352.

ticular with oil of turpentine, which is obtained by distilling a kind of resinous juice called turpentine, that exudes from the juniper.

Properties.

The greater number of volatile oils are liquid, and some of them are as transparent and colourless as water. This is the case with the oil of turpentine. But for the most part they are coloured. Some of them are yellow, as the oil of lavender; some brown, as the oil of rhodium; some blue, as oil of chamomile; but the greater number of volatile oils are yellow or reddish-brown.

Their odours are so various as to defy all description. It is sufficient to say, that all the fragrance of the vegetable kingdom resides in the volatile oils. Their taste is always acrid, hot, and exceedingly unpleasant. Their specific gravity is for the most part less than that of water; but some volatile oils, as those of canella and sassafras, are heavier than water. The specific gravity of the volatile oils varies from 0.8697 to 1.0439*.

Water dissolves a small portion of volatile oils, and acquires the odour and the taste of the oil which it holds in solution.

When heated, they evaporate very readily and without alteration. They are much more combustible than fixed oils, owing to their greater volability. They burn with a fine bright white flame, exhale a great deal of smoke, deposit much soot, and consume a greater proportion of the oxygen of the atmosphere than fixed oils. The products of their combustion are water and carbonic acid gas. From these facts it has been concluded that they are composed of the same ingredients

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* Fourcroy, vii. 362.

as the fixed oils, but that they contain a greater proportion of hydrogen *.

When exposed to the action of cold they congeal like the fixed oils; but the temperature necessary to produce this effect varies according to the oil. Some of them, as oil of anise and of fennel, become solid at the temperature of 50° : frozen oil of bergamot and of canella become liquid at 23° ; oil of turpentine at 14° †. Marqueron exposed several volatile oils to a cold of —17°. They congealed or rather crystallized partially, and at the same time emitted an elastic fluid. These crystals consisted partly of the oils themselves, partly of other substances. Some of them had the properties of benzoic acid ‡.

Changed by light.

Volatile oils, when exposed to the action of light in close vessels, and excluded from common air, undergo very singular changes. Their colour becomes deeper, they acquire a great deal of consistency, and their specific gravity is considerably increased. The cause of these changes is but imperfectly known. Tingry, to whom we are indebted for these interesting researches, has proved that light is a necessary agent. It was supposed formerly that they were occasioned by the absorption of oxygen; and when oxygen is present, it has been ascertained that it is absorbed: but Tingry has proved that the same changes go on when oxygen is excluded. This philosopher ascribes them to the fixation of light. If this be the real cause, the quantity of

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* Proust has observed that a quantity of volatile oil is formed when cast iron is dissolved in sulphuric or muriatic acid. It exhales in combination with the hydrogen gas which is emitted. Hence the disagreeable odour of that gas. *Jour. de Phys.* xlix. 155.

† Marqueron, *Jour. de Phys.* xlv. 136.

‡ Ibid.

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light fixed must be enormous. For as the specific gravity of the oils is increased considerably while the bulk continues the same, it is evident that the absolute weight must be increased proportionably. One circumstance, however, renders this conclusion somewhat doubtful, at least in its full extent; and that is, that the quantity of change was always proportional to the quantity of the oil and the quantity of air contained in the vessel *.

When exposed to the open air their colour becomes gradually deeper, and they acquire consistency, while they exhale at the same time a very strong odour. The air around, as Priestley first ascertained, is deprived of its oxygen, a quantity of water is formed, and the oils at last, for the most part, assume the form of resins †.

Volatile oils dissolve sulphur and phosphorus, and the solutions have nearly the same properties as those made by means of fixed oils.

They have no action on the metals, and seem scarcely capable of combining with the metallic oxides.

They combine only imperfectly, and in small quantity, with alkalies and earths. The French chemists have proposed to give these combinations the name of *savonules*, which Dr Pearson has translated by the term *saponules*; but these denominations have not been adopted by chemists ‡.

They absorb nitrous gas in great abundance, and

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* Tingry, *Jour. de Phys.* xlvi. 161. and 249.

† Resins are concrete vegetable juices; the distinguishing property of which is insolubility in water and solubility in alcohol. *Common resin*, or *rosin*, from which they derive their name, is one of them; and sealing wax consists almost entirely of another.

‡ The term *saponule* does not agree well with the idiom of our language. The word *subsoap*, or something similar, would have been better.

with great facility, and seemingly decompose it, acquiring a thick consistence and a resinous appearance, as if they had absorbed oxygen*.

Sulphuric acid decomposes volatile oils; carbonated hydrogen gas is emitted, and charcoal is precipitated. Nitrous acid inflames them, and converts them into water, carbonic acid, and charcoal. Oxy-muriatic acid converts them into substances analagous to resins.

Volatile oils are applied to a great number of uses. Some of them are employed in medicine; some of them, as oil of turpentine, are much used to dissolve resins, which are afterwards employed as varnishes; not to mention their employment in painting and in perfumery.

Empyreumatic oils.

Besides the oils which exist ready formed in the vegetable and animal kingdom, there are a variety of others which are obtained when animal or vegetable bodies are distilled by means of a heat above that of boiling water. These oils have received the appellation of *empyreumatic*, because they are formed by the action of fire. They have never been examined with attention; but several of them seem to possess the properties of the volatile oils. Their odour is always exceedingly disagreeable, and their taste acrid.

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* Priestley, i. 372.

SECT. III.

OF ALCOHOL.

History.

WINE has been known from the earliest ages. The Scriptures inform us that Noah planted a vineyard and drank wine; and the heathen writers are unanimous in ascribing the invention of this liquor to their earliest kings and heroes. Beer, too, seems to have been discovered at a very remote period. It was in common use in Egypt in the time of Herodotus *. Tacitus informs us that it was the drink of the Germans †. Whether the ancients had any method of procuring ardent spirits from these or any other liquors, does not appear. The Greeks and Romans seem to have been ignorant of ardent spirits altogether, at least we can discover no traces of any such liquor in their writings: But among the northern nations of Europe, intoxicating liquors were in use from the earliest ages. Whether these liquors resembled the beer of the Germans, we do not know. It is certain, at least, that the method of procuring ardent spirits by distillation was known in the dark ages; and it is more than probable that it was practised in the north of Europe much earlier. They are mentioned expressly by Thaddæus, Villanovanus, and Lully ‡.

Ardent spirits, such as brandy, for instance, rum and

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* Lib. ii. n. 77.

† *De Morib. Germ.* c . xxiii.

‡ Bergman, iv. art. ii. 4.

whisky, consist almost entirely of three ingredients, water, *alcohol* or *spirit of wine*, to which they owe their strength, and a small quantity of a peculiar oil, to which they owe their flavour.

Preparation.

When these spiritous liquors are distilled in a water bath, the first part that comes over is a fine light transparent liquid, known in commerce by the name of *rectified spirits*, and commonly sold under the denomination of alcohol or spirit of wine. It is not, however, as strong as possible, still containing a considerable portion of water. This water may be separated, and the alcohol obtained as pure as possible, by the following process: Saturate the spirit with a quantity of carbonat of potass, which has just immediately before been exposed for about half an hour in a crucible to a red heat, in order to deprive it of moisture. Carbonat of potass in this state has a strong attraction for water; it accordingly combines with the water of the spirit; and the solution of carbonat of potass thus formed sinks to the bottom of the vessel, and the alcohol, which is lighter, swims over it, and may easily be decanted off; or, what is perhaps better, the solution of potass may be drawn off from below it by means of a stop-cock placed at the bottom of the vessel. The alcohol, thus obtained, contains a little pure potass dissolved, which may be separated by distilling it in a water bath with a very small heat. The alcohol passes over, and leaves the potass behind. It is proper not to distil to dryness. This process is first mentioned by Lully.

Alcohol is said to have been discovered, or at least first accurately described, by Arnold de Villa Nova, who was born about the end of the thirteenth century. This chemist, who was professor of medicine at Montpelier, first formed tinctures, and introduced them into medicine [*].

Properties.

Alcohol is a transparent liquor, colourless like water, of a pleasant smell, and a strong penetrating agreeable taste. When swallowed it produces intoxication.

It is exceedingly fluid, and has never been frozen, though it has been exposed to a cold so great that the thermometer stood at —69°.

Its specific gravity, when pure, is only 0.800; but it is seldom obtained so low. The specific gravity of alcohol, as highly rectified as possible, is 8.200 [†]: that of the alcohol of commerce is seldom less than 8.371. It is almost unnecessary to remark, that the diminution of specific gravity is always proportional to the purity of the alcohol.

Alcohol is exceedingly volatile, boiling at the temperature of 176°; in which heat it assumes the form of an elastic fluid, capable of resisting the pressure of the atmosphere, but which condenses again into alcohol when that temperature is reduced. In a vacuum it boils at 56°, and exhibits the same phenomena: so that were it not for the pressure of the atmosphere, alcohol would always exist in the form of an elastic fluid, as transparent and invisible as common air. This subject was first examined with attention by Mr Lavoisier [‡]. The fact, however, had been known long before.

Alcohol is exceedingly combustible; and when set on fire, it burns all away with a blue flame, without

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[*] He is said also to have been the first who obtained the oil of turpentine. He obtained it by distilling turpentine. He employed it as a solvent of resins.

[†] Nicholson's *Dictionary*, p. 867.

[‡] *Jour. de Phys.* 1785.

leaving any residuum. Boerhaave observed, that when the vapour which escapes during this combustion is collected in proper vessels, it is found to consist of nothing but water. Junker had made the same remark: and Dr Black suspected, from his own observations, that the quantity of water obtained, if properly collected, exceeded the weight of the alcohol consumed. This observation was confirmed by Lavoisier; who found that the water produced during the combustion of alcohol exceeded the alcohol consumed by about $\frac{1}{7}$th part*.

Composition.

Different opinions were entertained by chemists about the nature of alcohol. Stahl thought that it was composed of a very light oil, united by means of an acid to a quantity of water. According to Junker, it was composed of phlogiston, combined with water by means of an acid. Cartheuser, on the other hand, affirmed, that it contained no acid, and that it was nothing else than pure phlogiston and water. But these hypotheses were mere assertions supported by no proof whatever. Lavoisier was the first who attempted to analyse it.

He set fire to a quantity of alcohol in close vessels by means of the following apparatus: BCDE (fig. 10.) is a vessel of marble filled with mercury. A is a strong glass vessel placed over it, filled with common air, and capable of containing about 15 pints (French). Into this vessel is put the lamp R filled with alcohol, the weight of which has been exactly determined. On the wick of the lamp is put a small particle of phosphorus. The mercury is drawn up by suction to the height IH. This glass communicates by means of the pipe LK with another glass vessel S filled with oxygen gas, and placed

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[*] *Mem. Par.* 1781, p. 493.

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over a vessel of water T. This communication may be ſhut up at pleasure by means of the stop-cock M.

Things being thus disposed, a crooked red hot iron wire is thrust up through the mercury, and made to touch the phosphorus. This instantly kindles the wick, and the alcohol burns. As soon as the flame begins to grow dim, the stop-cock is turned, and a communication opened between the vessels S and A; a quantity of oxygen gas rushes in, and restores the brightness of the flame. By repeating this occasionally, the alcohol may be kept burning for some time. It goes out, however, at last, notwithstanding the admission of oxygen gas.

The result of this experiment, which Mr Lavoisier repeated a great number of times, was as follows:

Alcohol consumed	76.7083 grains troy
Oxygen gas consumed . .	90.5060
Total . . .	167.2143

Aſter the combustion, there were found in the glass vessel 115.41 cubic inches of carbonic acid gas, the weight of which was 78.1192 grains troy. There was likewise found a considerable quantity of water in the vessel, but it was not possible to collect and weigh it. Mr Lavoisier, however, estimated its weight at 89.0951 grains; as he concluded, with reason, that the whole of the substances employed were still in the vessel. Now the whole contents of the vessel consisted of carbonic acid gas and water; therefore the carbonic acid gas and water together must be equal to the oxygen gas and alcohol which had been consumed.

But 78.1192 grains of carbonic acid gas contain, according to Mr Lavoisier's calculation [*], 55.279 grains

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[*] *Mem. Par.* 1781.

of oxygen: 90.506 grains, however, of oxygen gas had disappeared; therefore 35.227 grains must have been employed in forming water.

35.227 grains of oxygen gas require, in order to form water, 6.038 grains of hydrogen gas; and the quantity of water formed by this combination is 41.265 grains. But there were found 89.095 grains of water in the glass vessel; therefore 47.83 grains of water must have existed ready formed in the alcohol.

It follows from all these data, that the 76.7083 grains of alcohol, consumed during the combustion, were composed of

22.840	carbon
6.038	hydrogen
47.830	water
76.7*	

Such were the consequences which Mr Lavoisier drew from his analysis. He acknowledged, however, that there were two sources of uncertainty, which rendered his conclusions not altogether to be depended upon. The first was, that he had no method of determining the quantity of alcohol consumed, except by the difference of weight in the lamp before and after combustion; and that therefore a quantity might have evaporated without combustion, which, however, would be taken into the sum of the alcohol consumed. But this error could not have been great; for if a considerable quantity of alcohol had existed in the state of vapour in the vessel, an explosion would certainly have taken place. The other source of error was, that the quan-

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* *Mem. Par.* 1784.

tity of water was not known by actual weight, but by calculation.

To this we may add, that Mr Lavoisier was not warranted to conclude from his experiment, that the water found in the vessel, which had not been formed by the oxygen gas used, had existed in the alcohol in the state of water: he was intitled to conclude from his data, that the ingredients of that water existed in the alcohol before combustion; but not that they were actually combined in the state of water, because that combination might have taken place, and in all probability did partly take place, during the combustion. It follows, therefore, from Mr Lavoisier's experiments, that alcohol, supposing he used it perfectly pure, which is not probable, is composed of

0.5172	parts oxygen
0.2988	parts carbon
0.1840	parts hydrogen
1.0000	

But it gives us no information whatever of the manner in which these ingredients are combined. That alcohol contains oxygen, has been proved by a very ingenious set of experiments performed by Messrs Fourcroy and Vauquelin. When equal parts of alcohol and sulphuric acid are mixed together, the sulphuric acid suffers no change; but the alcohol is decomposed, being partly converted into water and partly into ether. Now it is evident that the alcohol could not have been converted into water unless it had contained oxygen *.

When alcohol, in the state of vapour, is made to pass

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* Nicholson's *Journal*, i. 391.

through a red hot porcelain tube, it is decomposed completely. Carbonated hydrogen gas, and carbonic acid gas, are disengaged; water passes into the receiver, and on its inner surface are deposited a number of small brilliant crystals, which Vauquelin ascertained to be a concrete volatile oil. The inside of the porcelain tube is coated with charcoal in the state of a fine black. This experiment was first made by Priestley [*]; but it was afterwards repeated with more care, and the nature of the products ascertained by the Dutch chemists [†].

Combination with water.

Alcohol has a strong affinity for water, and is miscible with it in every proportion. The specific gravity varies according to the proportion of the two liquids combined; but, as happens in almost all combinations, the specific gravity is always greater than the mean of the two liquids; consequently there is a mutual penetration: and as this penetration or condensation varies also with the proportions, it is evident that the specific gravity of different mixtures of alcohol and water can only be ascertained by experiment. As the spiritous liquors of commerce are merely mixtures of alcohol and water in different proportions, and as their strength can only be ascertained with precision by means of their specific gravity, it becomes a point of very great importance to determine with precision the proportion of alcohol contained in a spirit of a given specific gravity: and as the specific gravity varies with the temperature, it is necessary to make an allowance for that likewise.

The importance of this object, both for the purposes of revenue and commerce, induced the British Govern-

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[*] Priestley, iii. 425.

[†] *Jour. de Phys.* xlv. 186.

ment to employ Sir Charles Blagden to institute a very minute and accurate series of experiments. An account of these was published by Blagden in the Philosophical Transactions for 1790; and a set of Tables, exhibiting the result of them, was drawn up by Mr Gilpin, who had performed the experiments, and published in the Philosophical Transactions for 1794. The following TABLE, extracted from these, contains the specific gravity of different mixtures of alcohol and water at every 5° of temperature from 30° to 100°. The alcohol employed as a standard was of the specific gravity 0.825; and was composed, according to the experiments of Mr Gilpin, of 100 parts of alcohol of the specific gravity 0.814 and 4.5 of water.

Real Specific Gravities at the different Temperatures.

Heat.	Pure alcohol.	100 alcohol 5 water	100 alcohol 10 water	100 alcohol 15 water	100 alcohol 20 water	100 alcohol 25 water
30°	.83896	.84995	.85957	.86825	.87585	.88282
35	83672	84769	85729	86587	87357	88059
40	83445	84539	85507	86361	87134	87838
45	83214	84310	85277	86131	86905	87613
50	82977	84076	85042	85902	86676	87384
55	82736	83834	84802	85664	86441	87150
60	82500	83599	84568	85430	86208	86918
65	82262	83362	84334	85193	85976	86686
70	82023	83124	84092	84951	85736	86451
75	81780	82878	83851	84710	85496	86212
80	81530	82631	83603	84467	85248	85966
85	81291	82396	83371	84243	85036	85757
90	81044	82150	83126	84001	84797	85518
95	80794	81900	82877	83753	84550	85272
100	80548	81657	82639	83513	84308	85031

Real Specific Gravities at the different Temperatures.

Heat.	100 alcohol 30 water	100 alcohol 35 water	100 alcohol 40 water	100 alcohol 45 water	100 alcohol 50 water
30°	.88921	.89511	.90054	.90558	.91023
35	88701	89294	89839	90345	90811
40	88481	89073	89617	90127	90596
45	88255	88849	89396	89909	90380
50	88030	88626	89174	89684	90160
55	87796	88393	88945	89458	89933
60	87569	88169	88720	89232	89707
65	87337	87938	88490	89006	89479
70	87105	87705	88254	88773	89252
75	86864	87466	88018	88538	89018
80	86622	87228	87776	88301	88781
85	86411	87021	87590	88120	88605
90	86172	86787	87360	87889	88376
95	85928	86542	87114	87654	88146
100	85688	86302	86879	87421	87915

Heat.	100 alcohol 55 water	100 alcohol 60 water	100 alcohol 65 water	100 alcohol 70 water	100 alcohol 75 water
30°	.91449	.91847	.92217	.92563	.92889
35	91241	91640	92009	92355	92680
40	91026	91428	91799	92151	92476
45	90812	91211	91584	91937	92264
50	90596	90997	91370	91723	92051
55	90367	90768	91144	91502	91837
60	90144	90549	90927	91287	91622
65	89920	90328	90707	91066	91400
70	89695	90104	90484	90847	91181
75	89464	89872	90252	90617	90952
80	89225	89639	90021	90385	90723
85	89043	89460	89843	90209	90558
90	88817	89230	89617	89988	90342
95	88588	89003	89390	89763	90119
100	88357	88769	89158	89536	89889

Book II.

Real Specific Gravities at the different Temperatures.

Heat.	100 alcohol 80 water	100 alcohol 85 water	100 alcohol 90 water	100 alcohol 95 water	100 alcohol 100 water
30°	·93191	·93474	·93741	·93991	·94222
35	92986	93274	93541	93790	94025
40	92783	93072	93341	93592	93827
45	92570	92859	93131	93382	93621
50	92358	92647	92919	93177	93419
55	92145	92436	92707	92953	93208
60	91933	92225	92499	92758	93002
65	91715	92010	92283	92546	92794
70	91493	91793	92069	92333	92580
75	91270	91569	91849	92111	92364
80	91046	91340	91622	91891	92142
85	90882	91186	91465	91729	91969
90	90668	90967	91248	91511	91751
96	90443	90747	91029	91290	91531
100	90215	90522	90805	91066	91310

Heat.	95 alcohol 100 water	90 alcohol 100 water	85 alcohol 100 water	80 alcohol 100 water	75 alcohol 100 water
30°	·94447	·94675	·94920	·95173	·95429
35	94249	94484	94734	94988	95246
40	94058	94295	94547	94802	95060
45	93860	94096	94348	94605	94871
50	93658	93897	94149	94414	94683
55	93452	93696	93948	94213	94486
60	93247	93493	93749	94018	94296
65	93040	93285	93546	93822	94099
70	92828	93076	93337	93616	93898
75	92613	92865	93132	93413	93695
80	92393	92646	92917	93201	93488

Real Specific Gravities at the different Temperatures.

Heat.	70 alcohol 100 water	65 alcohol 110 water	60 alcohol 100 water	55 alcohol 100 water	50 alcohol 100 water
30°	.95681	.95944	.96209	.96470	.96719
35	95502	95772	96048	96315	96579
40	95328	95602	95879	96159	96434
45	95143	95423	95705	95993	96280
50	94958	95243	95534	95831	96126
55	94767	95057	95357	95662	95966
60	94579	94876	95181	95493	95804
65	94388	94689	95000	95318	95635
70	94193	94500	94813	95139	95469
75	93989	94301	94623	94957	95292
80	93785	94102	94431	94768	95111

Heat.	45 alcohol 100 water	40 alcohol 100 water	35 alcohol 100 water	30 alcohol 100 water	25 alcohol 100 water
30°	.96967	.97200	.97418	.97635	.97860
35	96840	97086	97319	97556	97801
40	96706	96967	97220	97472	97737
45	96563	96840	97110	97384	97666
50	96420	96708	96995	97284	97589
55	96272	96575	96877	97181	97500
60	96122	96437	96752	97074	97410
65	95962	96288	96620	96959	97309
70	95802	96143	96484	96836	97203
75	95638	95987	96344	96708	97086
80	95467	95826	96192	96568	96963

Real Specific Gravities at the different Temperatures.

Heat.	20 alcohol 100 water	15 alcohol 100 water	10 alcohol 100 water	5 alcohol 100 water
30°	.98108	.98412	.98804	.99334
35	98076	98397	98804	99344
40	98033	98373	98795	99345
45	97980	98338	98774	99338
50	97920	98293	98745	99316
55	97847	98239	98702	99284
60	97771	98176	98654	99244
65	97688	98106	98594	99194
70	97596	98028	98527	99134
75	97495	97943	98454	99066
80	97385	97845	98367	98991

From this Table, and from that of Poujet given before*, we see that in whatever proportion these liquids are mixed, a mutual penetration and condensation takes place. This condensation, in any given mixture, reaches its maximum very slowly; a proof that the liquids enter into combination very slowly. Hence the apparent muddiness after mixture. The condensation is the greatest possible when equal parts of water and alcohol constitute the mixture. It then amounts to almost $\frac{1}{35}$ of the whole. This condensation diminishes as the proportion of either of the ingredients is diminished; but it diminishes much faster when the water exceeds than when the proportion of alcohol is greatest. Thus in a mixture of one part of water and ten parts of alcohol, the condensation is $\frac{1}{114}$ of the whole; whereas in a mixture of one part of alcohol with ten parts of water, it amounts only to $\frac{1}{179}$ of the whole.

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* See p. 15. of this Volume.

Neither common air nor oxygen gas has any action upon alcohol.

Sulphurated and

Alcohol has no action upon sulphur while solid; but when these two bodies are brought together both in the state of vapour, they combine and form a reddish sulphuret, which exhales the odour of sulphurated hydrogen gas. This compound contains about 60 parts of alcohol and 1 part of sulphur. The sulphur is precipitated by water.

Phosphorated alcohol.

Alcohol dissolves also a little phosphorus when assisted by heat. This phosphorated alcohol exhales the odour of phosphorated hydrogen gas. When a little of it is dropt into a glass of water, a flame instantly makes its appearance, and waves beautifully on the surface of the water*. This phenomenon, which is occasioned by the emission of a little phosphorated hydrogen gas, can only be observed when the experiment is performed in a dark room.

Alcohol has no action upon charcoal, hydrogen gas, azotic gas, the metals, nor upon any of the metallic oxides.

Action on alkalies,

Alcohol dissolves the fixed alkalies very readily, and forms with them a reddish-coloured acrid solution. It is from this solution only that these alkalies can be obtained in a state of purity. When heat is applied to it, the alcohol is mostly decomposed; but the nature of the products has not been accurately ascertained. Ammonia also combines with alcohol with the assistance of heat: but at a temperature somewhat below the boiling point of alcohol, the ammonia flies off in the

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* Brugnatelli, *Ann. de Chim.* xxiv. 71.

state of gas, carrying with it, however, a little alcohol in solution.

None of the earths are acted upon by alcohol. It absorbs about its own weight of nitrous gas, which cannot afterwards be expelled by heat *.

Acids, Sulphuric acid, nitrous acid, and oxy-muriatic acid, decompose alcohol; but all the other acids are soluble in it, except the metallic acids, phosphoric acid, and perhaps also prussic acid.

Salts. Alcohol is capable of dissolving a great many saline bodies. A considerable number of these, with the quantities soluble, is exhibited in the following TABLES †.

I. *Substances dissolved in large Quantities.*

Names of the Substances.	Temperature.	240 parts of alcohol dissolve
Red sulphat of iron . .		
Nitrat of cobalt	54.5°	240 parts
copper . . .	54.5	240
alumina . . .	54.5	240
lime		300
magnesia . .	180.5	694
Muriat of zinc	54.5	240
alumina . .	54.5	240
magnesia . .	180.5	1313
iron	180.5	240
coppper . .	180.5	240
Acetite of lead	113	
copper ‡ . .		
Nitrat of zinc decomposed		
iron decomposed		
bismuth decomposed		

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* Priestley, i. 379.

† Morveau, *Jour. de Phys.* 1785.

‡ Withering, *Phil. Trans.* lxxii. 336.

II. *Substances dissolved in small Quantities.*

Names of the Substances.	240 parts of alcohol at the boiling temperature dissolve
Muriat of lime	240 parts
Nitrat of ammonia	214
Oxy-muriat of mercury . . .	212
Succinic acid	177
Acetite of Soda	112
Nitrat of silver	100
Refined sugar	59
Boracic acid	48
Nitrat of soda	23
Acetite of copper	18
Muriat of ammonia	17
Arseniat of potass	9
Superoxalat of potass	7
Nitrat of potass	5
Muriat of potass	5
Arseniat of soda	4
White oxide of arsenic	3
Tartrite of potass	1
Nitrat of lead *	
Carbonat of ammonia *	

III. *Substances insoluble in Alcohol,*

Sugar of milk,
Borax,
Tartar,
Alum,
Sulphat of ammonia,
lime,
barytes*,
iron (green),
copper,
silver,
mercury,
zinc,
potass,

Sulphat of soda,
magnesia,
Sulphite of soda
Tartrite of soda and potass,
Nitrat of lead,
mercury,
Muriat of lead,
silver†,
Common salt,
Carbonat of potass,
soda.

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* Withering, *Phil. Trans.* lxxii. 336.

‡ Macquer, Ibid.

When alcohol, containing certain saline bodies in solution, is set on fire, its flame is often tinged of different colours according to the body. Thus nitrat of strontian tinges it purple; boracic acid and cupreous salts tinge it green; muriat of lime gives it a red colour; nitre and oxy-muriat of mercury a yellow colour.

The affinities of alcohol are very imperfectly known. Those stated by Bergman are as follows:

Water,
Ether,
Volatile oil,
Alkaline sulphurets.

SECT. IV.

OF ETHER.

When alcohol is mixed with sulphuric acid, and several other acids, and the action of the acid is assisted by heat, the alcohol is decomposed and converted partly into a very light volatile fragrant liquor, known by the name of *ether*. The properties of the ether obtained are supposed to vary a little according to the acid employed: accordingly every particular kind is distinguished by the acid employed in its preparation. Thus the ether obtained by means of sulphuric acid is called *sulphuric ether;* that by means of nitrous acid, *nitrous ether*. It will be proper to consider each of these species separately.

I. *Sulphuric Ether.*

Discovery.

THE method of making sulphuric ether is described in the dispensatory of Valerius Cordus, published at Nuremberg about the year 1540. There ether is called *oleum vitroli dulce* *. It is likewise obscurely hinted at in some of the older chemical authors; but little attention was paid to it till a paper appeared in the Philosophical Transactions for 1730, written by a German, who called himself *Frobenius* †, containing a number of experiments on it. In this paper it first received the name of *ether*. The German chemists long distinguished it by the name of *naphtha*.

Preparation.

Sulphuric ether is usually prepared by the following process: A mixture of equal parts of alcohol and sulphuric acid is put into the retort, to which a large receiver is then luted. It is proper to surround the receiver with ice, or at least with cold water. Heat is applied; and as soon as the mixture boils, the ether comes over and is condensed, and runs in large striæ down the sides of the receiver. As soon as it amounts to one half of the alcohol employed, the process must be stopt. The ether thus obtained is not quite pure, almost always containing a little sulphurous acid.

This acid is usually separated by pouring the ether on a little potass, and distilling it over again by means of a moderate heat. Mr Dizé has found that black oxide of manganese produces this effect still more completely than potass. All that is necessary, is to mix a quantity of this black oxide in powder with the impure

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* Bergman, iv. 98.

† The name was supposed to have been feigned.

ether, and to let it remain for some time, agitating it occasionally. The sulphurous acid is converted into sulphuric, and combines with the manganese. The ether is then to be distilled over by the heat of a water bath *.

Properties.

Ether thus obtained is a limpid and colourless liquor, of a very fragrant smell, and a hot pungent taste. Its specific gravity is only 0.7581 †.

It is so volatile that it can scarcely be poured from one vessel to another without losing a considerable portion of it by evaporation. When poured out in the open air, it disappears in an instant, and during its evaporation produces a very considerable degree of cold. If a glass vessel containing water, and surrounded with a cloth, be dipt into ether two or three times, and the ether each time be allowed to evaporate from the cloth, the water in the glass freezes. In the open air ether boils at 98°, and in a vacuum at —20°. Were it not therefore for the pressure of the atmosphere, it would always exist in the gaseous state.

It is exceedingly inflammable, and when kindled in the state of vapour burns with rapidity, or rather explodes, if it be mixed with oxygen gas. When set on fire, it burns rapidly with a fine white flame, and leaves behind it a trace of charcoal. Lavoisier has remarked, that during its combustion an acid is generated. How well soever it has been rectified, it always exhibits traces of sulphuric acid ‡.

When ether in the state of vapour is made to pass through a red hot porcelain tube, it is decomposed completely, and a great quantity of carbonated hydrogen gas is obtained §.

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* *Jour. de Phys.* xlvi. 298. † Lavoisier. ‡ Scheele, ii. 108.

§ Dutch Chemists, *Jour. de Phys.* xlv. 184.

Ether when exposed to a cold of —46° freezes and crystallizes *.

Ether is soluble in ten parts of water, according to the Count de Lauraguis.

The action of the simple combustibles on ether has not been tried, if we except phosphorus, which it is capable of dissolving in small proportion. The solution is transparent; but the addition of a little alcohol to it renders it milky. This furnishes us with a method of ascertaining whether ether be sophisticated with alcohol †.

Ether has no action on metals; but it revives several of the metallic oxides when mixed with their solutions in acids. It takes gold from its solution in nitro-muriatic acid.

It is probable that it has no action on fixed alkalies and earths; but it combines, or at least mixes readily with ammonia.

It absorbs nitrous gas in considerable quantity.

Sulphuric acid seems capable of converting it into a peculiar kind of oil known by the name of sweet oil of wine.

If we fill a bottle, capable of holding three or four English pints, with oxy-muriatic acid gas, taking care to expel the water as completely as possible, and then throw into it about a dram, or half a dram, of good ether, covering its mouth immediately with a piece of light wood or paper, in a few seconds white vapour will be perceived moving circularly in the bottle: this will be soon followed by an explosion accompanied with

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* Fourcroy and Vauquelin, *Ann. de Chim.* xxix. 289.

† Brugnatelli, *Ann. de Chim.* xxiv. 73.

flame; at the same time a very considerable quantity of charcoal will be deposited, and the bottle will be found to contain carbonic acid gas [*].

Ether is capable of dissolving the volatile oils. It combines with alcohol in almost any proportion.

Composition.

Chemists entertained various opinions respecting the nature of ether. Macquer supposed that it was merely alcohol deprived by the acid of all its water. But it was generally believed that the acid entered partly into its composition. Scheele published a set of experiments on ether in 1782[†]; from which he drew as a consequence, that during the process the alcohol is deprived of phlogiston. These experiments were varied, and carried still farther by Pelletier; who adopted the theory of Scheele, modified according to the discoveries of Lavoisier. According to him ether is alcohol combined with oxygen. This theory was embraced by the greater number of chemists, and it was supposed that the alcohol obtained the new dose of oxygen from the sulphuric acid. But the formation of ether has been lately examined with much care by Fourcroy and Vauquelin. These ingenious chemists have concluded from their experiments, that during the process the alcohol is completely decomposed, and that ether is composed of the same ingredients as alcohol, but combined in different proportions. Ether, according to them, contains a greater proportion of hydrogen and oxygen, and a smaller proportion of carbon than alcohol [‡].

The theory of these chemists was disputed by Laudet [§]

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[*] Cruikshank, Nicholson's *Journ.* v. 205. [†] Scheele, ii. 105.

[‡] *Ann. de Chim.* xxiii. 203. and Nicholson's *Journal*, i. 391.

[§] *Ann. de Chim.* xxxiv. 282.

and Dabit [*], who endeavoured to prove that oxygen is always necessary for the formation of ether. This they did by repeating the experiments on ether, which had been formerly made by Scheele. They distilled a mixture of sulphuric acid, black oxide of manganese, and alcohol. The sulphuric acid was not decomposed as in common cases, no charcoal was deposited, no gas came over, the black oxide lost part of its oxygen, and the quantity of *ether* obtained was greater than usual. According to Dabit, ether contains a smaller proportion of hydrogen and a greater proportion of oxygen and carbon than alcohol. These objections were almost immediately answered by Fourcroy and Vauquelin, who proved that ether obtained by means of the black oxide of manganese possesses very different properties from sulphuric ether. Consequently its formation and composition cannot destroy their conclusions respecting the formation and composition of sulphuric ether [†].

Action of sulphuric acid and alcohol.

As the action of sulphuric acid on alcohol and the formation of ether is one of the most interesting phenomena in chemistry, and as it may enable us to form more precise ideas, both respecting the composition of alcohol and ether, it will be proper to examine it with attention.

1. Olefiant gas.

When four parts of sulphuric acid and one part of alcohol are mixed together, and a moderate heat applied, the mixture blackens, boils violently, and a great quantity of gas is disengaged. This gas, which was first examined by the Dutch chemists, received from them the name of *olefiant gas*. It is composed of carbon and hydrogen. Its specific gravity is to that of water as

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[*] *Ann. de Chim.* xxxiv. 289.

[†] Ibid. 319.

905 to 1000. It has a disagreeable fetid odour, and burns with a dense white flame exactly like the flame of oils. When mixed with oxy-muriatic acid gas, its bulk is diminished, drops of oil make their appearance, which swim for some time on the surface of the water, and then sink. This oil is formed by the combination of the oxygen of the acid with the olefiant gas; for when four parts of oxy-muriatic acid gas, and three parts of olefiant gas, as pure as possible, are mixed together over water, the gases disappear totally, with the exception of $\frac{1}{20}$ part, which is azotic gas, probably introduced along with the acid gas.

This oil is heavier than water; it is pearl-coloured, but becomes yellowish and limpid when kept for some time. Its taste and odour are both agreeable and peculiar. It is soluble in water, but not acted on by potass. When the mixture of the two gases is fired, immediately a great quantity of charcoal is precipitated in the form of fine soot *.

What remains in the retort after the disengagement of this gas, is chiefly sulphurous acid blackened with charcoal, and probably also some vegetable acid.

2. Oxalic acid.

When equal parts of sulphuric acid and alcohol are mixed together, the phenomena which take place are considerably different. If the mixture be made cautiously, and allowed to remain at the common temperature for about 30 hours, crystals of oxalic acid often form in it. †.

A combination of two parts of sulphuric acid and one of alcohol elevates the temperature to 201°, becomes immediately of a deep red colour, which changes to a

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* *Jour. de Phys.* xlv. 178.

† Cadet, Ibid. li. 231.

black a few days afterwards, and emits a smell perceptibly ethereal.

3. Ether.

When a mixture of equal parts of alcohol and sulphuric acid is exposed to the action of heat in a proper apparatus, the following phenomena take place, as has been ascertained by Fourcroy and Vauquelin.

1. When the temperature is elevated to 208°, the fluid boils, and emits a vapour which becomes condensed by cold into a colourless, light, and odorant liquor, which from its properties has received the name of *ether*. If the operation be properly conducted, no permanent gas is disengaged until about half the alcohol has passed over in the form of ether. Until this period there passes absolutely nothing but ether and a small portion of water, without mixture of sulphurous or of carbonic acid.

2. If the receiver be changed as soon as the sulphurous acid manifests itself, it is observed that no more ether is formed, but the sweet oil of wine, water, and acetous acid, without the disengagement hitherto of a single bubble of carbonic acid gas. When the sulphuric acid constitutes about four-fifths of the mass which remains in the retort, an inflammable gas is disengaged, which has the smell of ether, and burns with a white oily flame. This is what the Dutch chemists have called *olefiant gas*. At this period the temperature of the fluid contained in the retort is elevated to 230° or 234°.

3. When the sweet oil of wine ceases to flow, if the receiver be again changed, it is found that nothing more passes but sulphurous acid, water, carbonic acid gas; and that the residuum in the retort is a black mas, consisting for the most part of sulphuric acid thickened by carbon.

Theory of the decomposition of alcohol.

From these phenomena Fourcroy and Vauquelin have drawn the following deductions.

1. A small quantity of ether is formed spontaneously, and without the assistance of heat, by the combination of two parts of concentrated sulphuric acid and one part of alcohol.

2. As soon as ether is formed, there is a production of water at the same time; and while the first of these compositions takes place, the sulphuric acid undergoes no change in its intimate nature.

3. As soon as the sulphurous acid appears, no more ether is formed, or at least very little; but then there passes the sweet oil of wine, together with water and acetous acid.

4. The sweet oil of wine having ceased to come over, nothing further is obtained but the sulphurous and carbonic acids, and at last sulphur, if the distillation be carried to dryness.

The operation of ether is therefore naturally divided into three periods: the first, in which a small quantity of ether and water are formed without the assistance of heat; the second, in which the whole of the ether which can be obtained is disengaged without the accompaniment of sulphurous acid; and the third, in which the sweet oil of wine, the acetous acid, the sulphurous acid, and the carbonic acid, are afforded. The three stages have no circumstance common to all but the continual formation of water, which takes place during the whole of the operation.

A combination of sulphuric acid and alcohol in equal parts does not boil at less than 207° of temperature, while that of alcohol alone boils at 176°. Now since ebullition does not take place till the higher temperature, it is clear that the alcohol is retained by the affinity of the sulphuric acid, which fixes it more considerably. Now organic bodies, or their immediate products, when exposed to a lively brisk heat, without the possibility of escaping speedily enough from its action, suffer a partial or total decomposition, according to the degree of temperature. Alcohol undergoes this last alteration when passed through an ignited tube of porcelain. The reason, therefore, why alcohol is not decomposed when it is submitted alone to heat in the ordinary apparatus for distillation is, that the temperature at which it rises in vapours is not capable of effecting the separation of its principles ; but when it is fixed by the sulphuric acid or any other body, the elevated temperature it undergoes, without the possibility of disengagement from its combination, is sufficient to effect a commencement of decomposition, in which ether and water are formed, and carbon is deposited. Nothing more therefore happens to the alcohol in these circumstances than what takes place in the distillation of every other vegetable matter in which water, oil, acid, and coal, are afforded.

Hence it may be conceived that the nature of the products of the decomposition of alcohol must vary according to the different degrees of heat ; and this explains why at a certain period no more ether is formed but the sweet oil of wine and acetous acid. In fact, when the greatest quantity of the alcohol has been changed into ether, the mixture becomes more dense, and the heat which it acquires previous to ebullition is more considerable. The affinity of the acid for alcohol being increased, the principles of this acid become separated ; so that, on the one hand, its oxygen seizes the hydrogen, and forms much water, which is gradually volatilized; while, on the other, the ether retaining a greater quantity of carbon, with which at that temperature it can rise, affords the sweet oil of wine. This last ought therefore to be considered as an ether containing an extraordinary portion of carbon, which gives it more density, less volatility, and a lemon-yellow colour.

Such is the ingenious explanation of the formation of sulphuric ether proposed by Fourcroy and Vauquelin. They have succeeded completely in proving that the opinions formerly entertained respecting that singular process were erroneous; though their own explanation is not sufficiently precise to enable us to ascertain exactly the component parts of ether.

II. *Nitric Ether.*

Discovery.

Nitric ether is first mentioned in an epistle written by Kunkel to Voight, and published in 1681[*]; but no attention was paid to it by succeeding chemists till it was discovered a second time by Navier in 1742[†], and a third time by Sebastiani in 1746[‡].

Preparation.

The method of preparing it, proposed by Navier, was this: Twelve parts of alcohol are put into a strong bottle, which is kept surrounded with water, or rather with ice: eight parts of nitrous acid are poured in at intervals, the mixture being agitated after every addition. The bottle is then well corked, and the cork secured by leather. Ether gradually forms at the surface of the liquid. After five or six days, when the

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[*] *Epistola contra Spiritum Vini sine Acido.*

[†] *Mem. Par.* 1742.

[‡] *Diss. de Nitro,* 1746.

formation is supposed to be over, the cork is to be pierced with a needle to allow a quantity of nitrous gas to escape, which would otherwise carry the ether along with it. The cork is then to be drawn; the whole liquid is to be poured into a funnel, and by means of the finger the liquid below is allowed to run out while the ether is retained.

This method is somewhat hazardous; for the quantity of nitrous gas evolved is so great as often to burst the bottle. Dr Black substituted in place of it a very ingenious process. He poured into a glass the proper quantity of nitrous acid; over this was poured gently a stratum of water, and the alcohol was poured over all. Thus there were three strata of liquids in the vessel: the acid lowermost, and the alcohol uppermost, separated from each other by the water. The acid and alcohol gradually combined with the water, and coming into contact acted on each other without violence; and thus the ether was formed without risk.

Dehne has given another process for obtaining nitric ether exceedingly tedious, but not attended with any risk. The alcohol is put into a tubulated retort, to which a large receiver is luted; $\frac{1}{48}$th part of nitrous acid is to be added every four hours, drop by drop, till it amounts to about half the weight of alcohol; then the mixture becomes hot, and ether passes over into the receiver. After this a little more nitrous acid is to be added every morning and evening. Ether gradually forms on its surface. The acid is to be added till it falls down to the bottom of the retort in the form of green globules, indicating the formation of perfectly saturated nitrous acid. This is a proof that no more ether will be formed.

Various other methods of preparing nitrous ether have been proposed by chemists, as the distillation of a mixture of sulphuric acid, nitre, and alcohol, &c.

Purification.

Nitrous ether, by whatever process it is procured, is never pure at first, holding always in solution a considerable portion of nitrous gas: hence its extraordinary volatility. It contains also a certain portion of nitrous acid, and a little oil, to which it owes its yellow colour. The nitrous gas separates spontaneously when the ether is mixed with a considerable portion of water. By distilling it repeatedly from potass or sugar, the oil may be abstracted; and when kept for some time, the nitrous acid is decomposed, and a little water and oxalic acid formed, which sink to the bottom of the vessel *.

Properties.

Nitric ether, as far as is known, agrees very nearly in its properties with sulphuric ether: it is equally fluid, light, and combustible: its taste and odour are nearly the same, but not quite so pleasant, owing most probably to the foreign bodies, from which it cannot easily be completely freed.

The theory of its formation is not yet altogether understood. It is evident that it cannot be exactly the same with that of sulphuric ether, as it may be formed without artificial heat, and as the nitrous acid is undoubtedly decomposed from the very commencement of the process. Some light may be thrown upon the subject by a careful examination of the phenomena which take place during the action of nitrous acid on alcohol.

Action of nitric acid on alcohol.

1. When equal parts of alcohol and nitrous acid are mixed, a violent effervescence takes place; spontaneously if the acid be concentrated; on the application of

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* Deyeux, *Ann. de Chim.* xxii. 144.

Etherised nitrous gas.

heat if the acid be diluted. This effervescence is owing to the emission of a gas, which may be received in glass jars standing over water. This gas, which was first examined by the Dutch chemists*, is a compound of nitrous gas and ether. It has been termed for that reason *etherised nitrous gas.*

This gas has a disagreeable ethereal odour: it burns with a yellow flame; is completely absorbed by water, alcohol, and the solution of potass; ammonia has no action on it. When fired along with oxygen gas it detonates. Sulphuric, sulphurous, nitric, and muriatic acids, decompose it by abstracting the ether, and leaving nitrous gas behind.

What remains after this gas has separated consists chiefly of acetic acid.

2. When one part of alcohol and three parts of nitrous acid, of the specific gravity 1.261, are mixed together, and a very moderate heat applied, a great quantity of gas is disengaged, which consists chiefly of nitrous etherised gas and nitrous gas. When only $\frac{1}{12}$ part of the liquid remains in the retort, if it be allowed to cool a number of crystals of oxalic acid are formed†. By this process 1.167 parts of oxalic acid may be obtained from 16 parts of alcohol‡.

3. When one part of nitrous acid is poured upon its own weight of alcohol, and one part of sulphuric acid is added a little after, the mixture takes fire and burns with great brilliancy. When this experiment is performed in close vessels, the products are ether and oil,

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* *Jour. de Phys.* xlv. 245.

† Scheele and Hermstadt.

‡ Sage, *Jour. de Phys.* l. 346.

besides what remains in the vessel in which the combustion takes place*.

4. When nitric ether is prepared by the processes above described, the products are nitrous gas, ether, oil, acetic acid, oxalic acid, carbonic acid gas. Hence we see that the products are nearly the same as those which are obtained from the action of sulphuric acid on alcohol. The differences are chiefly two: 1. The nitrous acid is completely decomposed, and its decomposition commences whenever the two bodies are mixed. 2. No charcoal is precipitated; it combines with the oxygen of the acid, and flies off in the form of carbonic acid gas. It is possible, then, that nitric ether may be exactly the same with sulphuric ether; though this has not yet been proved.

Fulminating mercury.

5. When nitrous acid, partly saturated with mercury, is poured upon alcohol, and heat applied, the products are nearly the same, but the phenomena are very different. The curious appearances which accompany this mixture were first observed and explained by Mr Howard†. The process, as described by him, is as follows: Dissolve by means of heat 100 grains of mercury in a measured ounce and a half of nitrous acid of the specific gravity of about 1.3. Pour this solution upon two measured ounces of alcohol, and apply heat till the mixture begins to effervesce. The heat is then to be withdrawn. The action becomes violent and continues for some time; a dense white smoke issues from the vessel, which is heavier than the atmospheric air, and may be poured into glass jars, where it continues for some time like fine white clouds. Mr How-

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* Brugnatelli, *Ann. de Chim.* xxix. 327. † Nicholson's *Jour.* iv. 173.

ard has made it probable that this fume is composed of etherised nitrous gas holding oxide of mercury in solution. Meanwhile a white powder falls to the bottom of the mixture. When the effervescence is over, this white powder is to be separated by filtration, washed with pure water, and dried in a heat not exceeding 212°.

Mr Howard has shewn that this powder, which has the appearance of minute crystals, is a compound of oxalat of mercury and etherised nitrous gas. He has given it the name of *fulminating mercury*.

When heated to the temperature of 368°, it explodes with considerable violence. The same effect is produced by friction, by the blow of a hammer, by electricity, and by flint and steel. The products, after combustion, are carbonic acid gas, azotic gas, water, and mercury. It produces very violent effects, but only at a small distance. Concentrated sulphuric acid, when poured upon it, causes an immediate explosion; diluted sulphuric acid likewise decomposes it, but without exploding. A gas passes over, which is a mixture of carbonic acid, and of a peculiar inflammable gas which burns with a greenish flame; the same into which the etherised nitrous gas is converted by the action of diluted sulphuric acid. There remain in the sulphuric acid a white powder consisting of oxalat of mercury and a few globules of mercury *.

III. *Muriatic Ether.*

Discovery.

AFTER the discovery of sulphuric and nitric ether, various attempts were made by chemists to obtain ether

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* Howard, Nicholson's *Jour.* iv. 173.

by the action of muriatic acid on alcohol; but this acid dissolves in alcohol without producing any change in it. Oxy-muriatic acid, on the contrary, is capable of forming an ether with alcohol, as well as nitrous acid. This discovery was made before chemists were acquainted with oxy-muriatic acid in a separate state. Before that period several of its combinations with the metallic oxides were known. Now various metallic oxy-muriats, when distilled with alcohol, occasion the formation of ether; such as the oxy-muriat of mercury, of iron, of arsenic, and of antimony; but the salt which answers best is the oxy-muriat of tin. By means of this salt Courtanvaux formed ether, in 1759, by the following process: Three parts of liquid oxy-muriat of tin and one part of alcohol are mixed together; and after the vapours and heat produced have subsided, the mixture is put into a retort, to which two large receivers are attached, and distilled. There comes over first a little alcohol, then the ether*. This salt has been lately recommended as very proper for making muriatic ether by Klaproth †.

After the discovery of oxy-muriatic acid, Scheele showed that ether might be obtained by distilling a mixture of alcohol, black oxide of manganese, and muriatic acid; or by distilling sulphuric acid, common salt, black oxide of manganese, and alcohol: but the quantity which can be obtained by this process is trifling; for the oxy-muriatic acid acts upon the ether formed, and converts it into a kind of oil.

Preparation.

Van Mons has lately proposed the following process as the best: Saturate a given quantity of alcohol with muriatic acid, by distilling a mixture of two parts

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* *Jour. de Scav.* 1759, p. 549.

† Crell's *Annals*, 1796, ii. 99.

of common salt and one part of sulphuric acid into a Woulfe's apparatus containing two parts of alcohol. Mix this saturated alcohol with half a part of black oxide of manganese, and put into the Woulfe's apparatus a solution of pure potass in water, and distil with a low heat. The ether and oxy-muriatic acid pass over, and the potass prevents the acid from acting so violently on the ether*.

Properties.

Muriatic ether is transparent, colourless, and volatile, like sulphuric ether, which it resembles indeed exactly, except in two particulars: 1. When burnt it exhales an acrid odour, like that of sulphurous acid. 2. Its taste is astringent like that of alum. These peculiarities are probably owing to the mixture of some extraneous body.

The theory of the formation of muriatic ether must be exactly the same with that of nitric ether.

IV. *Acetic Ether.*

Discovery.

Ether may be produced also by the action of acetic acid on alcohol. This was discovered by the Count de Lauraguais in 1759*. He obtained it by distilling a mixture of acetic acid and alcohol with the same precautions as are employed in the distillation of sulphuric ether.

Preparation.

Scheele could not succeed in obtaining ether by this process; but he discovered another by which it may be obtained without difficulty. Nothing more is necessary than to add a little sulphuric acid to the mixture; or acetic ether may be obtained by dissolving

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* *Ann. de Chim.* xxxiv. 141.

† *Jour. de Scav.* 1759, p. 324.

one part of acetite of potass in three parts alcohol, adding more sulphuric acid than is sufficient to saturate the potass, and then distilling*.

Acetic ether has the properties of the other ethers, excepting only that the odour of acetic acid is perceptible in it. Most probably it differs from sulphuric ether only in holding a little acetic acid in solution.

Ether may be formed also by several other acids. Scheele obtained it by distilling a mixture of fluor spar, black oxide of manganese, alcohol, and sulphuric acid; Crell by means of sebacic acid; and Bergman by means of oxalic acid. Scheele found that the following acids did not form ether with alcohol†.

1. Muriatic,
2. Fluoric,
3. Phosphoric,
4. Boracic,
5. Benzoic,
6. Acetous,
7. Tartarous,
8. Citric,
9. Succinic,
10. Arsenic.

The different species of ether have not been examined with sufficient care; but the general opinion at present among chemists is, that there is only one ether, and that the differences which manifest themselves in the ethers prepared with different acids, are owing to foreign substances with which the ether is contaminated.

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* Scheele, ii. 117.

† Ibid.

CHAP. VI.

REMARKS ON THE PRIMARY COMPOUNDS.

SUCH are the properties of the *primary compounds;* a class of bodies which have been the longest known, which have been most accurately studied, and which constitute, without doubt, the most important instruments in chemistry. Their number, omitting the oils, amounts to 62. But of these there are 14 whose component parts are still unknown, and which, therefore, have been only classed among the primary compounds from analogy. These are the fixed alkalies, the earths, and muriatic and fluoric acids. The component parts of the others are 10; namely, oxygen, the simple combustibles, and four metals *. Of these 48 bodies there are sixteen composed of two ingredients; namely, ammonia, the oxides, and 10 acids: the rest contain 3 and some of them 4. Oxygen is a component part of all the primary compounds which have been decomposed except ammonia, and perhaps also prussic acid; two bodies which resemble each other in many of their properties.

The primary compounds might be divided into two classes, distinguished by the titles of *incombustibles* and *combustibles*.

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* The metallic oxides are passed over, because they have been described in the first Book.

Book II.

Incombustibles

1. The incombustible bodies amount to 26; namely,

Fixed alkalies	2
Earths	10
Water and oxides of azot	3
Sulphuric acid	1
Phosphoric acid	1
Carbonic	1
Metallic	4
Nitric	1
Muriatic	1
Boracic	1
Fluoric	1
	26 *

Of two kinds.

Now these bodies are of two kinds. The composition of some of them is entirely unknown; the rest are the products of combustion; that is to say, they consist of bases, which have already undergone combustion, and which are saturated with oxygen. From this arrangement must be excepted the oxides of azot, which are not the products of combustion nor of any similar process. They belong to another class of bodies, which may be denominated *supporters of combustion;* because without their presence combustion cannot go on: A set of bodies possessed of very singular properties, all analogous in their composition, and the grand agents in the most interesting chemical phenomena.

Combustibles

2. The combustibles, if we include the oils and reckon them as two, amount to 24; namely,

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* The sulphurous, phosphorous, nitrous, and oxy-muriatic acids, are, for obvious reasons, omitted.

Ammonia	1
Vegetable and animal acids	17
Oxides of carbon	2
Oils	2
Alcohol and ether	2
	24

Contain oxygen.

It is singular enough, that of all these bodies there are only two, namely, ammonia and prussic acid, which do not contain oxygen (for it can scarcely be doubted that oils contain less or more of that principle); and these two are, perhaps, the least combustible of the whole class. The most combustible of all, I mean alcohol and ether, contain a very considerable proportion of oxygen. Now this is perfectly analogous to several other phenomena which presented themselves while we were examining the simple bodies. Carbon, for instance, is by no means a very combustible body; it requires a high temperature, and even then consumes very slowly; but charcoal, which is carbon combined with oxygen, is exceedingly combustible. In like manner, it is exceedingly difficult to combine azot with oxygen; but nitrous gas, which is a compound of azot and oxygen, combines with it very rapidly whenever the two bodies come into contact. This observation, which holds very generally, would almost tempt one to suspect that all very combustible bodies contain oxygen, and that therefore we are not at present acquainted with pure sulphur and phosphorus; but that these bodies, in the state in which we can exhibit them, contain a certain portion of oxygen. At any rate, it may be laid down as a general rule, to which there are but few exceptions, that all very combustible bodies are compounds.

Though the five classes into which primary compounds have been divided in the preceding Chapters have been long known, and have always engaged the attention of chemical philosophers, the number of individuals which belong to these classes has been very much encreased. About the commencement of the 18th century only the three alkalies, four of the earths, two of the oxides, five acids, and the compound combustibles, were known, and these but imperfectly. Six earths, 3 oxides, and 28 acids have been added to the list of primary compounds by the labours of the philosophers of the 18th century. Nor ought we to forget that of these 36 new bodies, no less than 14 were discovered by the sagacity of the indefatigable Scheele.

DIVISION II.

OF

SECONDARY COMPOUNDS.

MANY of the *primary compounds*, as we have seen in the preceding Chapters, are susceptible of forming combinations with each other. Thus acids combine with alkalies, with earths, and with metallic oxides, and form compounds called *salts*: the earths combine with the fixed alkalies and form *glass*: oils combine with alkalies and form *soaps*. These, to which I have given the name of *secondary compounds*, come now under our consideration.

The secondary compounds, as far as we are at present acquainted with them, may be arranged under the five following Classes.

1. Combinations of earths.
2. Glass.
3. Salts.
4. Hydro-sulphurets.
5. Soaps.

These shall be the subject of the five following Chapters.

CHAP. I.

OF COMBINATIONS OF EARTHS.

SEVERAL of the earths are capable of entering into combination with each other and with metallic oxides, and of forming compounds distinguished by various names according to their external appearance. Some of these combinations are formed into vessels known by the names of *stoneware*, *porcelain*, *enamel*, &c. many of which are of great importance in manufactures and domestic economy.

Earth compounds imperfectly known.

This class of bodies is of the highest importance; but it has not hitherto been examined by chemists with that degree of attention to which it is entitled. A few only of the compounds into which the earths and the metallic oxides are capable of entering have been formed, and still fewer of these have been described with precision. The subject indeed is difficult, and till lately was not susceptible of accuracy, because the properties of the earths, and the methods of obtaining them pure, were unknown. It is true, indeed, that the greater number of these compounds exist ready formed in the mineral kingdom, constituting the solid basis of this globe of ours. But notwithstanding the rapid progress which the analysis of minerals has lately made, it is still very uncertain whether it would be safe to trust altogether the result of these analyses; especially as we are not able to form compounds artificially similar to those which exist ready formed in the earth.

It will be better, therefore, to refer the consideration of these numerous native compounds to the second part of this Work, and to satisfy ourselves at present with a general view of the compounds which the earths are capable of forming, a description of those mixtures which are employed in the manufacture of stoneware and porcelain, and an account of those combinations of earths and metallic oxides which form the different enamels with which these substances are covered. These topics will form the subject of the two following Sections.

SECT. I.

OF EARTHY COMBINATIONS IN GENERAL.

THAT several of the earths have a strong affinity for each other, and are therefore capable of forming combinations, is a fact now well known to the chemical world. But it is by no means an easy matter to form these combinations artificially. If the earths be mixed together in the state of a powder, they do not combine intimately; and as few of them are soluble in water, recourse cannot be had, except in a very few cases, to the intervention of that liquid. Chemists, therefore, when they wish to combine the earths together, have scarcely any other agent to employ except fire. This agent answers exceedingly well in combining the metals with each other, and converting them into alloys. But with respect to the earths the case is very different. For no fire which can be produced is sufficiently violent to melt a considerable quantity of any of the earths, barytes and strontian excepted.

Fusing temperature of the earths

It is true indeed that silica, and perhaps all the other earths, may be melted by a process invented by Saussure. He cements a very minute particle of quartz or any other substance whose fusibility is to be tried, to a slender fibre of *cyanite*[*], and exposes it in that state to the action of the blow-pipe. He supposes the intensity of the heat inversely proportional to the diameter of the globule produced. Any heat therefore whatever may be communicated by means of the blow-pipe, by diminishing sufficiently the bulk of the particle subjected to its action. The limit of intensity is when the particle cannot be farther diminished without rendering the globule produced too small to be seen distinctly by a microscope, and to be measured by means of a micrometer. Saussure found that the heat necessary to melt quartz is equal to 4043° Wedgewood; that which melts alumina is 18900° Wedgewood[†].

Lowered by mixture.

The temperature then at which the earths melt is inconceivably high: but the quantity of these bodies which can be in this manner subjected to experiment, is by far too minute to draw much satisfactory information from it respecting the nature of the compounds which the earths are capable of forming with each other. Luckily it is in many cases not necessary to have recourse to it. It is well known that several of the metals, which require a very high temperature to bring them to fusion, melt

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[*] This is a blue coloured transparent stone, to be afterwards described.

[†] *Jour. de Phys.* xlv. 3.

readily when mixed with a portion of some other metal. Thus platinum, the most infusible of them all, melts readily when combined with arsenic. The same thing happens with several of the earths; alumina, for instance, though perhaps the most refractory of them all, enters very speedily into fusion when mixed with a proper proportion of silica and lime. Chemists have taken advantage of this property. They have mixed the earths together in various proportions, and then subjected them to heat. The affinity between them was judged of by the degree of fusion which they underwent. Mr Pott was the chemist who first laid open this method of proceeding. His *Lithogeognosia*, which was published in 1746, must have been the result of immense labour. It may be considered as the harbinger of all the mineralogical discoveries which followed. Achard * of Berlin published in 1780 a long list of experiments, in which he exposed various mixtures of earth to the heat of a porcelain furnace. This was the first direct set of experiments on the combinations of earths; for Pott, and Macquer and Darcet who followed him, had confined themselves to native combinations. Mr Kirwan in 1794 published a still more accurate set of experiments † on the same subject. Since that time the combination of the earths has occupied the attention of Morveau ‡; not to mention the interesting experiments of Klaproth § and Saussure ||, and the ingenious speculations of Saussure and Dolomieu ¶. From the experi-

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[*] *Mem. Berlin*, 1780. 69.

[†] *Mineralogy*, i 49.

[‡] *Jour. de l'Ecole Polytechn.* I. iii. 298. and *Ann. de Chim.* xxxi. 246.

[§] Klaproth's *Beitrage*, i. 1.

[||] *Jour. de Phys.* xlv. 3.

[¶] *Jour. de Phys.* passim.

ments of these philosophers, and from the accurate mineralogical analyses of Klaproth and Vauquelin, the following consequences may be drawn.

Action of the earths on each other.

1. There is an affinity between all the different earths: But this affinity varies considerably in intensity. Certain earths combine readily with each other in almost every situation, while others cannot be combined without difficulty. There are some combinations of earths which are found native and abundant; others, on the contrary, are seldom or never met with.

2. Certain earths when mixed together become very fusible, while other mixtures are as refractory as the simple earths themselves. The affinity between the earths must not be judged of by this increase of fusibility; for several earths which have a strong affinity for each other do not form fusible mixtures at all. In general, mixtures of earths are fusible only when mixed in certain determinate proportions.

1. Barytes.

3. Barytes has a strong affinity for lime, silica, alumina, and magnesia. Morveau has shown that when barytic and lime water are mixed together, the two earths precipitate in combination; that barytic water separates silica from potass; and that when the muriats of barytes and magnesia are mixed together, the two earths precipitate combined[*]: and Vauquelin has shown that barytes readily combines, not only with silica, but also with alumina[†]. Hitherto, however, no combination of barytes with any of these earths has been found native. Barytes indeed scarcely ever enters as an ingredient into the composition of stones.

Barytes with lime or with silica forms a mixture which may be fused by the application of heat; but it

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[*] *Ann. de Chim.* xxxi. 248.

[†] Ibid. xxix. 270.

does not form a fusible mixture with any of the other earths, as far as is known by experiment.

2. Strontian.

4. Strontian resembles barytes in its affinities and action on the other earths, except lime and magnesia. It manifests no affinity for these bodies, and cannot be combined with them, either by the action of heat or by solution. In this respect it differs very much from barytes, which has a strong affinity for these bodies.

3. Lime.

5. Lime has a strong affinity for barytes, alumina, and silica. Scheele first observed, that when alumina is mixed with lime-water, it combines with the lime, and leaves the water in a state of purity*. When muriat of lime and of alumina are mixed together, the same combination takes place, and is precipitated†. Gadolin first remarked that lime-water forms a precipitate with silicated potass; and Morveau ascertained that this precipitate is a compound of the two earths. Lime enters readily into fusion when mixed with barytes or with silica; but no mixture of lime and any other earth, except these, is fusible, as far as is known. It has not been possible to combine it with strontian and zirconia either by fusion or by solution.

Lime is found in much greater abundance than barytes or strontian. Like these earths it is almost always combined with some other substance, and like them also much more frequently with acids than with earths. When combined with earths, it almost always makes a part of a triple compound, consisting of two other earths besides itself combined together‡. Two different combinations of this kind are known;

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[*] Scheele, i. 196.

[†] Morveau, *Ann. de Chim.* xxxi. 253.

[‡] Shistose hornstone, however, is a compound of silica and lime.

the first, consisting of silica, alumina, and lime; the second, of silica, magnesia, and lime. The appearance and properties of these native compounds vary according to the proportions of the different ingredients; so that each of them includes under it a variety of species. Some of the metallic oxides, especially oxide of iron, not unfrequently enter into these combinations. To the first of these combinations belong the *zeolites*, *chrysoberyl*, and the *garnets;* and to the second *asbestus;* minerals whose properties shall be considered afterwards.

4. Magnesia.

6. Magnesia has a strong affinity for barytes and alumina. Clouet and Hachette have ascertained, that if muriats of magnesia and alumina be mixed together, and the earths precipitated by means of potass, the alumina and magnesia combine, and form a compound not acted upon by potass *. Magnesia, when mixed with silica, forms a fusible compound; but the mixture of this earth with barytes, with strontian, with lime, or with alumina, is not fusible in the heats of our furnaces.

Magnesia is frequently found native combined with the other earths. These native combinations consist sometimes of two earths, sometimes of three, and in general some metallic oxide is also present. They may be comprehended under four classes:

1. Alumina and magnesia,
2. Silica and magnesia,
3. Silica, alumina, and magnesia,
4. Silica, lime, and magnesia.

To the first of these classes belongs the *ruby;* to the second *steatites;* to the third, the *cyanite* or *sappare* of Saus-

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* *Ann. de Chim.* xxxi. 257.

sure; and to the fourth, *asbestus*. A soapy feel, and a certain degree of softness and opacity, has been considered as a characteristic of the earthy combinations which contain magnesia; but the ruby and cyanite are both of them transparent and hard. It is worthy of attention, that magnesia enters into fewer fusible compounds than any of the alkaline earths.

5. Alumina.

7. Alumina, as has been already remarked, has a strong affinity for barytes, strontian, lime, and magnesia. It has also an affinity for silica. When silicated and aluminated potass are mixed together, the mixture in about an hour becomes opaque and gelatinous, evidently in consequence of the combination of the two earths *. Alumina enters into fusion with none of the other earths except lime, and not even with the fixed alkalies. In this respect it differs exceedingly from silica, which, from the numerous fusible compounds that it is capable of forming, was formerly called the *vitrifiable earth*. But alumina enters into several triple earthy mixtures which are fusible. Thus mixtures of alumina and silica with any of the alkaline earths, and with magnesia, are fusible.

Alumina is found native in great abundance, and almost always combined with other earths or with metallic oxides, for which it has a very strong affinity. The native earthy combinations, of which it constitutes an ingredient, may be divided into six classes. These are,

1. Alumina and magnesia,
2. Alumina and silica,
3. Alumina, silica, and barytes,

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* Morveau, *Ann. de Chim.* xxxi. 248.

4. Alumina, silica, and lime,
5. Alumina, silica, and magnesia,
6. Alumina, silica, and glucina.

To the first of these classes belongs the *ruby;* to the second, *mica, talc, chalcedony,* the *topaz,* &c.; to the third, *staurolite;* to the fourth, *zeolites;* to the fifth, *cyanite;* and to the sixth, the *emerald.* These minerals will be described hereafter. All the compounds into which a considerable proportion of alumina enters are pretty heavy, and several of them are exceedingly hard.

6. Silica. 8. Silica has a strong affinity for barytes, strontian, lime, magnesia, alumina, and zirconia. When a mixture of this last earth and silica is heated strongly, it shews a tendency to fusion*. It fuses, as we have seen already, with barytes, strontian, lime, and magnesia; so that alumina is the only earth hitherto tried with which it does not enter into fusion.

Silica is found native more abundantly than any of the other earths. It also enters into a greater variety of combinations, but almost always with earthy bodies. The combinations of which it is known to constitute a part may be reduced under nine classes; namely,

1. Silica and alumina,
2. Silica and lime,
3. Silica and magnesia,
4. Silica and zirconia,
5. Silica, alumina, and lime,
6. Silica, alumina, and magnesia,
7. Silica, alumina, and glucina,
8. Silica, alumina, and barytes,
9. Silica, lime, and magnesia.

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* Morveau, *Ann. de Chim.* xxxi. 259.

All of these classes have been mentioned already, and instances given of minerals belonging to each except the fourth, to which belong only the *zircon* and the *hyacinth*.

The most beautiful earthy combinations are those which consist chiefly of silica and alumina. To that class belong almost all the gems. The combinations of these two earths are also the most useful; for they constitute the basis of porcelain, stoneware, glass pots, and all the different earthen utensils.

Earths often frothe during fusion.

9. During the fusion of several mixtures or combinations of earths, especially those which are found native, the mixture very often frothes considerably, and emits a great number of air bubbles. The emission of these air bubbles can only be referred to one or other of three causes. Either a quantity of water leaves the mixture in the form of steam, or the metallic oxides, which are almost always present, are reduced, and allow their oxygen to escape in the form of gas; or, lastly, the earths themselves undergo some change, and let go some one or other of their component parts in the form of gas. It is probable that the phenomenon is partly owing to all these causes; for these earthy mixtures are much lighter after having been exposed to the action of the fire than they were before. Thus a mixture of equal parts of silica and magnesia, after being heated to 134° Wedgewood, lost 0.135 of its weight; and a mixture of equal parts of alumina and barytes lost in the same situation 0.275 of its weight *. Now so great a loss as this cannot be ascribed to any other cause than the evaporation of water.

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* Morveau, *Jour. de l'Ecole Polytechnique*, I. iii. 306.

Again, several minerals which are coloured by a metallic oxide become transparent when exposed to a very violent heat; a change which must be occasioned by the revival or dissipation of the metal. This is the case, for instance, with the brown obsidian lava of Dolomieu, with the lazulite, and with schorl [†]. Now it is exceedingly difficult to free the earth completely from all metallic bodies, especially alumina, the earth most remarkable for giving the property of frothing to earthy mixtures.

Concerning the third cause of the frothing of minerals, namely, the decomposition of the earths themselves, nothing like precision can be expected till the component parts of the earths be discovered. Humbolt announced some time ago, that the earths have the property of absorbing oxygen from the atmosphere. In that case the frothing might, in some instances at least, be ascribed to the emission of this oxygen on the application of heat: But the experiments of Humbolt have been tried without success by Saussure, Fabroni, Champy, Berthollet, and Delametherie [*]. I tried the experiment with garden mould, which I enclosed in a glass jar over water immediately after it had been turned up by a mole. The quantity of air was not apparently changed after the earth had remained in contact with it for three weeks [‡]; but it extinguished a candle, and precipitated lime abundantly from lime-water. It was composed of about one-third part of carbonic acid gas; the remainder was atmospheric air.

[†] Saussure, *Jour. de Phys.* xlv. 16.

[*] Ibid. lii. 6

[‡] It had probably increased considerably; for the carbonic acid must have been partly absorbed by the water.

Sometimes have a double fusion.

10. There is another phenomenon respecting the fusion of earthy combinations which has not been hitherto explained. Some minerals, when exposed to the action of heat, melt very readily, and generally with a good deal of frothing; but if the heat be continued, they soon become solid again, and do not fuse unless the temperature be considerably augmented. This is the case with *prehnite*, *thallite*, and some *felspars*. Thus the prehnite undergoes its first fusion at 21° Wedgewood, its second not till it be heated to 81°[*]. It cannot be doubted that in this case some one or other of the ingredients which contributed to the first fusion must be driven off; especially as the mineral after fusion loses entirely its original appearances and properties.

This often depends on the cooling.

A change no less curious is produced on the appearance and fusibility of some minerals, by the slowness or rapidity with which they are cooled after being subjected to fusion. Whinstone, for instance, is a mineral which fuses when raised to a temperature between 40° and 55° Wedgewood. If it be allowed after fusion to cool rapidly, it is converted into a dark-coloured glass, much more fusible than the original whinstone; but if it be made to cool very slowly, it assumes an appearance which has some resemblance to the original whinstone. In this state it is much less fusible than the glass. Sir James Hall, the discoverer of this curious fact, has given the whin in this last state the name of *crystallite*, a term suggested by Dr Hope. Thus the rock on which Edinburgh Castle is built fuses at the temperature of 45° Wedgewood. By rapid cooling it

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[*] Saussure, *Jour. de Phys.* xlv. 14.

is converted into a glass which melts at 22° ; by slow cooling into a *crystallite* which melts at 35°. The whin of Salisbury Craig fuses at 55° ; its glass at 24° ; its crystallite at 38° *.

This striking difference in fusibility seems to depend upon the way in which the component parts of the mineral are combined. When cooled rapidly, these component parts have not time to combine according to their affinities, but are huddled irregularly together. Of course the force of the affinities of those component parts which have a tendency to combine, must conspire with the action of the fire to destroy the cohesion of the parts, the consequence of which must be fusion. Whereas in the crystallite, the component parts having had time to combine according to their affinities, instead of conspiring with the divellent action of the fire, oppose it by conspiring or coinciding with the force of cohesion. In the first case, two forces conspire to produce fusion; in the second, only one. Something similar to this may perhaps take place in those minerals which undergo a double fusion, the first in a lower heat than the second.

SECT. II.

OF STONEWARE.

Definition. UNDER the denomination *stoneware* I mean to comprehend all the different artificial combinations of earthy

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* *Edin. Trans.* v. 75.

bodies which are applied to useful purposes. These vary in their names according to their external appearance, the manner in which they are manufactured, and the purposes to which they are applied. Thus we have porcelain, stoneware, pots, crucibles, bricks, tyles, &c. All these substances, however, are formed on the same principles, nearly of the same materials, and owe their good qualities to the same causes.

Antiquity.

These combinations have been known from the reremotest ages of antiquity. Bricks were employed in building by the most ancient nations, and were no doubt suggested by the great degree of hardness which clay acquires when exposed to the sun. Stoneware is likewise of very ancient date, and seems to have originated among the Asiatic nations. It was well known to the Jews, as we learn from the Old Testament, long before the Babylonish captivity. Porcelain, or the finest kind of stoneware, was early brought to perfection in China and Japan.

Properties.

These different substances are not formed by mixing together the pure earths, which would be a great deal too expensive; but natural combinations or mixtures of earths are employed. These combinations must possess the following properties: 1. They must be capable, when reduced to powder, of forming with water a paste sufficiently ductile to be made into any form which is required. 2. This paste, after being exposed to a sufficient heat, or after being *baked* as it is termed, must acquire such a permanent degree of hardness as to be able to resist the action of the weather and of water. 3. The vessels formed of it must in that state be capable of resisting changes of temperature. 4. They must be able to resist a strong heat without being melted.

5. They must not be permeable to liquids, nor liable to be acted on by chemical agents.

Common clay possesses a good many of these qualities. When finely ground, it may be formed into a very ductile paste; heat makes it hard enough to strike fire with steel, and capable of resisting the action of most chemical agents; and it is not liable to be melted by heat. Clay accordingly was the first substance employed, and it is still employed for a variety of purposes.

Bricks and tiles.

Bricks, for instance, are always made of this substance. The clay is dug out of the earth, and after being exposed for some time to the air is reduced to powder, and formed into a paste with water. The bricks are then formed in moulds, exposed for some time to dry in the open air, and then burnt in a large furnace constructed on purpose. Tiles which are employed for covering houses are formed in the same way. The clay, however, is finer, and it is usually ground in a mill.

Bricks and tiles should be impervious to water: they should be capable of withstanding the action of heat, and not be subject to moulder. It is obvious that these qualities must depend upon the nature of the clay of which they are formed, and on the degree in which they have been burned. Clay is a mixture of alumina and silica in various proportions. When the proportion of alumina is great, the brick contracts much in its dimensions, and is apt to crack during the burning. Clay therefore must be chosen which contains the proper proportion of silica, or the defect must be remedied by adding sand. Bergman recommends the addition of a little lime, which has the property of rendering the clay fusible*. The clay of which bricks and tiles are made contains some oxide of iron: hence the red colour which it acquires when burnt.

But though the addition of lime may be proper in some cases in the manufacture of bricks and tiles, it would be exceedingly improper in other cases. Lime ought to be carefully excluded from the clay destined for making stoneware and every other utensil which is to be exposed to a strong heat, as it renders the clay fusible. Now lime enters not unfrequently into the composition of clays. It is evident therefore that all clays are not proper for the manufacture of stoneware. They must be free from lime, barytes, and every other ingredient which renders them fusible. They must also be free from metallic oxides, which not only render them fusible, but also injure the colour of the porcelain. The clays which answer are those which consist of a mixture of alumina and silica. These are known by the names of potter's clay, tobacco pipe clay, percelain clay, &c. according to the purposes to which they are applied. It is necessary to mix the clay with some fine colourless sand, in order to prevent the vessels from contracting too much during the baking.

Stoneware.

Thus stoneware is composed of two materials, pure clay and sand; and the beauty of the ware depends upon the purity and fineness of these two materials. What is called English stoneware is composed of tobacco pipe clay and powdered flints; delft ware is composed of clay and fine sand; and the coarsest wares of still more common clay and sand.

The materials are ground very fine in a mill, then mixed together, and formed into a paste. The diffe-

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* Bergman, iv. 340.

rent vessels are coarsely moulded on the potter's wheel, and allowed to dry till they can bear handling. After this they receive their destined form completely; and when they are sufficiently dry, they are covered with the requisite enamel, and then put into the furnace and baked.

Porcelain.

Such is the process for making stoneware which has been practised from time immemorial in Europe; but the method of manufacturing that beautiful semitransparent ware called porcelain is of much later date. Specimens of it were brought first from China and Japan to modern Europe*. These were admired for their beauty, were eagerly sought after, and soon became the ornaments of the tables of the rich. Various attempts were made to imitate them in different countries of Europe, but the greater number were without success. Saxony, however, soon produced porcelain scarcely inferior to that of Japan in beauty, and superior to it in solidity and strength: But its composition was kept secret; nor were there any accurate ideas respecting the component parts of porcelain among men of science, till Reaumur published his dissertations on the subject in 1727 and 1729.

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* Porcelain vessels were known to the Romans, and called by them *vasa murrhina*. They were first brought to Rome by Pompey after the defeat of Mithridates, as we are informed by Pliny (lib. xxxvii. 2). The Romans were ignorant of the mode of manufacturing them, but imported them from Pontus and Parthia. After the taking of Alexandria, a vessel of porcelain was the only part of the spoil retained by Augustus. That the vasa murrhina of the Romans were the same as our porcelain vessels, has been ascertained, as Whitaker informs us, by the porcelain found in the ruins of the ancient Lyons. The name *porselain*, if we believe Whitaker, comes from the French name of the plant *portulaca oleracea* or *purslain*, which has a purple coloured flower. It got that name because the porcelain of the ancients was always of a purple colour. See Whitaker's *Course of Hannibal over the Alps*, i. 55.

That celebrated philosopher examined the porcelain of Japan and the different imitations of it which had been produced in France and other parts of Europe. The texture of the first was compact and solid, but that of the imitations was porous. When both were exposed to a strong heat, the first remained unaltered, but the others melted into glass. From these experiments he drew the following ingenious conclusions.

Porcelain owes its semitransparency to a kind of semivitrification which it has undergone. Now it may receive this two ways: 1. Its component parts may be such as easily vitrify when sufficiently heated; but the degree of heat given may be just sufficient to occasion a commencement of vitrification. This porcelain when strongly heated will easily melt. Such, therefore, was the composition of the European imitations of porcelain. 2. It may be composed of two ingredients; one of which easily vitrifies, but the other is not altered by heat. When a porcelain composed of such materials is baked in a sufficient heat, the fusible part melts, invelopes the infusible, and forms a semitransparent substance, which is not farther altered by the same degree of heat. Such therefore must be the porcelain of Japan. Father Entrecolles, a missionary to China, had sent an account of the Chinese mode of making porcelain, which coincided exactly with this ingenious thought of Reaumur. The ingredients, according to him, are a hard stone called *petunse*, which they grind to powder, and a white earth called *kaolin*, which is intimately mixed with it. Reaumur found the petunse fusible, and the kaolin infusible, when exposed separately to a violent heat.

These notions of Reaumur set manufacturers upon the right road; and since the publication of his dissertation, porcelain works have been established in different parts of Europe, especially in France, and by the celebrated Wedgewood in Britain, which rival and even excel the porcelain of the east. The particular processes followed at every manufactory are kept secret; but the component parts are in all cases analogous to those suggested by Reaumur. One of them is a pure white clay, or *steatites*, which answers the purposes of the kaolin, and enables the workmen to form the porcelain on the potter's wheel. The other ingredient is probably a species of felspar, to which the petunse of the Chinese belongs.

Enamels.

It is necessary to cover vessels, whether of stoneware or porcelain, with an enamel, both for the purpose of of beauty and utility; for the body of the vessel, or *biscuit* as it is called, would not be sufficiently compact to contain liquids. By enamel is meant a thin coat of opaque glass. The materials which compose this external glazing differ according to the fineness of the vessels. The glazing of coarse vessels is formed by covering their surface while hot with a little litharge or common salt; both of which have the property of running into an opaque glass at a moderate heat when spread thin upon an earthen vessel.

The glazing of fine vessels consists of white enamel. This is made as follows: One hundred parts of lead are melted with from 15 to 40 parts of tin, and the mixture oxidated completely, by exposing it to heat in an open vessel. One hundred parts of this oxide are mixed with 100 parts of a fine white sand composed of 3 parts silica and 1 part of talc, and with about 25 parts of common salt. This mixture is melted, then reduced to powder, and formed into a paste, which is spread thin over the porcelain vessel before it be baked. The excellency of a good enamel is, that it easily fuses into a kind of paste at the heat which is necessary for baking porcelain, and spreads equably on the vessel, forming a smooth glassy surface without losing its opacity or flowing completely into a glass. Its whiteness depends upon the proportion of the tin.

Method of colouring porcelain.

It is usual to paint both stoneware and porcelain of various colours. These paintings are often excellent, both in elegance of workmanship and in brilliancy of colours. The colours are given by means of metallic oxides, which are mixed up with other ingredients proper to constitute an enamel, and applied in the usual manner with a pencil.

1. Purple is given by means of the purple oxide of gold precipitated by the smallest possible quantity of muriat of tin. This oxide is mixed with a proper quantity of powdered glass, borax, and oxide of antimony, and applied with a pencil. It cannot bear a strong heat without losing its colour.

2. Red is given by oxide of iron. A mixture of 2 parts of sulphat of iron and 1 part of alum is calcined slowly, till it acquires a fine red colour when cold. This powder is mixed with the usual flux, and applied with a pencil.

3. Yellow is given by the oxide of silver; green, by the oxide of copper; blue, by the oxide of cobalt; and violet, by the oxide of manganese.

In some cases these colouring matters are not mixed with a flux or enamel at all, but applied in a liquid form to the surface of the biscuit, which imbibes them. The porcelain in that case is said to be *stained*. Yellow is the colour which can be easiest applied in that way.

CHAP. II.

OF GLASS.

THE fixed alkalies have a strong affinity for several of the earths, especially for silica and alumina, which they dissolve in considerable quantity, especially when assisted by heat. When a strong heat is applied to a mixture of fixed alkali and silica, it melts, and forms a transparent mass well known by the name of *glass*.

Discovery.

The method of making this very useful compound was known at a very early period. According to Pliny, the discovery was owing to an accident. Some merchants, with a ship-load of soda from Egypt, had cast anchor at the mouth of the river Belus in Phœnicia, and were dressing their dinner on the sand. They made use of large lumps of soda to support their kettles, and lighted fires under them. The heat melted the soda and the siliceous sand together, and the result was glass. For some time after this accidental discovery the manufacture of glass was confined to the river Belus. The manufacture of glass seems to have been carried to a considerable degree of perfection among the ancients. They mention drinking glasses, glass prisms, and coloured glasses of various kinds. But perfectly transparent glass was considered as very valuable; for Nero gave L. 50,000 for two glass cups with handles: a proof that their processes must have been far less perfect than ours. It was usual for them to melt the materials of their glass into a black mass called *ammonitrum*, of which statues were sometimes made. This ammonitrum was again melted and purified by refiners. Glass panes seem to have been first used in windows in the third century, but they did not come into common use till long after *.

Materials.

The materials employed in the manufactory of glass may be reduced under three classes; namely, alkalies, earths, and metallic oxides.

1. Alkalies,

The fixed alkalies may be employed indifferently; but soda is preferred in this country. The soda of commerce is usually mixed with common salt, and combined with carbonic acid. It is proper to purify it from both of these foreign bodies before using it. This, however, is seldom done.

2. Earths,

The earths are silica, lime, and sometimes a little alumina. Silica constitutes the basis of glass. It is employed in the state of fine sand or flints; and sometimes, for making very fine glass, rock-crystal is employed. When sand is used, it ought if possible to be perfectly white; for when it is coloured with metallic oxides, the transparency of the glass is injured. Such sand can only be employed for very coarse glasses. It is necessary to free the sand from all the loose earthy particles with which it may be mixed, which is done by washing it well with water.

Lime renders glass less brittle, and enables it to withstand better the action of the atmosphere. It ought in no case to exceed the twentieth part of the silica em-

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* See Dr Falconer's paper on this subject, *Manchester Memoirs*, ii. 95.

ployed, otherwise it corrodes the glass pots. This indeed may be prevented by throwing a little clay into the melted glass; but in that case only a green glass is obtained.

3. Oxides.

The metallic oxides employed are the red oxide of lead or litharge, and the white oxide of arsenic. The red oxide of lead, when added in sufficient quantity, enters into fusion with silica, and forms a glass without the addition of any other ingredient. Five parts of minium and two of silica form a glass of an orange colour and full of striæ. Its specific gravity is 5. The red oxide of lead renders glass less brittle, and more fusible; but when added beyond a certain proportion, it injures the transparency and the whiteness of glass.

The white oxide of arsenic answers the same purposes with that of lead; but on account of its poisonous qualities, it is seldom used. It is customary to add a little nitre to the white oxide of arsenic, to prevent the heat from reviving it, and rendering it volatile. When added beyond a certain proportion, it renders glass opaque and milky like the dial-plate of a watch. When any combustible body is present, it is usual in some manufactures to add a little white oxide of arsenic. This supplying oxygen, the combustible is burnt, and flies off; while the revived arsenic is at the same time volatilized.

Method of making glass.

After mixing the alkali and sand together, it is usual to expose them for some time to a moderate heat. This serves several purposes. It drives off all combustible bodies which may happen to be mixed with the sand; it produces a commencement of combination which makes the glass afterwards less liable to corrode the clay pots in which it is melted; and the alkali, by this incipient combination, is not so apt to be volatilized; which might be the case if the materials were exposed at once to a violent heat. The mixture, after being thus heated, is called the *frit*. Through the domes in which the frit is heated it is usual to see very thin bubbles of glass passing; a proof that some of the materials are volatilized during this first part of the process.

The frit, while still hot, is introduced into large pots made of a mixture of pure clay and baked clay, and exposed to a heat sufficient to melt it completely. The fusion must be continued till the effervescence occasioned by the separation of the carbonic acid from the soda has subsided, and the opaque scum, known by the name of *glass-gall*, which collects on the surface of the glass, must be removed. This scum is occasioned by the common salt and other foreign bodies which are always mixed with the soda of commerce. When the fusion has been continued the proper time, the furnace is allowed to cool a little. In that state the glass is exceedingly ductile, and readily assumes any shape that the workman pleases.

If the glass vessels, after being formed, were cooled rapidly, they would contract unequally, and become in consequence so brittle as to fall to pieces whenever they were handled. To prevent this inconvenience, they are put into a large red hot furnace, which is allowed to cool very slowly to the temperature of the air. This process is called *annealing*.

Its properties.

The properties that distinguish good glass are well known. It is perfectly transparent; its hardness is very considerable; its specific gravity varies from 2.3 to 4, according to the proportion of metallic oxide which it contains. When cold it is brittle; but at a red heat it is one of the most ductile bodies known, and may be drawn out into threads so fine as to be scarcely visible to the naked eye. It is almost perfectly elastic, and of course is one of the most sonorous of bodies. There are but few chemical agents which have any action on it. Fluoric acid dissolves it with great rapidity, and so do the fixed alkalies when assisted by heat. Dr Priestley has shown also, that the long continued action of hot water is capable of decomposing it: a discovery which explains sufficiently the siliceous earth obtained by Boyle and Margraff when they subjected water to tedious distillations in glass vessels.

Different kinds.

There are different kinds of glass manufactured for different purposes: the principal of these are flint glass, crown glass, and bottle glass.

Flint glass is formed of soda, pounded flints, and oxide of lead. It is the densest, most transparent, and most beautiful glass, and is often called crystal. Crown glass contains no lead. It is composed of soda and fine sand. This kind is used for the panes of windows. Bottle glass is the coarsest of all. It is composed of kelp or the refuse of soap boilers, and common sand. Its green colour is owing to the presence of iron. Of these species the most fusible is flint glass, and the least fusible bottle glass. According to the experiments of Saussure, flint glass melts at the temperature of 19° Wedgewood, crown glass at 30°, and bottle glass at 47°*.

Coloured glass.

Glass is often tinged of various colours by mixing

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* *Jour. de Phys.* xlv. 14.

with it while in fusion some one or other of the metallic oxides.

Blue glass is formed by means of oxide of cobalt.

Green, by the oxide of iron or of copper.

Violet, by oxide of manganese.

Red, by a mixture of the oxides of copper and iron.

Purple, by the purple oxide of gold.

White, by the oxide of arsenic and of zinc.

Yellow, by the oxide of silver and by combustible bodies.

Its defects.

Opticians, who employ glass for optical instruments, often complain of the many defects under which it labours. The chief of these are the following:

1. *Streaks*. These are waved lines, often visible in glass, which interrupt distinct vision. They are probably owing sometimes to want of complete fusion, which prevents the different materials from combining sufficiently; but in some cases also they may be produced by the workmen lifting up the glass at two different times which is to go to the formation of one vessel or glass.

2. *Tears*. These are white specks or knots, occasioned by the vitrified clay of the furnaces, or by the presence of some foreign salt.

3. *Bubbles*. These are air-bubbles which have not been allowed to escape. They indicate want of complete fusion, either from too little alkali, or the application of too little heat.

4. *Cords*. These are asperities on the surface of the glass, in consequence of too little heat.

CHAP. III.

OF SALTS.

Salt explained.

The word SALT was originally confined to *muriat of soda*, or *common salt*; a substance which has been known and in common use from the remotest ages. It was afterwards generalized by chemists, and employed by them in a very extensive and not very definite sense. Every body which is sapid, easily melted, soluble in water, and not combustible, has been called a *salt*.

Salts were considered by the older chemists as a class of bodies intermediate between earths and water. Many disputes arose about what bodies ought to be comprehended under this class, and what ought to be excluded from it. Acids and alkalies were allowed by all to be salts; but the difficulty was to determine concerning earths and metals; for several of the earths possess all the properties which have been ascribed to salts, and the metals are capable of entering into combinations which possess saline properties.

In process of time, however, the term *salt* was restricted to three classes of bodies; namely, *acids*, *alkalies*, and the *compounds* which acids form with alkalies, earths, and metallic oxides. The first two of these classes were called *simple salts*; the salts belonging to the third class were called *compound* or *neutral*. This last appellation originated from an opinion long entertained by chemists, that acids and alkalies, of which they are composed, were of a contrary nature, and that they counteracted one another; so that the resulting compounds possessed neither the properties of acids nor of alkalies, but properties intermediate between the two.

Chemists have lately restricted the term *salt* still more, by tacitly excluding acids and alkalies from the class of salts altogether. At present, then, it denotes only the compounds formed by the combination of acids with alkalies, earths, and metallic oxides*.

No part of chemistry has been cultivated with more zeal than the salts, especially for these last 40 years. During that time the number of saline bodies has been enormously increased, and the properties of a very great number have been determined with precision. Still, however, this wide and important region is very far from being completely explored.

Number of salts.

Chemists have agreed to denominate the salts from the acids which they contain: The earth, alkali, and metallic oxide, combined with that acid, is called the *base* of the salt. Thus common salt being a compound of muriatic acid and soda, is called a *muriat*; and soda is called the base of common salt. Now since there are 32 acids and 55 bases, it would appear, at first sight, that there are 1760 salts; but of the 42 metallic oxides at present known, there are a considerable number which cannot combine with many of the acids. This is

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* The terms *salt* and *neutral salt*, therefore, are now ſynonymous. Probably the last of these will be gradually dropt altogether; at least it ought to be so.

the case also with silica, and perhaps with some of the other earths. We must therefore subtract all these from the full number 1760. However, to compensate this deficiency, at least in part, there are several acids capable of combining with two bases at once. Thus the tartarous acid combines at once with potass and soda.

Triple salts.

Such combinations are called *triple salts*, and they increase the number of salts considerably. There are some salts, too, which are capable of combining with an additional dose of their acid, and others which combine with an additional dose of their base. The French chemists denote the first of these combinations by adding to the usual name of the salt the phrase *with excess of acid*, or by prefixing to it the word *acidulated*: They denote the second by subjoining the phrase with *excess of base*. This method of naming has the merit indeed of being precise; but it is exceedingly awkward and intolerably tedious. The ingenious mode of naming these combinations proposed by Dr Pearson ought certainly to be preferred. It is equally precise, if not more so, and far more convenient in every respect.

Supers and subsalts.

It consists in prefixing to the usual name of the salt the preposition *super*, to denote an excess of acid, and the preposition *sub* to denote an excess of base *. Thus *sulphat of potass* denotes the salt in its state of perfect saturation, without any excess either of the sulphuric acid or of the potass; *supersulphat of potass* is the same salt with an excess of acid; *subsulphat of patass* is the same salt with excess of base. These three different kinds must increase the number of saline compounds very considerably; but the precise number of salts is not known,

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* Pearson's *Translation of the Chemical Nomenclature*, p. 52.

as many of them remain still unexamined by chemists. Probably they are not much fewer than 2000. Some idea may be formed of the progress which this branch of chemistry has made, by recollecting that 40 years ago not more than 30 salts in all were known.

Of these 2000, however, a considerable number may be considered as still unknown, as they have been merely formed without being examined. Of those which are known, the greater number have not been applied to any use, and therefore do not deserve a very particular description.

Nomenclature.

As the different genera of salts are denominated from their acids, it is evident that there must be as many genera as there are acids. The terminations of the names of these genera differ according to the nature of the acids which constitute them. When that acid contains a maximum of oxygen, the termination of the genus is *at*; when it does not contain a maximum of oxygen, the termination of the genus is *ite*. Thus the salts which contain sulphuric acid are called *sulphats*; those which contain sulphurous acid are called *sulphites*. This distinction is of some consequence, because the salts differ very much, according as the acid is saturated with oxygen or not. The *ites* are seldom permanent: when exposed to the air, they usually attract oxygen, and are converted into *ats*. This distinction, however, applies only to the salts which contain acids composed of a single base; it does not apply at all to the salts composed of the vegetable and animal acids. The terminations of these acids in *ic* and *ous* are entirely arbitrary, and so are the terminations of the genera of salts named from them. The only rule observed is, that when the acid terminates in *ic*, the genus of salts named from it terminates in *at*; when the acid ends in *ous*, the genus of salts ends in *ite*[*].

Every particular species of salt is distinguished by subjoining to the generic term the name of its base. Thus the salt composed of sulphuric acid and soda is called *sulphat of soda*. Triple salts are distinguished by subjoining the names of both the bases connected by hyphens. Thus the compound of tartarous acid, potass, and soda, is called *tartrite of potass-and-soda.*

Arrangement.

Before the correction of the chemical nomenclature by Morveau in 1781, chemists usually referred the genera of salts to the bases, and distinguished the species by the acids. That celebrated philosopher entirely reversed that method by introducing the new generic terms formed from the acids. And his ingenious nomenclature having been sanctioned and improved in 1787 by Lavoisier, Berthollet, and Fourcroy, who joined with him in forming a new chemical nomenclature, has now become universally prevalent. As far as relates to the salts which have alkaline and earthy bases, this method introduced by Morveau is certainly proper; for in them the acids in a great measure stamp the character of the salt, and therefore ought to constitute the generic distinction: but it does not apply equally well to the salts whose bases are metallic oxides; for in them it is not the acid but the base which stamps the character. In them, therefore, the genera ought to be reversed: they ought to be derived not from the acids but from

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[*] This mode of naming is defective. It would have been much better to have restricted the termination *at* to permanent salts, and the termination *ite* to those which are converted into the *ats* by absorbing oxygen. With respect to the metallic salts the nomenclature is still very defective.

the bases, or rather from the metals whose oxides constitute the base.

Divisible into two classes.

The salts then naturally divide themselves into two grand classes; the first of which comprehends the alkaline and earthy salts, which derive their most important characters from their acids; the second comprehends the metalline salts, whose bases on the contrary stamp their most important properties. I shall therefore divide this Chapter into two Sections; in the first of which I shall describe the alkaline and earthy salts, in the second the metalline.

SECT. I.

OF ALKALINE AND EARTHY SALTS.

As the salts belonging to this Section may be arranged with greatest propriety according to their acids, they naturally divide themselves into 32 genera, every particular acid constituting a genus. But of these genera some must be omitted altogether, because the salts which belong to them have not been examined. Every genus will comprehend under it as many species as there are bases; besides the triple salts and the *subs* and the *supers* *.

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* The most complete account of the alkaline and earthy salts which has yet appeared, has been given by Fourcroy in the 3d and 4th volumes of his *Systeme des Connoissances Chimiques.*

Genus I. Sulphats.

Sulphuric acid is capable of combining with all the alkalies and earths except silica. The sulphats are almost all capable of assuming a crystallized form. Their taste, when they have any, is almost always bitter. They may be distinguished from other saline bodies by the following properties.

Properties.

1. They are insoluble in alcohol. When they are dissolved in water, alcohol precipitates them from that liquid, and it precipitates them crystallized.

2. Heat does not decompose them. To this, however, there are some exceptions.

3. When heated to redness along with charcoal, they are converted into sulphurets.

4. When barytic water, or a solution of any salt containing barytes, is dropt into a solution of any of the sulphats in water, a copious white precipitate immediately falls, which is insoluble in acetous acid.

The sulphats at present known amount to 15.

Sp. 1. *Sulphat of Barytes.*

This salt is found abundantly in different parts of the earth, and was formerly denominated *ponderous spar*, from its great weight. Its composition was first ascertained by Gahn.

Crystals.

Hauy has ascertained that the form of its integrant particles is a right angled prism, whose bases are rhombs with angles of 101½° and 78½°. The primitive form of its crystals is the same; but it occurs native in a variety of other forms. It cannot be crystallized by art.

Chap. III.

Properties.

This salt is insoluble in water, or at least only soluble in 43.000 times its weight of water at the temperature of the atmosphere *.

Sulphuric acid dissolves it when concentrated and boiling, but it is precipitated by the addition of water.

When suddenly heated, it breaks in pieces and flies about with a crackling noise. This phenomenon, which is called *decrepitation,* is occasioned by the sudden conversion of the water which it contains into steam. When heated very violently it melts, and before the blow-pipe is converted into a white opaque globule. According to Saussure, a heat equal to 35° Wedgewood is required to fuse it †.

When formed into a thin cake with flour and water, and heated to redness, it phosphoresces in the dark. This was first observed in a variety of this substance known by the name of Bologna stone. Lemery informs us, that the property was discovered by an Italian shoemaker named Vincenzo Casciarolo. This man found a Bologna stone at the foot of Mount Paterno, and its brightness and gravity made him suppose that it contained silver. Having exposed it to the fire, doubtless in order to extract from it the precious metal, he observed that it was luminous in the dark. Struck with the discovery, he repeated the experiment, and it constantly succeeded with him. It is evident that by the calcination it must be converted, at least partly, into sulphuret.

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* Kirwan's *Min.* i. 136.

† *Jour. de Phys.* xlv. 15.

Composition.

According to Fourcroy*, the native sulphat of barytes is composed of . . . . 13 acid
84 barytes
3 water

100

Artificial sulphat of 33 acid
64 barytes
3 water

100

According to Thenart†, artificial sulphat is composed of . . . . . . 25.18 acid
74.82 barytes

100

It is decomposed by two salts; namely, carbonat of potass and carbonat of soda. The decomposition takes place either when it is boiled in a solution of these salts in water, or when they are heated together in a crucible.

Sp. 2. *Sulphat of Potass.*

Formation.

This salt may be formed by saturating diluted potass with sulphuric acid, and then evaporating the solution gently till crystals appear. It seems to have been known at a very early period by chemists, and a great variety of names were given to it, according to the manner of forming it, or the fancy of the operator. Some of these names were, *specificum purgans*, *nitrum fixum*, *arcanum duplicatum*, *panacea holsatica*, *sal de duobus*, *sal polychrest glaseri*, &c.; but it was commonly known

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* Fourcroy, iii. 25.

† *Ann. de Chim.* xxxii. 266.

by the name of *vitriolated tartar* till the French chemists called it *sulphat of potass*, when they formed their new nomenclature in 1787*.

Crystals.

When the solution of sulphat of potass is sufficiently diluted, it affords by evaporation hexahedral pyramids, or short hexangular prisms, terminated by one or more hexangular pyramids. But these crystals vary much in their figure, according to the care with which they are prepared.

Properties.

It has a very disagreeable bitter taste. Its specific gravity is 2.298, according to Brisson; according to Hassenfratz 2.4073 †.

It is soluble in the temperature of 60° in 16 times its weight of water; in a boiling heat, it is soluble in 5 times its weight ‡.

It suffers no alteration in the air.

When placed upon burning coals, it decrepitates, but suffers no other alteration. In a red heat it melts. It is sometimes luminous in the dark, as Mr Giobert has observed §.

Composition.

According to Bergman, it is composed of

40	acid
52	potass
8	water
100	

According to Kirwan, of

45.2	acid
54.8	potass
100	

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* Bergman called it *alkali vegetabile vitriolatum*, and Morveau *vitriol of potass*.

† *Ann. de Chim.* xxviii. 12.

‡ Bergman.

§ *Ann. de Chim.* x. 40.

Hitherto it has been applied to little use. It is a purgative; but its disagreeable taste and its sparing solubility in water prevent it from being much employed.

It is decomposed by the following salts:

1. All barytic salts.
2. Nitrat and muriat of lime and of strontian.
3. All metallic salts, whose base forms an insoluble compound with sulphuric acid, as the oxides of mercury, silver, lead.
4. The tartrites, at least partially.

Sp. 3. *Supersulphat of Potass.*

This salt may be prepared by heating together a mixture of three parts of sulphat of potass and one part of sulphuric acid. It was first distinguished from the last species by Rouelle senior.

Properties.

It usually crystallizes in long slender needles, but it may be obtained in six sided prisms. Its taste is acrid, and it reddens vegetable blues.

It is soluble in two parts of water at the temperature of 60°, and in less than its weight of boiling water.

It is scarcely altered by exposure to the air.

When heated it melts readily and assumes the appearance of oil, but it becomes as white as ever when allowed to cool. A very violent and long continued heat dissipates the excess of acid, and converts it into sulphat.

In other respects this salt agrees with the sulphat of potass.

Sp. 4. *Sulphat of Soda.*

Discovery.

This salt was first discovered by Glauber a German chemist, and for that reason was long known by the name of *Glauber's salt*. He himself called it *sal mirabile*. It may be prepared by saturating soda with sulphuric acid; but it is more usually obtained by decomposing common salt in order to procure muriatic acid.

Properties.

Its crystals are transparent, and when formed by slow evaporation, are six-sided prisms terminated by dihedral summits. The sides of the prisms are usually channelled, and the crystals are almost always exceedingly irregular.

Its taste at first has some resemblance to that of common salt, but soon becomes very disagreeably bitter.

It is soluble in 2.67 times its weight of water at the temperature of 60°, and in 0.8 of boiling water.

When exposed to the air, it loses great part of its water, and falls into a white powder[*], but it is not otherwise altered.

When exposed to heat, it first undergoes the *watery fusion*[†], then its water is evaporated, it is reduced to a white powder, and at last in a red heat it melts. Mr Kirwan has observed, that part of the acid, as well as the water, is driven off by the application of a strong heat[‡].

Composition.

It is composed, according to Bergman, of

27	acid
15	soda
58	water
100	

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[*] Substances which fall to powder in this manner are said to *effloresce*.

[†] When substances, on the application of heat, melt by means of the water they contain, they are said to undergo the watery fusion.

[‡] *Irish Transactions*, v.

According to the latest experiments of Kirwan[*], of

23.52	acid
18.48	soda
58.00	water
100	

and after being dried in a heat of 700°, it is composed of . . . . 56 acid

56	acid
44	soda
100	

This salt is consumed in great quantities as a purgative.

It is decomposed by the following salts:

1. By all the salts which decompose sulphat of potass, except the tartrites.
2. By most salts whose base is potass.

Sp. 5. Sulphat of Strontian.

Discovery.

This salt, for the discovery of which we are indebted to Dr Hope and Mr Klaproth, may be composed artificially by dropping sulphuric acid into Strontian water; in which case it has the form of a white powder. But it exists abundantly in different parts of the world, usually crystallized in rhomboidal prisms.

Properties.

This salt is tasteless. It is soluble in 3840 parts of boiling water. Sulphuric acid dissolves it readily when assisted by heat, but it is precipitated by the addition of water to the solution[†].

In the greater number of its properties it has a considerable resemblance to sulphat of barytes.

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[*] Nicholson's *Journal*, iii. 215.

[†] Hope. *Trans. Edin.* iv. 10.

Composition.

It is composed, according to the analysis of Vauquelin[*], of . . . . . . 46 acid
54 strontian

100

According to Klaproth[†], Clayfield[‡], Henry[§], and Kirwan[||], of 42 acid
58 strontian

100

Sulphat of strontian is decomposed by the following salts:

1. Carbonat of potass and of soda,
2. All barytic salts,
3. Sulphites of potass and of soda,
4. Phosphats of potass, of soda, of ammonia,
5. Borat of ammonia.

Sp. 6. *Sulphat of Lime.*

History.

This salt was well known to the ancients under the name of *gypsum*; but the composition of gypsum was not known till Margraff and Macquer analysed it, and proved it to be a compound of sulphuric acid and lime. The salt formed by the artificial union of these two bodies was formerly called *selenite*, probably from its whiteness.

The properties of this salt were first examined with precision by Bergman.

It is found abundantly in different parts of the world, so that it is seldom formed artificially. When pure, it

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[*] *Jour. de Min.* An. vi. 6.

[†] Beytrage, ii. 97.

[‡] Nicholson's *Jour.* iii. 39.

[§] Ibid. p. 137.

[||] Ibid. p. 215.

is frequently crystallized. The primitive form of its crystals is, according to Hauy, a right angular prism with rhomboidal bases, whose angles are 113° and 67°. Its integrant particles have the same form; but it is more usually found crystallized in octahedrons, in six-sided prisms with four-sided summits, or lenticular. These crystals are often exceedingly transparent.

Properties.

It has a slightly nauseous taste, scarcely perceptible, except by drinking a glass of water impregnated with it*.

It is soluble in 500 parts of water at the temperature of 60°, and in 450 of boiling water.

It is not affected by exposure to the air.

It is soluble in sulphuric acid.

When heated, it loses its water of crystallization, decrepitates, and falls into a soft white powder. This powder, when its water has been driven off by the application of a red heat, absorbs water very rapidly, and solidifies it; at the same time a slight increase of temperature takes place: so that if it be formed into a paste with water, it dries in a few minutes. In this state it is called *plaster of Paris*, and is much employed for forming casts, &c. in consequence of this property.

Sulphat of lime, when exposed to a violent heat, melts; before the blow-pipe it gives an opaque vitreous globule. The temperature necessary to produce this effect is, according to Saussure, 51° of Wedgewood†.

Composition.

It is composed, according to Bergman, of

46	acid
32	lime
22	water
100	

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* Macquer.

† *Jour. de Phys.* xlv. 16.

Mr Kirwan informs us that these are its component parts when it has been dried in the temperature of 66°. In higher heats it loses a greater proportion of its water, and in a white heat it loses the whole. Its component parts, after being dried in the temperature of 170°, after being heated to redness, and after being exposed to a white heat, are, according to this philosopher, as follows [†]:

1. Dried in 170°.	2. In a red heat.	3. In a white heat.	
50.39	55.84	59	acid
35.23	38.81	41	lime
14.38	5.35	0	water
100.00	100.00	100	

Decomposition.

It is decomposed by the following salts:

1. Carbonats of potass, soda, and ammonia,
2. All barytic, and probably all strontian, salts,
3. Sulphites of potass and soda,
4. Phosphats, fluats, and borats of potass, soda, and ammonia,
5. All the oxalats.

Sp. 7. Sulphat of Ammonia.

History.

THIS salt was discovered by Glauber, and called by him *secret sal ammoniac*. It was also called *vitriolated ammoniac*. It may be prepared by saturating ammonia with sulphuric acid, or by decomposing sal ammoniac by means of sulphuric acid.

Its crystals are generally small six-sided prisms, whose planes are unequal, terminated by six-sided pyramids.

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[*] Nicholson's *Journal*, iii. 215.

Properties.

It has a sharp bitter taste.

It is soluble in twice its own weight of water at the temperature of 60°, and in its own weight of boiling water.

When exposed to the air, it slowly attracts moisture.

When heated, it first decrepitates, then melts, and in close vessels sublimes, but with some loss of its alkali*. In that state it might be called *supersulphat* of ammonia, as it contains an excess of acid, has an acid taste, and reddens vegetable blues. When heated nearly to redness, the greatest part of it is decomposed. Some sulphurous acid comes over and some ammonia, a great quantity of azotic gas is disengaged, and in all probability water is formed †.

Composition.

According to the experiments of Mr Kirwan, it is composed of . . . .

54.66	acid
14.24	ammonia
31.10	water
100.00 ‡	

Sulphat of ammonia is decomposed by the following salts:

Decomposition.

1. All barytic and strontian salts.
2. Carbonats of barytes, lime, potass, soda, magnesia, and probably strontian.
3. Sulphites, nitrats, muriats, phosphats, fluats, and borats of potass and soda.
4. Sulphite, nitrat, and muriat of magnesia.
5. Nitrat and muriat of lime.
6. Muriat of alumina.

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[*] Kirwan's *Min.* ii. 11.

[†] Hatchett, *Phil. Trans.* lxxxvi. 314.

[‡] Nicholson's *Journal*, iii. 215.

7. Most salts with base of lead, silver, mercury.
8. Also yellow oxide of iron, oxide of zinc, red oxide of lead *.

Sp. 8. *Sulphat of Magnesia.*

History.

THIS salt was first observed in the springs at Epsom in England by Grew in 1675; but Dr Black was the first who accurately ascertained its composition. Before his time it was confounded with sulphat of soda. It has been called *Epsom salt, sal catharticus amarus,* and *Seydler salt.*

Properties.

It crystallizes in quadrangular prisms, whose plains are equal, surmounted by quadrangular pyramids, or by dihedral summits. The primitive form of its crystals is, according to Hauy, a four-sided prism, whose bases are squares. The form of its integrant particles is a three-sided prism, whose bases are rectangular isosceles triangles.

This salt is scarcely ever prepared artificially, as it is found abundantly in nature. It exists in considerable quantity in sea-water; and the uncrystallized residuum in the salt pans, after all the common salt has crystallized, consists almost wholly of this salt dissolved in water. In that state it is usually called *bittern,* and sometimes in Scotland *spirit of salt.*

It has an excessively bitter taste. Its specific gravity is 1.66 *.

At the temperature of 60° it is soluble in its own weight of water, and in $\frac{3}{4}$ths of its weight of boiling

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* Hatchett, *Phil. Trans.* lxxxvi. 314.

† Hassenfratz, *Ann. de Chim.* xxviii. 12.

water. The volume of water is increased $\frac{1}{4}$th by adding the salt*.

When exposed to the air it effloresces, and is reduced to powder.

When exposed to heat it undergoes the watery fusion, and by increasing the temperature its water is evaporated, but it cannot be decomposed by means of heat. Before the blow-pipe it melts with difficulty into an opaque vitreous globule.

Composition.

It is composed, according to Bergman, of

33 acid
19 magnesia
48 water

100†

According to Kirwan of 29.35 acid
17.00 magnesia
53.65 water

100.00‡

When dried, its component parts, according to the same philosopher, are 63.32 acid
36.68 magnesia

100.00

Sulphat of magnesia is decomposed by the following salts:

Decomposition.

1. All barytic and strontian salts.
2. All alkaline sulphites, nitrats, phosphats, fluats, borats, and carbonats.

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* Bergman.

† *Opusc.* i. 378.

‡ Nicholson's *Journ* iii. 215.

3. Nitrat, muriat, and carbonat of lime.
4. Muriat of soda, below the temperature of 32° *.

This salt is sometimes employed as a purgative; but its great use is to yield magnesia. Almost all the magnesia of commerce is extracted from this salt. It is dissolved in water, and the magnesia precipitated by alkalies.

Sp. 9. *Sulphat of Magnesia-and-ammonia.*

THIS salt was pointed out by Bergman; but Fourcroy was the first chemist who examined its properties †.

Preparation.

It may be prepared by mixing together saturated solutions of sulphat of ammonia and of magnesia. Crystals almost immediately precipitate, which consist of the two salts combined together. Or it may be prepared by pouring ammonia into a solution of sulphat of magnesia. Part only of the magnesia is precipitated. This is to be removed by filtration; and on evaporating the solution, the compound salt is obtained in crystals.

Properties.

This salt crystallizes in octahedrons. Its taste is acrid and bitter. Its specific gravity is 1.696 ‡. It is less soluble in water than either of its component parts.

When heated, it undergoes the watery fusion; and if the heat be increased, it is decomposed. It is not altered by exposure to the air.

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* Scheele and Gren, *Ann. de Chim.* xxiii.

† *Ann. de Chim.* iv. 211.

‡ Hassenfratz, *Ann. de Chim.* xxviii. 12.

Composition.

It is composed, according to the analysis of Fourcroy, of . . . . 68 sulphat of magnesia
32 sulphat of ammonia
100

This salt has not been applied to any use.

Sp. 10. *Sulphat of Glucina.*

This salt was first examined by Vauquelin, the discoverer of its base.

It is prepared by saturating sulphuric acid with glucina. The acid dissolves the earth readily, and the solution by evaporation yields small needleform crystals, the figure of which has not been ascertained.

Properties.

It has a very sweet and somewhat astringent taste. It is very soluble in water; the solution readily assumes the consistence of a syrup, but is brought with difficulty to crystallize.

When heated it undergoes the watery fusion, loses its water of crystallization, and falls to powder. At a red heat it is decomposed completely, the acid is driven off, and the earth remains in a sate of purity.

The infusion of nut galls, when dropped into the solution of this salt, occasions a yellowish white precipitate.

Sp. 11. *Sulphat of Yttria.*

This salt was first formed by Gadolin, and afterwards it was examined with more precision by Ekeberg[*] and Vauquelin[†].

Sulphuric acid dissolves yttria readily, and some ca-

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[*] Crell's *Annals*, 1799, ii. 68.

[†] *Ann. de Chim.* xxxvi. 156.

loric is evolved during the process. As the solution goes on, the sulphat crystallizes in small brilliant grains.

Properties.

These crystals are irregular, but most frequently, according to Eckeberg, they have the form of flat six-sided prisms terminated by four-sided summits. These crystals are not altered by exposure to the air. Their taste is astringent and sweetish, though not so much so as sulphat of glucina. They require at least 50 parts of water at the temperature of 60° to dissolve them.

Oxalic acid, prussiat of potass, and the infusion of nut galls, occasion a precipitate in the aqueous solution of this salt.

It is decomposed by phosphat of soda.

Sp. 12. *Sulphat of Alumina.*

This salt may be formed by dissolving alumina in sulphuric acid, evaporating the solution to dryness, dissolving it again in water, and evaporating it till it crystallizes. Little attention has hitherto been paid to this salt, which was never properly distinguished from *alum* till two memoirs, one by Vauquelin and another by Chaptal, on the nature of alum, made their appearance in the 22d volume of the *Annales de Chimie.*

Properties.

It crystallizes in thin plates, soft, and pliant, and of a pearly lustre. Its taste is astringent. It is very soluble in water, and does not crystallize without difficulty. When heated it loses its water of crystallization, and falls to powder. A strong heat decomposes it completely by volatilizing the acid. It is not altered by exposure to the air. According to Bergman, it is composed of

50	acid
50	alumina
100	

Decomposition.

It is decomposed by the following salts:

1. All salts whose bases are barytes, potass, soda, and probably strontian.
2. Sulphite, nitrat, muriat, phosphat, and carbonat of ammonia and of magnesia.
3. Fluat and borat of ammonia.
4. Nitrat, muriat, and carbonat of lime.

This salt combines very readily with an excess of sulphuric acid, and is converted into *supersulphat* of alumina.

Sp. 13. *Alum.*

History.

THE στυπτηρια of the Greeks, and the *alumen* of the Romans, was a native substance, which appears to have been nearly related to *green vitriol* or *sulphat of iron*; and which consequently was very different from what we at present denominate *alum*. From the researches of Professor Beckman, it appears that we owe the discovery of alum to the Asiatics; but at what period, or by what means, the discovery was made, is altogether unknown.

It continued to be imported from the East till the 15th century, when a number of alum works were established in Italy. In the 16th century it was manufactured in Germany and Spain; and during Queen Elizabeth's reign an alum work was established in England by Thomas Chalomer.

The alum of commerce is usually obtained from earths containing sulphur and clay, or sulphuric acid and clay.

The composition of alum has been but lately understood with accuracy. It has been long known, indeed, that one of its ingredients is sulphuric acid*; and the experiments of Geoffroy, Hellot, Pott, Margraff, and Maquer, proved incontestibly that alumina is another ingredient. But sulphuric acid and alumina are incapable of forming alum. Manufacturers knew that the addition of a quantity of potass, or of ammonia, or of some substance containing these alkalies, is almost always necessary; and it was proved that in every case in which such additions are unnecessary, the earth from which the alum is obtained contained already a quantity of potass. Various conjectures were made about the part which potass acts in this case; but Chaptal and Vauquelin appear to have been the first chemists that ascertained by decisive experiments that alum is a triple salt, composed of sulphuric acid, alumina, and potass or ammonia, united together.

Varieties.

As alum contains an excess of acid, it belongs to the class of supersulphats. Vauquelin has shewn that there are three varieties. The first, composed of sulphuric acid, alumina, and potass, is *supersulphat of alumina-and-potass*; the second, composed of sulphuric acid, alumina, and ammonia, may be called *supersulphat of alumina-and-ammonia*; the third variety consists of a combination of the two preceding, and therefore contains four ingredients. The properties of these varieties do not differ very much. The first and the third are frequent in commerce, the second is uncommon.

Properties.

Alum crystallizes in regular octahedrons, consisting of two four-sided pyramids applied base to base. The sides are equilateral triangles. The form of its inte-

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* Some chemists have thought proper to call the sulphuric acid, obtained by distilling alum, *spirit of alum*.

grant particles, according to Hauy, is the regular tetrahedron.

Its taste is sweetish and very astringent. It always reddens vegetable blues. Its specific gravity is 1.7109*.

At the temperature of 60° it is soluble in from 15 to 20 parts of water, and in $\frac{3}{4}$ths of its weight of boiling water.

When exposed to the air it effloresces slightly.

When exposed to a gentle heat it undergoes the watery fusion. A strong heat causes it to swell and foam, and to lose about 44 *per cent.* of its weight, consisting chiefly of water of crystallization†. What remains is called *calcined* or *burnt alum*, and is sometimes used as a corrosive. By a violent heat, the greater part of the acid may be driven off.

Composition.

The first variety of alum is composed, according to the experiments of Vauquelin, of

49	sulphat of alumina
7	sulphat of potass
44	water
100	

According to Kirwan, crystallized alum is composed of

17.66	acid
12.00	base
70.34	water
100.00	

Burnt alum, of

36.25	acid
63.75	base
100.00 ‡	

Alum has the property of dissolving a little alumina,

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* Hassenfratz, *Ann. de Chim.* xxviii. 12.

† Kirwan's *Min.* ii. 14.

‡ Nicholson's *Jour.* iii. 215.

and of forming another variety, which crystallizes in cubes. In this state it is less soluble in water, and has less action on vegetable blues. This variety is known by the name of *cubic alum*.

Alum is decomposed by the same salts as the sulphat of alumina.

Alum is of great importance as a mordant in dyeing. It is used also in the manufacture of leather; it is employed by calico-printers, engravers, &c. not to mention its use in medicine, in preserving animal substances from putrefaction, and in preventing wood from catching fire.

Homberg's pyrophorus.

If three parts of alum and one of flour or sugar be melted together in an iron ladle, and the mixture dried till it becomes blackish and ceases to swell; if it be then pounded small, put into a glass phial, and placed in a sand-bath till a blue flame issues from the mouth of the phial, and after burning for a minute or two be allowed to cool*, a substance is obtained known by the name of *Homberg's pyrophorus*, which has the property of catching fire whenever it is exposed to the open air, especially if the air be moist.

This substance was accidentally discovered by Homberg about the beginning of the 18th century, while he was engaged in his experiments on the human fæces. He had distilled a mixture of human fæces and alum till he could obtain nothing more from it by means of heat; and four or five days after, while he was taking the residuum out of the retort, he was surprised to see it take fire spontaneously. Soon after, Lemery the Younger discovered that honey, sugar, flour, or almost any animal or vegetable matter, could be substituted

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* Care must be taken not to keep it too long exposed to the heat.

Book II. Division II.

for human fæces; and afterwards Mr Lejoy de Suvigny shewed that several other salts containing sulphuric acid might be substituted for alum *. Scheele proved that alum deprived of potass was incapable of forming pyrophorus, and that sulphat of potass might be substituted for alum †. And Mr Proust has shewn that a number of neutral salts, composed of vegetable acids and alkalies, or earths, when distilled by a strong fire in a retort, left a residuum which took fire spontaneously on exposure to the air.

These facts have thrown a great deal of light on the nature of Homberg's pyrophorus, and enabled us in some measure to account for its spontaneous inflammation. It has been ascertained that part of the sulphuric acid is decomposed during the formation of the pyrophorus, and of course a part of the alkaline base becomes uncombined with acid, and the charcoal, which gives it its black colour, is evidently divided into very minute particles. It has been ascertained, that during the combustion of the pyrophorus a quantity of oxygen is absorbed. The inflammation is probably occasioned by the charcoal; the sulphuret of potass also acts an essential part. Perhaps it produces a sudden increase of temperature by the absorption and solidification of water from the atmosphere.

Sp. 14. *Aluminated Alum.*

This name may be given to a salt formed by saturating any of the varieties of alum with alumina. It may be prepared by boiling a solution of alum with pure alumina; the compound, as it forms, gradually precipitates

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* See Macquer's *Dictionary*.

† Scheele on *Fire* and on *Pyrophorus*.

in the form of a white powder. It was formerly denominated *alum saturated with its earth.*

Properties.

This salt does not crystallize, but has always the form of a tasteless powder. It is insoluble in water, and not altered by exposure to the air. Heat has no effect upon it unless it be very violent, and in that case part of the acid is disengaged.

Sulphuric acid converts it into alum. It is less easily decomposed by other bodies than alum. Several of the acids dissolve slowly its last dose of alumina, and convert it into alum.

This salt has not hitherto been applied to any use. Alum is capable also, as Chaptal informs us, of combining with several other bases, and of forming many triple salts, which have never yet been examined with attention *.

Sp. 15. *Sulphat of Zirconia.*

THIS salt was first formed by Klaproth, but Vauquelin has described it with more precision. It is prepared by dissolving zirconia in sulphuric acid, and evaporating the solution to dryness.

Properties.

It is usually in the form of a white powder. It may, however, be obtained in small needleform crystals. It has no taste, and is insoluble in water. It is not altered by exposure to the air.

It is very easily decomposed by heat: the acid readily flies off, and leaves the earth in a state of purity. This decomposition may be accomplished even by boiling in water; the earth precipitates, and the acid remains in solution.

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* *Ann. de Chim.* xxii. 293.

Klaproth informs us, that with excess of acid sulphat of zirconia forms transparent stelliform crystals, soluble in water, and having an astringent taste*.

This salt is too imperfectly known, and too difficult to procure, to be applied to any use.

GENUS II. SULPHITES.

Preparation.

THESE salts are formed by saturating the alkaline and earthy bases with sulphurous acid. The easiest process is that which was followed by Berthollet, and afterwards by Vauquelin and Fourcroy. The proper mixture of sulphuric acid and mercury for obtaining sulphurous acid is to be put into a glass vessel, from which there passes a tube into a small bottle containing a little water. From this bottle there passes another tube into one of Woulfe's bottles, which contains the alkaline or earthy base designed to be combined with sulphurous acid, either dissolved or suspended in water. When the apparatus is properly adjusted, heat is applied to the mixture of mercury and acid; sulphurous acid gas passes over first into the bottle with water, where the sulphuric acid, if any passes along with it, is detained; thence it passes into the Woulfe's bottle, where it combines with the base. When the base is saturated, crystals of sulphite often form spontaneously, or they may be obtained by evaporating the solution.

The sulphites were first pointed out by Stahl; but scarcely any of them were examined except sulphite of potass, till Berthollet made a set of experiments on them

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* *Jour. de Phys.* xxxvi. 187.

about the year 1790[*]. But a much more complete description of them was published by Fourcroy and Vauquelin from their own experiments in the year 1797[†].

Sulphites are distinguished by the following properties:

Characters.

1. A disagreeable taste, analogous to that of burning sulphur.

2. When heated, they generally emit sulphur, and are converted into sulphats.

3. When exposed to the air, especially if they be moist, they absorb oxygen, and are converted into sulphats.

4. Oxy-muriatic acid and nitrous acid, when poured into a solution of them in water, converts them instantly into sulphats.

The sulphites at present known amount to eight.

Sp. 1. *Sulphite of Barytes.*

This salt was mentioned by Berthollet; but it was first described by Fourcroy and Vauquelin. When prepared by the above described process, it is in the state of a white powder; but it may be obtained crystallized in opaque needles, or in transparent tetrahedrons with their angles truncated, by dissolving it in sulphurous acid and evaporating slowly. It has but very little taste. Its specific gravity is 1.6938[‡]. It is insoluble in water.

Properties.

When heated strongly, sulphur is disengaged, and sulphat of barytes remains. A long exposure to the air is necessary before it is converted into a sulphat.

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[*] *Ann. de Chim.* ii. 54.

[†] Ibid. xxiv. 229.

[‡] Hassenfratz, Ibid. xxviii. 12.

Composition.

It is composed of . . . 39 acid
59 barytes
2 water

100

Decomposition.

It is decomposed by the following salts:

1. All the sulphats[*].
2. All the alkaline and earthy phosphats, except phosphats of barytes, lime, and silica.
3. Nitrat and muriat of strontian.
4. Carbonats of potass, soda, and ammonia.

This salt has hitherto been applied to scarcely any use. Fourcroy employs it dissolved in sulphurous acid as a method of ascertaining the purity of sulphurous acid. If it occasions a precipitate, it is a proof that the acid contains a mixture of the sulphuric.

Sp. 2. *Sulphite of Lime.*

THIS salt was first mentioned by Berthollet, and described by Fourcroy and Vauquelin.

Properties.

When obtained by the above described process, it has the form of a white powder; but if an excess of sulphurous acid be added, it dissolves and crystallizes on cooling in six-sided prisms, terminated by long six-sided pyramids. It has scarcely any taste; however, when kept long in the mouth, it communicates to the tongue a taste which is manifestly sulphureous.

It requires about 800 parts of water to dissolve it.

When exposed to the air, it effloresces very slowly, and its surface is changed into sulphat of lime. When heated, it loses its water of crystallization, and falls to

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[*] Salts with the same base are always supposed excluded.

powder. A violent heat disengages some sulphur, and converts it into sulphat of lime.

Composition.

It is composed of	48 acid
	47 lime
	5 water
	100

Decomposition.

It is decomposed by the following salts:

1. All the alkaline and earthy phosphats.
2. Fluats and carbonats of barytes, strontian, potass, soda, and ammonia, and fluat of magnesia.
3. Almost all metallic salts.

Sp. 3. *Sulphite of Potass.*

THIS salt was formed by Stahl, but was first accurately described by Berthollet, Fourcroy, and Vauquelin. It was formerly known by the name of *sulphureous salt of Stahl.*

It may be formed by passing sulphurous acid into a saturated solution of carbonat of potass till all effervescence ceases. The solution becomes hot, and crystallizes by cooling *.

Properties.

Its crystals are white and transparent; their figure that of rhomboidal plates. Its crystallization often presents small needles diverging from a common centre †. Its specific gravity is 1.586 ‡.

Its taste is penetrating and sulphureous. At the common temperature of the atmosphere it is soluble in its own weight of water, but much more soluble in boiling water.

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* Fourcroy and Vauquelin, Nicholson's *Journal*, i. 317.

† Ibid. ‡ Hassenfratz, *Ann. de Chim.* xxviii. 12.

When exposed to the air, it effloresces, becomes opaque and hard, and is gradually converted into *sulphat of potass* by absorbing oxygen.

When exposed to a sudden heat, it decrepitates, loses its water: at a red heat some sulphurous vapours are emitted; at last a portion of sulphur separates, and the residuum is sulphat of potass, with a slight excess of alkali.

Nitric and oxy-muriatic acids convert it into sulphat of potass by imparting oxygen.

It decomposes the oxides of gold, silver, mercury, the red oxide of lead, the black oxide of manganese, and the brown oxide of iron. When the green oxide of iron, or the white oxide of arsenic, is boiled with it in water, and an acid added, a precipitate takes place consisting of these oxides united to some sulphur, and the salt is converted into a sulphat: at the same time sulphurated hydrogen gas is emitted.

The proportion of its ingredients has not been determined.

Decomposition.

It is decomposed by the following salts:

1. All the alkaline and earthy sulphats, except those of barytes and potass.
2. Nitrats of barytes, soda, strontian, lime, magnesia, glucina, alumina, zirconia.
3. Muriats of barytes, soda, strontian, lime, ammonia, magnesia, glucina.
4. Phosphats of soda, ammonia, glucina, alumina, zirconia.
5. Fluats of barytes, strontian, magnesia, soda, ammonia.
6. Carbonat of soda.
7. All metallic salts except carbonats.

This salt has not hitherto been applied to any use.

Sp. 4. *Sulphite of Soda.*

This salt was first accurately described by Fourcroy and Vauquelin.

Properties.

It is white and perfectly transparent. Its crystals are four-sided prisms, with two very broad sides and two very narrow ones, terminated by dihedral summits. Its specific gravity is 2.9566 *.

Its taste is cool and sulphureous.

It is soluble in four times its weight of cold water, and in less than its weight of boiling water.

By exposure to air it effloresces, and is slowly converted into a sulphat.

When exposed to heat it undergoes the watery fusion, and afterwards exhibits precisely the same phenomena as the sulphite of potass.

Metallic oxides and salts affect it precisely as they do sulphite of potass.

Composition.

It is composed of . . . 31 acid
18 soda
51 water

100

Decomposition.

It is decomposed by the following salts:

1. All the alkaline and earthy sulphats except those of barytes and soda.
2. Nitrats of barytes, strontian, lime, magnesia, glucina, alumina, zirconia.
3. All the earthy and alkaline muriats except those of potass, soda, and silica.
4. Phosphats of lime, magnesia, ammonia, glucina, alumina, zirconia.

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* Hassenfratz, *Ann. de Chim.* xxviii. 12.

5. Fluats of barytes, strontian, magnesia, ammonia.
6. Borat and carbonat of potass.
7. Almost all metallic salts.

This salt has not been applied to any use.

Sp. 5. *Sulphite of Strontian.*

Unknown.

Sp. 6. *Sulphite of Ammonia.*

This salt was first described by Fourcroy and Vauquelin *.

Properties.

It crystallizes in six-sided prisms terminated by six-sided pyramids; or in four-sided rhomboidal prisms, terminated by three-sided summits.

Its taste is cool and penetrating like that of the other ammoniacal salts, but it leaves a sulphureous impression in the mouth.

It is soluble in its own weight of cold water, and much cold is produced. Its solubility is increased by heat: so that a saturated boiling solution crystallizes on cooling.

When exposed to the air, it attracts moisture, and is soon converted into a sulphat. No other sulphite undergoes this change so rapidly.

When heated, it decrepitates, a little ammonia is disengaged, and the salt then sublimes in the state of supersulphite of ammonia.

Its habitudes with metallic oxides and salts are nearly the same with those of the above described sulphites, only it is capable of forming with several of them triple salts †.

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* Nicholson's *Journal*, i. 317.

† Ibid.

Composition.

It is composed of . . .	60 acid
	29 ammonia
	11 water
	100

Decomposition.

It is decomposed by the following salts:

1. Sulphats of magnesia, alumina, zirconia.
2. Nitrats and muriats of barytes, strontian, lime, magnesia, glucina, alumina, zirconia.
3. Phosphats of glucina, alumina, zirconia, and superphosphat of lime.
4. Fluats of barytes, strontian, and magnesia.
5. Borats of barytes, strontian, magnesia, potass, and soda.
6. Carbonats of barytes, potass, and soda.

This salt has not been applied to any use.

Sp. 7. Sulphite of Magnesia.

THIS salt has only been examined by Fourcroy and Vauquelin.

It is prepared like the others, by saturating carbonat of magnesia with sulphurous acid, a violent effervescence takes place, and the liquid becomes warm. The sulphite as it forms remains at the bottom in the form of a white powder: But if an excess of acid be added, it dissolves, and may be obtained in crystals by subsequent exposure to the air.

Properties.

Its crystals are white and transparent, and in the form of depressed tetrahedrons. Its specific gravity is 1.3802 *.

Its taste is mild and earthy at first, and afterwards sulphureous.

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* Hassenfratz, *Ann. de Chim.* xxviii. 12.

It becomes opaque when exposed to the air; but is very slowly converted into a sulphat.

At the temperature of 60° it is soluble in 20 parts of water. Boiling water dissolves a greater proportion of it; but the solution crystallizes on cooling. When its solution in water is exposed to the air, this salt is very soon converted into a sulphat.

By exposure to heat, it softens, swells up, and becomes ductile like gum; and loses 0.45 parts of its weight. In a strong heat the acid is disengaged, and the earth remains pure.

Composition.

It is composed of	39 acid
	16 magnesia
	45 water
	100

Decomposition.

It is decomposed by the following salts:

1. Sulphats of magnesia, alumina, zirconia.
2. Nitrats of barytes, lime, glucina, alumina, zirconia.
3. Phosphats of lime, potass, soda, ammonia, glucina, alumina, zirconia.
4. Fluats of barytes, strontian.
5. Borats of strontian, potass, soda, ammonia.
6. Carbonats of barytes, strontian, lime, potass, soda, ammonia.

This salt has not been applied to any use.

Sp. 8. *Sulphite of Ammonia-and-Magnesia.*

THIS salt has only been mentioned by Fourcroy. It may be formed by mixing together the solution of sulphite of ammonia and sulphite of magnesia, or by pouring ammonia into the sulphite of magnesia.

Its crystals are transparent, but their figure has not been determined. It is less soluble in water than either of its component parts. When exposed to the air, it is gradually converted into sulphat.

Its other properties have not been examined.

Sp. 9. Sulphite of Glucina.

Unknown.

Sp. 10. Sulphite of Yttria.

Unknown.

Sp. 11. Sulphite of Alumina.

THIS salt was first formed by Berthollet; it has been described by Fourcroy and Vauquelin.

Properties.

When formed by the usual process, it remains in the state of a white powder, and does not crystallize though dissolved in an excess of acid.

It is white and soft, and has an earthy and sulphureous taste. It is insoluble in water. When exposed to the air it is gradually converted into sulphat. Its solution in sulphurous acid undergoes this change much more rapidly. When heated, its acid disengages and the alumina remains behind, mixed however with a small proportion of sulphat of alumina.

Composition.

It is composed of . . . . 32 acid
44 alumina
24 water

100

This salt has not been applied to any use.

Sp. 12. Sulphite of Zirconia.

Unknown.

GENUS III. NITRATS.

THE most important of the nitrats have been long known, and in consequence of the singular properties which they possess, no class of bodies has excited greater attention, or been examined with more unwearied industry. They may be distinguished by the following properties:

Characters.

1. Soluble in water, and capable of crystallizing by cooling.

2. When heated to redness, along with combustible bodies, a violent combustion and detonation is produced.

3. Sulphuric acid disengages from them fumes, which have the odour of nitric acid.

4. When heated along with muriatic acid, oxy-muriatic acid is exhaled.

5. Decomposed by heat and yield at first oxygen gas.

The nitrats at present known are 12 in number. Few of them combine with an excess of acid or of base, so that there are hardly any supernitrats or subnitrats.

Sp. 1. *Nitrat of Barytes.*

THIS salt was formed immediately after the discovery of barytes. Vauquelin has lately added considerably to our knowledge of its properties.

It is usually prepared by dissolving native carbonat of barytes in nitric acid, or by decomposing sulphuret of barytes by means of nitric acid, and evaporating the filtered solution till the nitrat crystallizes.

Properties.

Its crystals are regular octahedrons, and often they adhere to each other in the form of stars. Sometimes it is obtained in small brilliant plates. Its specific gravity is 29.149*. It is very easily reduced to powder.

Its taste is hot, acrid, and austere.

It is soluble in 12 parts of water at the temperature of 60°, and in about 3 or 4 parts of boiling water. As the solution cools the salt may be obtained in crystals.

It is but little altered by exposure to the air.

When thrown on burning coals it decrepitates, undergoes a kind of fusion, and then becomes dry. When strongly heated in a crucible, the whole of the acid is gradually driven off, and the barytes remain pure.

It detonates less violently with combustibles than most of the other nitrats.

Composition.

It is composed, according to Fourcroy and Vauquelin, of . . . . 38 acid

50 barytes

12 water

100

According to Kirwan, its component parts are

32 acid

57 barytes

11 water

100 †

Decomposition.

According to Fourcroy, it is decomposed by the following salts:

1. All the sulphats and sulphites.
2. Phosphats, borats, and carbonats of potass, soda, ammonia.
4. Oxalat of ammonia.

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* Hassenfratz, *Ann. de Chim.* xxviii. 12.

† Nicholson's *Jour.* iii. 215.

This salt has been used to detect the presence of sulphuric acid, especially when it is suspected in nitrous acid; which it does by the precipitate of sulphat of barytes, that immediately falls. It is formed also in order to extract from it barytes in a state of purity.

Sp. 2. *Nitrat of Potass or Nitre.*

As this salt, known also by the name of *salt petre*, is produced naturally in considerable quantities, particularly in Egypt, it is highly probable that the ancients were acquainted with it; but scarcely any thing certain can be collected from their writings. If Pliny mentions it at all, he confounds it with soda, which was known by the names of *nitron* and *nitrum.* It is certain, however, that it has been known in the east from time immemorial. Roger Bacon mentions this salt in the 13th century under the name of *nitre.*

Production.

No phenomenon has excited the attention of chemical philosophers more than the continual reproduction of nitre in certain places after it had been extracted from them. Prodigious quantities of this salt are necessary for the purposes of war; and as Nature has not laid up great magazines of it as she has of some other salts, this annual reproduction is the only source from which it can be procured. It became, therefore, of the utmost consequence, if possible, to discover the means which Nature employed in forming it, in order to enable us to imitate her processes by art, or at least to accelerate and facilitate them at pleasure. Numerous attempts accordingly have been made to explain and to imitate these processes.

Stahl, setting out on the principle that there is only one acid in nature, supposed that nitric acid is merely sulphuric acid combined with phlogiston; and that this combination is produced by putrefaction: he affirmed accordingly, that nitre is composed by uniting together potass, sulphuric acid, and phlogiston. But this opinion, which was merely supported by very far-fetched analogies, could not stand the test of a rigorous examination.

Lemery the Younger accordingly advanced another; affirming that all the nitre obtained exists previously in animals and vegetables, and that it is formed in these substances by the processes of vegetation and animalization. But it was soon discovered that nitre exists, and is actually formed, in many places where no animal nor vegetable substance had been decomposed; and consequently this theory was as untenable as the former. So far indeed is it from being true that nitre is formed by these processes alone, that the quantity of nitre in plants has been found to depend entirely on the soil in which they grow *.

At last by the numerous experiments of several French philosophers, particularly by those of Thouvenel, it was discovered that nothing else is necessary for the production of nitre but a basis of lime, heat, and an open, but not too free communication with dry atmospheric air. When these circumstances combine, the acid is first formed, and afterwards the alkali makes its appearance. How the air furnishes materials for this production is easily explained, now that the component parts of the nitric acid are known to be oxygen and azot: but how lime contributes to their union it is not so easy to see. The appearance of the potass is equally extroardinary.

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* Bouillon.

If any thing can give countenance to the hypothesis that potass is composed of lime and azot, it is this singular fact.

Nitre is found abundantly on the surface of the earth in India, South America, and even in some parts of Spain. In Germany and France it is obtained by means of artificial *nitre* beds. These consist of the refuse of animal and vegetable bodies undergoing putrefaction, mixed with calcareous and other earths. It has been ascertained that if oxygen gas be presented to azot at the instant of its disengagement, nitrous acid is formed. This seems to explain the origin of the acid in these beds. The azot disengaged from these putrefying animal substances combines with the oxygen of the air. The potass is probably furnished, partly at least, by the vegetables and the soil.

The nitre is extracted from these beds by lixiviating the earthy matters with water. This water, when sufficiently impregnated, is evaporated, and a brown coloured salt obtained, known by the name of *crude nitre.* It consists of nitre, common salt, nitrat of lime, and various other salts. The foreign salts are either separated by repeated crystallizations, or by washing the salt repeatedly with small quantities of water; for the foreign salts being more soluble are taken up first.

Nitre, when slowly evaporated, is obtained in six-sided prisms, terminated by six-sided pyramids; but for most purposes it is preferred in an irregular mass, because in that state it contains less water.

Properties.

The primitive form of its crystals, according to Hauy, is a rectangular octahedron, composed of two four-sided pyramids applied base to base; two of the sides are inclined to the other pyramid at an angle of 120°; the other two at an angle of 111°. The form of its integrant particles is the tetrahedron.

The six-sided prism is the most common form which it assumes. Sometimes, instead of six-sided pryramids, these prisms are terminated by 18 facets, disposed in three ranges of six, as if three truncated pyramids were piled on each other; sometimes it crystallizes in tables.

The specific gravity of nitre is 1.9369 *. Its taste is sharp, bitterish, and cooling. It is very brittle.

It is soluble in seven times its weight of water at the temperature of 60°, and in nearly its own weight of boiling water †.

It is not altered by exposure to the air.

When the solution of nitre is exposed to a boiling heat, part of the salt is evaporated along with the water, as Wallerius, Kirwan, and Lavoisier, observed successively. When exposed to a strong heat it melts, and congeals by cooling into an opaque mass, which has been called *mineral crystal.* Whenever it melts, it begins to disengage oxygen; and by keeping it in a red heat, about the third of its weight of that gas may be obtained: towards the end of the process azotic gas is disengaged. If the heat be continued long enough, the salt is completely decomposed, and pure potass remains behind.

Detonates with charcoal.

It detonates more violently with combustible bodies than any of the other nitrats. When mixed with one third part of its weight of charcoal, and thrown into a red hot crucible, or when charcoal is thrown into red hot nitre, detonation takes place, and one of the most brilliant combustions that can be exhibited. The residuum is carbonat of potass. It was formerly called *nitre fixed by*

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* Hassenfratz, *Ann. de Chim.* xxviii. 12.

† *Bergman.*

charcoal. The alchymists performed this experiment in a tubulated earthen retort, to which an apparatus of glass vessels was luted. After every portion of nitre and charcoal which they threw in, they shut up the retort. The carbonic acid and azotic gas which were disengaged often burst their apparatus. To the small quantity of water which they obtained in their vessels, they gave the name of *clyssus*, and ascribed to it a great many virtues.

A still more violent detonation is produced by using phosphorus instead of charcoal. When a mixture of nitre and phosphorus is struck smartly with a hot hammer, a very violent detonation is produced [*].

Nitre oxidates all the metals at a red heat, even gold and platinum [†].

Composition.

Nitre, according to Bergman, is composed of

31 acid
61 potass
8 water

100

According to the latest experiments of Kirwan, after being dried in the temperature of 70°, it is composed of . . . . 44.0 acid
51.8 potass
4.2 water

100.0 [‡]

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[*] Brugnatelli, *Ann. de Chim.* xxvii. 74.

[†] Tennant, Bergman, and Morveau.

[‡] Nicholson's *Journal*, iii. 215.

Nitre is decomposed by the following salts:

1. Sulphats of soda, ammonia, magnesia, alumina.
2. Muriat and acetite of barytes.

Gunpowder,

One of the most important compounds formed by means of nitre is *gunpowder*, which has completely changed the modern art of war. The discoverer of this compound, and the person who first thought of applying it to the purposes of war, are unknown. It is certain, however, that it was used in the 14th century. From certain archives quoted by Wiegleb, it appears that cannons were employed in Germany before the year 1372. No traces of it can be found in any European author previous to the 13th century; but it seems to have been known to the Chinese long before that period.

Gunpowder is composed of	76	parts nitre
	15	charcoal
	9	sulphur
	100	

How prepared.

These ingredients are first reduced to a fine powder separately, then mixed intimately, and formed into a thick paste with water. After this has dried a little, it is placed upon a kind of sieve full of small holes, through which it is forced. By that process it is divided into grains, the size of which depends upon the size of the holes through which they have been squeezed. The powder, when dry, is put into barrels, which are made to turn round on their axes. By this motion the grains of gunpowder rub against each other, their asperities are worn off, and their surfaces are made smooth. The powder is then said to be glazed.

Gunpowder, as is well known, explodes violently when a red heat is applied to it. This combustion takes place even in a vacuum ; a vast quantity of gas is emitted, the sudden production of which is the cause of all the violent effects which this substance produces. Their combustion is evidently owing to the decomposition of the nitre by the charcoal and sulphur. The products are carbonic acid gas, azotic gas, sulphurous acid gas, and probably sulphurated hydrogen. Mr Cruickshank has ascertained that no perceptible quantity of water is formed. What remains after the combustion is potass combined with a small portion of carbonic acid, sulphat of potass, a very small proportion of sulphuret of potass, and unconsumed charcoal *. This mixture soon attracts moisture, and the sulphuret which it contains enables it to act strongly on metallic bodies.

Fulminating powder.

When three parts of nitre, two parts of potass, and one part of sulphur, all previously well dried, are mixed together in a warm mortar, the resulting compound is known by the name of *fulminating powder*. If a little of this powder be put into an iron spoon, and placed upon burning coals, or held above the flame of a candle, it gradually blackens, and at last melts. At that instant it explodes with a very violent report, and a strong impression is made upon the bottom of the spoon, as if it had been pressed down very violently. This sudden and violent combustion is occasioned by the rapid action of the sulphur on the nitre. By the application of the heat, the sulphur and potass form a sulphuret, which is combustible at a lower heat probably than even sulphur. Sulphurated hydrogen gas, azotic gas, and perhaps also sulphurous acid gas, are disenga-

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* Cruickshank, Nicholson's *Jour.* iv. 258.

ged almost instantaneously. It is to the sudden action of these on the surrounding air that the report is to be ascribed. Its loudness evidently depends upon the combustion of the whole powder at the same instant, which is secured by the previous fusion that it undergoes; whereas the grains of gunpowder burn in succession.

White and black flux.

Nitre is used not only in the formation of gunpowder, but also by metallurgists and other artists. It is from it too that all the nitrous acid is obtained. The process has been described formerly under the head of *nitric acid.* A mixture of equal parts of tartar and nitre, deflagrated in a crucible, is known by the name of *white flux.* It is merely a mixture of carbonat of potass with some pure potass. When two parts of tartar and one of nitre are deflagrated in this manner, the residuum is called *black flux* from its colour. It is merely a mixture of charcoal and carbonat of potass.

Sp. 3. *Nitrat of Soda.*

THIS salt was called formerly *cubic nitre.* It has not been much examined.

Properties.

It forms rhomboidal crystals. Its specific gravity is 2.0964*.

It has a cool sharp taste, and is somewhat more bitter than nitre.

It is soluble in about three parts of water at the temperature of 60°, and in less than its weight of boiling water.

When exposed to the air it rather attracts moisture.

Its phenomena in the fire are the same with those of nitre, excepting that it does not melt so easily.

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* Hassenfratz, *Ann. de Chim.* xxviii. 12.

Composition.

It is composed, according to Bergman, of

43	acid
32	soda
25	water
100	

According to the latest experiments of Kirwan, after being dried in a heat of 400°, its component parts are

53.21	acid
40.58	soda
6.21	water
100.00	

After being ignited, it contains

57.55	acid
42.34	soda
99.89*	

It is decomposed by the following salts:

1. Sulphats of magnesia and alumina.
2. Muriat, phosphat, fluat, borat, and carbonat of potass.
3. Muriat of barytes.

This salt has been applied to no use.

Sp. 4. *Nitrat of Strontian.*

THIS salt was first formed by Dr Hope; it was afterwards examined by Klaproth and Pelletier; but the most complete description of it was published by Vauquelin about the end of the year 1797 *.

It may be prepared either by dissolving carbonat of strontian in nitric acid, or by decomposing sulphuret of

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* Nicholson's *Jour.* iii. 215.

† *Jour. de Min.* An. vi. 7.

strontian by means of that acid. The solution is to be evaporated to dryness, redissolved in water, and evaporated slowly till the salt crystallizes.

Properties.

Nitrat of strontian crystallizes in regular octahedrons not unlike the crystals of nitrat of barytes. It has a strong pungent cooling taste. Its specific gravity is 3.0061.

It is soluble in its own weight of water at the temperature of 60°, and in little more than half its weight of boiling water. It is insoluble in alcohol.

In a dry air it effloresces, but in a moist air it deliquesces.

It deflagrates on hot coals. Subjected to a heat in a crucible, it decrepitates gently, and then melts. In a red heat it boils, and the acid is dissipated. If a combustible substance be at this time brought into contact with it, a deflagration with a very vivid red flame is produced*. It is by means of this decomposition that strontian is obtained in the greatest purity. When a crystal of nitrat of strontian is put into the wick of a candle, it communicates a beautiful purple flame.

Composition.

According to Vauquelin, it is composed of

48.4	acid
47.6	strontian
4.0	water
100.0 †	

According to Kirwan, when in the state of crystals, it is composed of . .

31.07	acid
36.21	strontian
32.72	water
100.00	

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* Hope, *Edin. Trans.* iv. 12.

† *Jour. de Min.* An. vi. 10.

Decomposition.

Nitrat of strontian is decomposed, according to Fourcroy, by the following salts:

1. Sulphats of potass, soda, lime, ammonia, magnesia, glucina, alumina.
2. Sulphites of barytes, potass, soda, ammonia, alumina.
3. Muriats of barytes, potass, soda.
4. Phosphats of barytes, potass, soda, ammonia.
5. Fluats of soda and ammonia.
6. Borats of potass, soda, and ammonia.
7. Carbonats of barytes, potass, soda.

This salt has been applied to no use except to obtain pure strontian.

Sp. 5. *Nitrat of Lime.*

THIS salt has been long known to chemists. Native nitre is almost always contaminated with it. It may be prepared by dissolving carbonat of lime in nitric acid; evaporating the solution to the consistence of a syrup, and then allowing it to cool slowly. The salt is precipitated in the state of crystals.

Properties.

Its crystals are six-sided prisms, terminated by long pyramids; but it is oftener obtained under the form of long slender brilliant needles. Its taste is very acrid and bitter. Its specific gravity is 1.6207 †.

Scarcely any salt is more soluble in water. At the temperature of 60°, one part of water dissolves four parts of nitrat of lime, and boiling water dissolves any quantity of it whatever. Boiling alcohol dissolves its own weight of it. Considerable difficulty attends its crystallization, as is the case with all very soluble salts.

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† Hassenfratz, *Ann. de Chim.* xxviii. 12.

When exposed to the air, it very soon attracts moisture, and melts altogether. This strong affinity for moisture renders it sometimes useful for drying the gases. They are made to pass through tubes containing dried nitrat of lime; and this salt, during their passage through it, abstracts great part of the water which they hold in solution.

Balduin's phosphorus.

This nitrat, when heated, readily undergoes the watery fusion. When the water of crystallization is evaporated, the salt becomes dry, and often acquires the property of shining in the dark. In that state it was formerly known by the name of *Balduin's phosphorus*; because this property of nitrat of lime was first pointed out by Balduin*. When strongly heated it is decomposed; nitrous gas, oxygen gas, and azotic gas are emitted, and the pure lime remains behind. This salt scarcely possesses the property of detonating with combustible bodies, in consequence probably of the great proportion of its water of crystallization.

Composition.

According to Bergman, nitrat of lime is composed of . . . . 43 acid
32 lime
25 water
100

According to the latest experiments of Kirwan, after being well dried in the air, it is composed of

57.44 acid
32.00 lime
10.56 water
100.00†

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* His account of it was published in 1675, under the title of *Phosphorus Hermeticus seu Magnes Luminaris.*

† Nicholson's *Journal*, iii. 215.

Decomposition.

Nitrat of lime, according to Fourcroy, is decomposed by the following salts :

1. Sulphats of potass, soda, ammonia, magnesia, glucina, alumina.
2. Sulphites of potass, soda, strontian, ammonia, glucina, alumina.
3. Muriats of barytes, potass, soda, strontian.
4. Phosphats of barytes, strontian, potass, soda, ammonia.
5. Fluats of strontian, potass, soda, ammonia.
6. Borats of barytes, strontian, potass, soda, ammonia.
7. Carbonats of barytes, strontian, potass, soda.

This salt has not hitherto been applied to much use. Native nitrat of lime might, however, be decomposed for its acid as well as nitre.

Sp. 6. Nitrat of Ammonia.

THIS salt has been long known : It was formerly distinguished by the names of *nitrum semivolatile*, and *nitrum flammans*. Berthollet examined it in the course of his experiments on the component parts of nitric acid ; and Mr Davy has added considerably to our knowledge of its composition and decomposition *.

It may be prepared by dissolving carbonat of ammonia in diluted nitrous acid, and evaporating the solution till the salt crystallizes.

Properties.

The appearance of this salt varies very much, according to the temperature at which its solution is evaporated. In a moderate heat, 70° or 100° for instance, and by slow cooling, it is obtained in six-sided prisms, terminated by long six-sided pyramids. When the so-

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* Davy's *Researches*, p. 71.

lution is evaporated at the temperature of 212°, the crystals are channelled and have a fibrous texture, or they are formed of long soft elastic threads. When dried in a heat of about 300°, it assumes the form of a white compact mass. These differences are owing to different proportions of water of crystallization which the salt contains.

Nitrat of ammonia has a very acrid, bitter, disagreeable taste. Its specific gravity is 1.5785*.

At the temperature of 60° this salt is soluble in two parts of water: it dissolves in half its weight of boiling water. It must be observed, however, that its solubility varies with the proportion of water of crystallization which it contains. When exposed to the air, nitrat of ammonia soon attracts moisture and deliquesces.

When this salt, in the state of fibrous or prismatic crystals, is heated, it becomes fluid at a temperature below 300°; between 360° and 400° it boils without decomposition; but when heated to 450°, or somewhat higher, it is gradually decomposed, without losing its water of crystallization. Compact nitrat, on the other hand, undergoes little or no change till it is exposed to a temperature higher than 260°. Between 275° and 300° it sublimes slowly without decomposition, and without becoming fluid. At 320° it melts, and at the same time is partly decomposed, partly sublimed †.

When this salt is decomposed in a temperature not exceeding 500°, it is wholly converted into gaseous oxide of azot and water. From the experiments of Mr Davy, it appears that these products are nearly in the proportion of four parts of gas to three parts of water ‡.

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* Hassenfratz, *Ann. de Chim.* xxviii. 12.

† Davy, p. 85.

‡ Ib. p. 105.

When it is exposed to a heat above 600°, this salt explodes, and is totally decomposed, being converted into nitrous acid, nitrous gas, water, and azotic gas. This phenomenon, observed long ago, induced the older chemists to give this salt the name of *nitrum flammans*. The nature of the decomposition was first ascertained by Berthollet, and more lately it has been examined by Mr Davy.

Composition.

Nitrat of ammonia, according to Mr Kirwan, is composed of . . . . 57 acid
23 ammonia
20 water

100 [*]

According to Fourcroy, it is composed of
46 acid
40 ammonia
14 water

100

According to Davy, in the three different states of prismatic, fibrous, and compact salt, its component parts are combined in the following proportions [†]:

Prismatic.	Fibrous.	Compact.	
69.5	72.5	74.5	acid
18.4	19.3	19.8	ammonia
12.1	8.2	5.7	water
100.0	100.0	100.0	

The apparent difference between these results and the analysis of Kirwan is owing to this, that Mr Kir-

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[*] Nicholson's *Journal*, iii. 215.

[†] Davy, p. 71.

wan's acid contains less water than that which Davy has taken for a standard.

Nitrat of ammonia is decomposed, according to Fourcroy, by the following salts:

1. Sulphats of magnesia, glucina, alumina.
2. Muriats of barytes, potass, soda, strontian, lime.
3. Phosphats of potass, soda.
4. Fluats, borats and carbonats of potass, soda.

This salt has been applied to no other use than to yield by its decomposition gaseous oxide of azot.

Sp. 7. *Nitrat of Magnesia.*

THE composition of this salt was first ascertained by Dr Black. Bergman is the only chemist who has given a detailed description of it.

Properties.

It is usually prepared by saturating nitric acid with magnesia, and evaporating it to a proper consistency. The salt crystallizes as the solution cools.

It crystallizes in rhomboidal prisms, and often in small needles attached to one another. Its taste is very bitter and disagreeable. Its specific gravity is 1.736*.

At the temperature of 60° it is soluble in little more than its weight of water, and still more soluble in boiling water. Alcohol dissolves $\frac{1}{9}$th of its weight of it†.

When exposed to the air, it gradually attracts moisture and deliquesces.

When heated, it undergoes the watery fusion; and when its water is evaporated, it assumes the form of a dry powder. In a strong heat it gives a little oxygen gas, then nitrous gas, and lastly nitrous acid; and the

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* Hassenfratz, *Ann. de Chim.* xxviii. 12.

† Bergman.

earth remains behind in a state of purity. It scarcely detonates with any of the combustible bodies.

Composition.

According to Bergman, it is composed of

43 acid
27 magnesia
30 water

100*

Acccording to Kirwan, of 46 acid
22 magnesia
32? water

100†

Decomposition.

Nitrat of magnesia, according to Fourcroy, is decomposed by the following salts:

1. Sulphats of ammonia, glucina, alumina.
2. Sulphites of potass, soda, strontian, ammonia.
3. Muriats of barytes, potass, soda, strontian, lime.
4. Phosphats of potass, soda, ammonia.
5. Fluats of barytes, potass, soda, ammonia.
6. Borats and carbonats of potass and soda.

Sp. 8. *Nitrat of Ammonia-and-magnesia.*

This salt was first described by Fourcroy in 1790. It may be prepared by mixing together the solutions of nitrat of ammonia and nitrat of magnesia, or by decomposing either of these salts in part by the base of the other. When the two salts are mixed together, the nitrat of ammonia-and-magnesia gradually precipitates in crystals.

These crystals are in the form of fine prisms. They

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* *Opusc.* i. 378.

† Nicholson's *Jour.* iii. 215.

Properties.

have a bitter acrid ammoniacal taste. They are soluble at 60° in about 11 parts of water; but boiling water dissolves a greater proportion of them. When exposed to the air, they gradually attract moisture; but much more slowly than either of their component parts.

The phenomena which this compound exhibits, when heated, are similar to those which its component parts exhibit in like circumstances.

Composition.

According to Fourcroy, it is composed of

78	nitrat of magnesia
22	nitrat of ammonia
100 *	

Sp. 9. *Nitrat of Glucina.*

This salt was first described by Vauquelin. It is prepared by saturating nitric acid with glucina. When this solution is evaporated by means of a small heat, the salt gradually assumes the form of a powder, but cannot be obtained in the state of crystals.

Properties.

Its taste is sweet and astringent. It is exceedingly soluble in water, so much so indeed that it is very difficult to obtain it in a dry state. When evaporated, it becomes thick and glutinous like honey. When exposed to the air, it attracts moisture very rapidly.

When heated, it readily melts; and if the heat be increased, the acid escapes, and leaves the earth in a state of purity.

When tincture of nut galls is dropt into a solution of this salt, a yellowish brown precipitate immediately ap-

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* *Ann. de Chim.* iv. 215.

pears. Nitrat of glucina may be readily distinguished from nitrat of alumina by this property.

The proportions of the component parts of this salt have not hitherto been ascertained. According to Fourcroy and Vauqelin, it is decomposd by the following salts:

Decomposition.

1. Sulphites of potass, soda, ammonia, magnesia.
2. Muriats of barytes, potass, soda, strontian, lime, ammonia.
3. Phosphats of potass, soda, ammonia.
4. Fluats and borats of potass, soda, ammonia.
5. Carbonats of potass, soda, and magnesia

This salt has not hitherto been applied to any use.

Sp. 10. *Nitrat of Yttria.*

THIS salt was first formed by Mr Eckeberg; it has been more lately examined by Vauquelin. It may be prepared by dissolving yttria in nitric acid. The solution has a sweet astringent taste, and in most of its properties agrees with nitrat of glucina. Like it, this salt can scarcely be obtained in the state of crystals. If during the evaporation, a heat somewhat too strong be applied, the salt becomes soft and assumes the appearance of honey, and on cooling becomes hard and brittle like a stone. When exposed to the air, it very soon attracts moisture, and deliquesces

Properties.

When sulphuric acid is poured into this solution, crystals of sulphat of yttria are instantly precipitated[*].

Sp. 11. *Nitrat of Alumina.*

THOUGH this salt has been known to chemists for

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[*] *Ann. de Chim.* xxxvi. 156.

many years past, it has not hitherto been examined with precision.

It is prepared by dissolving alumina in nitric acid, and evaporating the solution till the salt crystallizes. This salt always contains an excess of acid, and is therefore one of the few *supernitrats* with which we are acquainted.

Properties.

It crystallizes with great difficulty in thin soft plates, which have but little brilliancy. This salt has an acid and astringent taste. Its specific gravity is 1.645 *.

It is exceedingly soluble in water, and when evaporated is converted into a glutinous mass of the consistence of honey. It often assumes, on cooling, the form of a jelly. When exposed to the air, it very soon attracts moisture and deliquesces.

When heated, the acid is disengaged with great facility, and the earth remains behind in a state of purity.

According to Fourcroy, nitrat of alumina is decomposed by the following salts †:

Decomposition.

1. Sulphats of potass, soda, strontian, ammonia, magnesia, glucina.
2. Muriats of barytes, potass, soda, strontian, lime, ammonia, glucina.
3. Phosphats of potass, soda, ammonia, glucina.
4. Fluats and borats of potass, soda, ammonia.
5. Carbonats of potass, soda, magnesia, glucina.
6. Oxalats, tartrites, and prussiats.

This salt has been applied to no use.

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* Hassenfratz, *Ann. de Chim.* xxviii. 12.

† Fourcroy, iv. 213.

Sp. 12. *Nitrat of Zirconia.*

THIS salt was first formed by Klaproth. Vauquelin has given us a detailed description of it.

It may be easily formed by pouring nitric acid on newly precipitated zirconia.

Properties.

It always contains an excess of acid. By evaporating, a yellowish transparent matter is obtained, exceedingly tenacious and viscid, and which dries with difficulty. It has an astringent taste, and leaves on the tongue a viscid matter, owing to its being decomposed by the saliva. It is only very sparingly soluble in water; the greatest part remains under the form of gelatinous and transparent flakes. Like all the other salts into which zirconia enters, it is decomposed by heat. It is decomposed also by sulphuric acid, which occasions a white precipitate soluble in excess of acid; by carbonat of ammonia, which produces a precipitate soluble by adding more carbonat; and by an infusion of nut galls in alcohol, which produces a white precipitate soluble in an excess of the infusion, unless the zirconia contains iron; in which case the precipitate is a greyish blue, and part of it remains insoluble, giving the liquor a blue colour. This liquor, mixed with carbonat of ammonia, produces a matter which appears purple by transmitted light, but violet by reflected light. Gallic acid also precipitates nitrat of zirconia of a greyish blue, but the colour is not so fine. Most of the other vegetable acids decompose this salt, and form combinations insoluble in water *.

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* Vauquelin, *Ann. de Chim.* xxii. 199.

GENUS IV. NITRITES.

THE existence of these salts was first pointed out by Bergman and Scheele; the two philosophers to whom we are indebted for the first precise notions concerning the difference between nitric and nitrous acids. They cannot be formed by combining directly nitrous acid with the different earthy and alkaline bases; nor have any experiments made to combine nitrous gas with the nitrats been attended with success.

Preparation.

The only method of obtaining these salts at present known is that which was long ago pointed out by Bergman and Scheele*. It consists in exposing a nitrat to a pretty strong heat till a quantity of oxygen gas be disengaged from it. What remains in the retort after this process is a *nitrite;* but the length of time necessary for producing this change has not yet been ascertained with any degree of precision. If the heat be applied too long, the nitrat will be totally decomposed, and nothing but the base will remain, as happened to some of the French chemists on attempting to repeat the process of Bergman and Scheele.

Nitrite of potass is the only salt formed by this process of which an account has been given. Scheele's process for obtaining it is as follows: Fill a small retort with nitre, and keep it red hot for half an hour. When it is allowed to cool, it is found in the state of a nitrite. It deliquesces when exposed to the air, and red vapours of nitrous acid are exhaled when any other acid is poured upon it.

As the nitrites have never been examined by che-

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* Bergman, iii. 308.—Scheele, i. 59.

Little known.

mists, and as it has not even been determined whether any considerable number of the nitrats can be converted into these salts, it would be in vain, in the present state of our knowledge, to attempt a particular description of them. It may, however, be considered as exceedingly probable that no such salts as the nitrites of ammonia, glucina, yttria, alumina, and zirconia, exist or can be formed, at least by the process of Scheele and Bergman; for the nitrats with these bases are decomposed completely by the action of a heat too moderate to hope for the previous emission of oxygen gas.

From the few observations that have been made, it may be concluded that the nitrites are in general deliquescent, very soluble in water, decomposable by heat as well as nitrats; that their taste is cooling like that of the nitrats, but more acrid and nitrous; that by exposure to the air they are gradually converted into nitrats by absorbing oxygen; but this change takes place exceedingly slowly*.

GENUS V. MURIATS.

THE muriats are the genus of salts which have been longest known, and from which indeed the whole of the class have borrowed their name; for to them belongs common salt, the most important and the most indispensably necessary of all the salts. They may be distinguished by the following properties:

Characters.

1. When heated, they melt, and are volatilized without undergoing decomposition.

2. Not in the least altered by combustibles, even when assisted by heat.

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* Fourcroy, iii. 155.

3. Soluble in water. For the most part they raise the boiling point of water.

4. Effervesce with sulphuric acid, and white acrid fumes of muriatic acid are disengaged.

5. When mixed with nitric acid, they exhale the odour of oxy-muriatic acid.

The alkaline and earthy muriats at present known amount to twelve.

Sp. 1. *Muriat of Barytes.*

THE properties of this salt were first investigated by Scheele and Bergman. Dr Crawford wrote a treatise on its medical virtues in 1790*, and Van Mons has more lately treated of the different processes for preparing it †.

Preparation.

The easiest method of preparing it would be to dissolve carbonat of barytes in water and crystallize the solution; but as the carbonat of this earth is rare, the salt is usually formed by calcining in a crucible a mixture of sulphat of barytes and charcoal, decomposing the sulphuret formed by means of muriatic acid, filtrating the solution, evaporating it till a pellicle begins to form on its surface, then allowing it to cool slowly. The crystals of muriat of barytes gradually deposite. If the salt happens to be contaminated with iron, which is often the case, the crystals are to be calcined, dissolved in water, the solution filtered and crystallized again. By this process the oxide of iron is separated.

Properties

The primitive form of muriat of barytes is, according to Hauy, a four-sided prism, whose bases are squares. Its integrant particles have the same figure. It crystallizes

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* *Medical Communications*, ii. 301.

† *Jour. de Phys.* xlv. 297.

most commonly in tables. Sometimes it assumes the form of two eight-sided pyramids applied base to base. This salt has an exceedingly acrid astringent taste. Its specific gravity is 2.8257 *.

This salt is soluble in about five parts of water at the temperature of 60°. It is still more soluble in boiling water. Alcohol is also capable of dissolving it.

It is not altered by exposure to the open air. When heated, it decrepitates and dries, and when the temperature is very high it melts; but no heat which we can apply is capable of decomposing it.

Composition.

According to Kirwan, this salt in the state of crystals is composed of . . . . 20 acid
64 barytes
16 water

100

When dried, it contains 23.8 acid
76.2 barytes

100.0 †

Muriat of barytes, according to Fourcroy, is decomposed by the following salts:

Decomposition.

1. All the alkaline and earthy sulphats ‡, nitrats, and sulphites.
2. Phosphats and borats of potass, soda and ammonia.

Use.

This salt has been recommended as a cure for scrofulous disorders. The dose is from 5 to 20 drops or more.

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* Hassenfratz, *Ann. de Chim.* xxviii. 12.

† Nicholson's *Journal*, iii. 215.

‡ According to Pissis, it does not decompose sulphat of lime, nor sulphat of potass.—*Ann. de Chim.* xv. 317.

Care ought to be taken not to use it in too great quantities, as, like all other barytic salts, it is poisonous.

In chemistry it is much employed as a reactive to detect the presence of sulphuric acid. When dropt into a liquid holding that acid in solution, an insoluble precipitate of sulphat of barytes immediately appears. Bergman informs us that this precipitate is exceedingly visible, even when the acid amounts only to 0.0002 of the liquid. Even when only 0.00009 of sulphuric acid is present, a slight cloud appears in a few minutes after dropping in the muriat *.

Sp. 2. *Muriat of Potass.*

THIS salt was formerly called *febrifuge* or *digestive salt of Sylvius,* and *regenerated sea salt.*

It is usually prepared by dissolving soda in muriatic acid, and evaporing the solution till the salt crystallizes.

Properties.

Its crystals are cubes, but often rather irregular.

It has a disagreeable bitter taste. Its specific gravity is 1.836 †.

It is soluble in three times its weight of water at the temperature of 60°. It is rather more soluble in boiling water; but the difference is not sufficient to obtain crystals by allowing a saturated boiling solution of this salt to cool. Regular crystals can only be obtained by abandoning the solution to spontaneous evaporation.

It suffers little alteration from exposure to the air.

When exposed to heat, it decrepitates, melts when heated to redness, and at last is volatalized in a white smoke, but without decomposition.

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* Bergman, i. 100.

† Kirwan.

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Composition.

According to Bergman, it is composed of

31	acid
61	potass
8	water.
100 *	

According to Kirwan, when dried in the temperature of 80°, its component parts are

36	acid
64	potass
100 †	

Decomposition.

According to Fourcroy, it is decomposed by the following salts:

1. Sulphats of soda, ammonia, glucina, alumina, zirconia.
2. The earthy and alkaline nitrats.
3. Fluat of barytes.
4. All salts whose base is oxide of silver ‡.

Hitherto this salt has been applied to no use.

Sp. 3. *Muriat of Soda.*

History.

This salt has been known and in common use as a seasoner of food from the earliest ages. It is known by the names of *common* or *sea salt;* sometimes it is called *sal gem.* In this country the term *salt* is usually applied to it without any addition. The nature of its acid was discovered by Glauber, if it was not known earlier. Stahl affirms in his *Specimen Beccherianum*, that

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* *Opusc.* i. 134. † Nicholson's *Journal*, iii. 215.

‡ If muriat of potass and carbonat of soda be mixed together in water, we may crystallize either of them we please according to the temperature: below 66°, the muriat crystallizes; above 66° the carbonat.—Kasteleyn, *Ann. de Chim.* xxx. 201.

its base is an alkali; but Duhamel was the first who showed how to obtain that base in a separate state, and who demonstrated the difference between it and potass.

This salt exists in great abundance native, and therefore is never formed artificially by chemists. Immense masses of it are found in different countries, which require only to be dug out and reduced to powder. In that state it is called *rock salt*. The water of the ocean also contains a great proportion of this salt, to which indeed it owes its taste, and the power which it possesses of resisting freezing till cooled down to zero. When this water is evaporated sufficiently, the salt precipitates in crystals. It is by this process that it is obtained in this country. But the salt of commerce is not sufficiently pure for the purposes of chemistry, as it contains usually muriat of lime, &c; but it may be obtained pure by the following process: Dissolve it in four times its weight of pure water, and filter the solution. Drop into it a solution of carbonat of soda as long as any precipitate continues to fall. Separate the precipitate by filtration, and evaporate slowly till the salt crystallizes.

Properties.

Muriat of soda usually crystallizes in cubes, which, according to Hauy, is the primitive form of its crystals and of its integrant particles. Sometimes the angles of the cubes are truncated, and in urine the crystals of common salt, as Fourcroy and Vauquelin have ascertained, assume the form of octahedrons.

Its taste is universally known, and is what is strictly speaking denominated *salt*. Its specific gravity is 2.120*.

It is soluble in 2$\frac{14}{17}$ times its weight of water at the

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* Kirwan.

temperature of 60°; and in $2\frac{13}{17}$ its weight of boiling water *.

It is not affected by exposure to the air. The muriat of soda of commerce indeed contains, besides other impurities, a quantity of muriat of lime, which renders it deliquescent.

When heated, it decrepitates. In a red heat it melts and evaporates in a white smoke without undergoing decomposition.

Composition.

According to Bergman it is composed of

52	acid
42	soda
6	water
100 †	

According to the latest experiments of Kirwan, when dried in the temperature of 80°, its component parts are

38.88	acid
53.00	soda
8.12	water
100.00 ‡	

Decomposition.

According to Fourcroy, it is decomposed by the following salts:

1. Sulphats of ammonia, glucina, alumina.
2. Sulphite of potass.
3. Nitrats of strontian, lime, ammonia, magnesia, glucina, alumina, zirconia.
4. Phosphat of potass.
5. Fluats of barytes and potass.
6. Borat of ammonia.

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* Bergman.

† *Opusc.* i. 134.

‡ Nicholson's *Jour.* iii. 215.

7. Carbonats of barytes [*], strontian [†], potass [‡].
8. Red oxides of iron and lead [§].

Uses.

The uses to which this salt is subservient are exceedingly numerous. It is the most common and the most useful seasoner of food; it preserves meat from putrefaction and butter from rancidity: it serves for an enamel to the surfaces of coarse stoneware; it is an ingredient in many processes of dyeing: metallurgists use it in many of their assays. Its utility in chemistry is equally extensive. From it alone are muriatic and oxymuriatic acids obtained; and from it also of late great quantities of soda have been extracted and introduced with advantage as a substitute for the soda formerly obtained from the combustion of vegetables.

Methods of extracting soda from it.

The acid is easily extracted from this salt by means of sulphuric acid: but to obtain the alkali at a cheap rate is not so easy The methods which have hitherto succeeded may be reduced to two.

1. Muriat of soda is decomposed by means of some substance which has a stronger affinity for muriatic acid than soda has. The soda by this process is set at liberty, and may be obtained by evaporation and crystallization. Barytes and potass would answer this purpose completely; but unluckily these bodies cannot be obtained sufficiently pure, except at an expence which precludes their employment. There are, however, three substances, which are also capable of setting the base of common salt at liberty, and of furnishing soda, either pure or in the state of carbonat. These are *litharge*, *lime*, and *iron*.

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[*] Morveau, *Ann. de Chim.* xxi. 112.
[†] Vauquelin, *Jour. de Min.*
[‡] This seems to have been first discovered by Hagen in 1768.
[§] Scheele.

1 By litharge.

When about four parts of litharge and one of common salt, properly pounded and mixed, are macerated in a little water for several hours and stirred repeatedly, the muriatic acid gradually combines with the oxide of lead, and forms a muriat, while the soda is left in solution, and may be obtained separately by filtration and evaporation. The decomposition goes on still more rapidly if the mixture be heated during the process.

The fact that the red oxide of lead decomposes muriat of soda, which was first observed by Scheele, has given occasion to much speculation among chemists. Mr Hassenfratz endeavoured to account for it by supposing that the oxide is combined with carbonic acid, and that therefore it is a case of compound affinity. Mr Curaudau has proved that carbonic acid, instead of promoting, impedes the decomposition; and that, in fact, carbonat of lead is incapable of decomposing muriat of soda. He concludes, therefore, that the phenomenon cannot be accounted for by the commonly received laws of affinity *. Vauquelin has proved more lately, that the decomposition by means of litharge is complete, provided the quantity of that oxide be greater than that of common salt; that the resulting compound is a submuriat of lead totally insoluble in water, and which is not decomposed by alkalies. Hence he ascribes the decomposition to the attraction of muriat of lead for an excess of oxide †. But this does not account completely for the decomposition, provided it be true that oxide of lead has a weaker affinity for muriatic acid than soda has. Berthollet has at last explained this apparent anomaly by proving, that when two sub-

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* *Ann. de Chim.* xiv. 15.

† Ibid. xxxi. 3.

stances are mixed with a third for which each has an affinity, they divide it between them in proportions corresponding to the quantity of each: And if the compound formed by one of these substances with the third be insoluble, that substance combines with the whole of the third body, and takes it completely from the other; because the insoluble compound being in fact totally abstracted from the mixture, the decomposition and partition commences again as at first after every partition. Thus when oxide of lead and muriat of soda are mixed together, the oxide and alkali divide the muriatic acid between them, so that some of the common salt is decomposed, and some muriat of lead formed immediately after the mixture. But this being in the state of *submuriat*, or altogether insoluble, separates completely from the rest; in consequence of which a new partition of the muriatic acid between the oxide and the alkali takes place; and this continues, provided the quantity of litharge be sufficient till the common salt is entirely decomposed.

2. Lime.

That the alkali may be extracted from common salt by means of lime, may be considered as a fact for which likewise we are indebted to Scheele. Cahausen indeed had hinted at it in 1717; but his treatise had been forgotten[*]. Scheele ascertained that a mixture of lime and common salt, formed into a paste, and placed in a moist cellar, was covered with an efflorescence of soda in fifteen days[†]. In 1782 Morveau and Carny procured a patent from the French government to establish a manufactory at Croisic for extracting soda from common salt by means of lime. Their process was exactly

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[*] See his *Helmontius Extaticus*.

[†] Scheele, ii. 15.

the same with that of Scheele, only upon a larger scale. It does not appear, however, that the manufactory was ever established. Berthollet has rendered it probable that the soda which is found abundantly on the west of Egypt, is formed naturally by a similar process *.

3. Iron.

To Scheele likewise we are indebted for the discovery that common salt may be decomposed by iron. He observed that a wooden vessel placed in a cellar, and containing brine, had its iron hoops covered with an efflorescence of soda. This induced him to dip a plate of iron into a solution of common salt, and to suspend it in a cellar. After an interval of fourteen days, he found his iron incrusted with soda †. The same decomposition takes place also if zinc or copper be substituted for iron §.

2. The second method of extracting soda from common salt is less direct. It consists in displacing the muriatic acid by means of some other acid, which may be afterwards easily decomposed or displaced in its turn: thus the soda is left behind at last in a state of purity. The acids which have been made choice of are the sulphuric and the acetous; the boracic, phosphoric, and arsenic acids might indeed be employed, as they decompose common salt in a high temperature. The products in that case would be borat of soda, or the phosphat, or arseniat, of the same base, according to the acid. These salts might be afterwards decomposed by means of lime, and the soda obtained separate. But these acids are a great deal too high priced to admit of their employment.

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* *Ann. de Chim.* xxxiii. 345.

† Scheele, ii. 14.

§ Athenas, *Ann. de Chim.* xix. 92.

Chap. III.

4. Sulphuric acid, and its compounds.

Sulphuric acid may be either employed in a separate state, or in combination with bases, when the salts which it then forms can be procured at a sufficiently cheap rate. Alum, sulphat of lime, and sulphat of iron, have been respectively employed with advantage to decompose common salt, and obtain sulphat of soda. Alum is said to have been first employed for that purpose by Constantini, a physician of Melle near Osnaburg, about 1750. The process, it is affirmed, does not succeed except at a low temperature[*]. Sulphat of lime decomposes common salt when formed with it into balls, and exposed to a strong heat[†]. Much discussion has taken place among the German chemists about the possibility of decomposing common salt by means of sulphat of iron. That sulphat of soda may be obtained by exposing a mixture of these two salts to a strong heat, was first announced by Vander Ballen. This was contradicted by Hahneman, but confirmed by the experiments of Tuhten[‡], Lieblein[||], and Wiegleb[§]. It succeeded completely with the French commissioners Lelievre, Pelletier, Darcet, and Giroud, who were appointed, in 1794, to examine the different processes for obtaining soda from common salt. They ascertained also that pyrites or sulphurated oxide of iron may be employed for the same purpose[¶].

After obtaining the sulphat of soda, it is necessary to expel the acid in order to obtain the soda separately. This is accomplished by calcining the salt mixed with

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[*] *Jour. de. Min.* No. iii. p. 55.

[†] Malherbe and Athenas, *Ann. de Chim.* xix.

[‡] Crell's *Annals*, 1790, ii. 406.

[||] Ibid. p. 509.

[§] Ibid. 1793. i. 204.

[¶] *Ann. de Chim.* xix. 58.

a certain portion of charcoal or of pitcoal. By this process it is converted into sulphuret of soda, and the sulphur may be abstracted by the intervention of iron or chalk. When the sulphuret of soda is nearly in fusion, small bits of iron (the parings of tinplate answer best) are thrown in gradually in sufficient quantity to decompose the sulphuret. The fire is raised till the mixture melts. The iron, having a stronger affinity for the sulphur, combines with it and leaves the soda, which may be separated by solution in water, filtration, and evaporation*. Carbonat of lime may be employed also for the same purpose †.

5. Acetite of lead.

Some chemists have proposed to decompose common salt by means of acetite of lead, using either the acetite of commerce, or one formed on purpose, by combining litharge with the acid liquor obtained by distilling wood. The acetite of soda formed by mixing common salt with these acetites is afterwards calcined, in order to decompose and expel the acetous acid. But these salts are too high priced to be employed with advantage to extract soda from common salt.

Sp. 4. *Muriat of Strontian.*

This salt was first examined by Dr Hope ‡. It was afterwards described by Pelletier and Vauquelin §.

It may be prepared by dissolving carbonat of strontian in muriatic acid, or by decomposing sulphuret of strontian by means of that acid. The solution is then

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* Alban, *Ann. de Chim.* xix. 77.—The process was discovered by Malherbe. See *Jour. de Min.* No. iii. p. 67.

† Leblanc, *Ann. de Chim.* xix. 61.

‡ *Trans. Edin.* iv. 12.

§ *Jour. de Min.* An. vi. p. 11.

to be evaporated to a proper consistence, in order to obtain the muriat in crystals.

Properties.

Its crystals are very long, slender, hexagonal prisms. It has a peculiar, sharp, penetrating taste. Its specific gravity is 1.4402[*].

Three parts of these crystals are soluble in two parts of water at the temperature of 60°. Boiling water dissolves any quantity of them whatever. They are soluble also in alcohol, and give its flame a purple tinge.

They suffer no change when exposed to the air except it be very moist; in which case they deliquesce.

When heated, they first undergo the watery fusion, and are then reduced to a white powder. A very violent heat decomposes this salt.

Muriatic acid precipitates this salt from its solution in water. That acid, therefore, has a stronger affinity for water than the salt has[†].

Composition.

According to Bergman, it is composed of

23.6 acid
36.4 strontian
40.0 water
100.0

According to Kirwan, it contains, when in the state of crystals, ... 18 acid
40 strontian
42 water
100

When dried, its component parts, according to the same philosopher, are 31 acid
69 strontian
100[‡]

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[*] Hassenfratz, *Ann. de Chim.* xxviii. 12.

[†] Hope.

[‡] Nicholson's *Journal*, iii. 215.

Decomposition.

Muriat of strontian, according to Vauquelin and Fourcroy, is decomposed by the following salts:

1. Sulphats of potass, soda, lime, ammonia, magnesia, glucina, alumina, zirconia.
2. Sulphites of barytes, potass, soda, ammonia, glucina, zirconia.
3. Nitrats of lime, ammonia, magnesia, glucina, alumina, zirconia.
4. Phosphats of barytes, potass, soda, ammonia.
5. Borats of potass, soda, and also borax.
6. Carbonats of potass, soda, ammonia.

This salt has not hitherto been applied to any use.

Sp. 5. *Muriat of Lime.*

THIS salt has been long known to chemists. It was formerly called *fixed ammoniac*, because it was commonly obtained by decomposing sal ammoniac by means of lime.

It is usually prepared by dissolving carbonat of lime in muriatic acid, and evaporating the solution till it crystallizes.

Properties.

Its crystals are six-sided striated prisms, terminated by very sharp pyramids.

Its taste is very bitter. Its specific gravity is 1.76*.

It is soluble in about half its weight of cold water, and still more soluble in boiling water. It is exceedingly difficult to obtain crystals from this solution, in consequence of the great solubility of the salt in hot water. If the evaporation be carried a little too far, the whole assumes on cooling the form of a very hard white mass; on the other hand, if it be not carried far

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* Hassenfratz, *Ann. de Chim.* xxviii. 12.

enough, no crystals are formed at all. Mr Walker has ascertained, that when the evaporation is carried on till the specific gravity of the solution is 1.450 at the temperature of 80°, it crystallizes when exposed to an atmosphere whose temperature is 32° : when its specific gravity at 80° is 1.490, it assumes on cooling the form of a hard pearl-coloured mass*.

When this salt is exposed to the air, it attracts moisture very speedily, and deliquesces.

When exposed to the action of heat, it swells up, melts, and then loses its water of crystallization. A violent heat separates a small portion of its acid. When thus reduced to a submuriat, it has the property of shining in the dark, as Homberg first observed : hence it has been called the *phosphorus of Homberg*.

Composition.

According to Bergman, it is composed of

31 acid
44 lime
25 water

100†

According to Kirwan, after having been dried in a red heat, its component parts are,

42 acid
50 lime
8 water

100‡

Decomposition.

According to Fourcroy, it is decomposed by the following salts :

1. Sulphats of potass, soda, ammonia, magnesia, glucina, alumina, zirconia.

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* Nicholson's *Journal*, v. 226.

† *Opusc.* i. 136.

‡ Nicholson's *Journal*, iii. 215.

2. Sulphites of potass, soda, ammonia, glucina, alumina, zirconia.
3. Nitrats of ammonia, magnesia, glucina, alumina, zirconia.
4. Phosphats of barytes, strontian, potass, soda, ammonia.
5. Fluats of barytes, strontian, magnesia, potass, soda, ammonia.
6. Borats of barytes, strontian, potass, soda, ammonia.
7. Carbonats of potass, soda, and ammonia.

This salt is now employed with great advantage in procuring artificial cold.

Sp. 6. *Muriat of Ammonia.*

History.

THIS salt was known to the ancients, and was called by them *sal ammoniac*, because it was found in great quantities near the temple of Jupiter Ammon in Africa [*]. Its composition was first pointed out by Geoffroy junior in 1716 and 1723 [†], and afterwards more precisely by Duhamel in 1735 [‡]. For many years the whole of the sal ammoniac used in Europe was imported from Egypt. In that country the greater part of the fuel consists of the dung of their cattle formed into balls and dried. These excrementitious matters seem to contain muriat of soda, or rather muriat of ammonia ready formed; owing perhaps to the saline matters on which the animals feed. The soot formed during the combustion of this fuel is carefully collected and put into large glass bottles, which are exposed, in furnaces constructed on purpose, to a pretty strong heat. The sal ammoniac gradually sublimes, and attaches itself to

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[*] Pliny, lib. xxxi. c. 7.

[†] *Mem. Par.*

[‡] Ibid.

the upper part of the bottles, where it forms a cake of some inches in diameter. Though this process was communicated to the Academy of Sciences in 1719 by Lemere, French consul at Cairo, it was a considerable time before the chemists in Europe thought of imitating it, or of preparing sal ammoniac themselves. The first manufactory in Germany was begun by Gravenhorst in 1759 *. Soon after it was made in France by Baumé, and in Scotland by Dr Hutton.

Preparation.

The processes most commonly followed in Europe have been, 1. To form a sulphat of ammonia; to mix that salt with muriat of soda; and to expose the mixture to a heat sufficient to sublime the muriat of ammonia. The ammonia is usually obtained by the distillation of animal substances, or from soot. 2. To decompose muriat of lime by means of ammonia. 3. To combine muriatic acid directly with ammonia, and to sublime.

Properties.

Sal ammoniac is usually in the form of a hard elastic cake; but by solution in water, and proper evaporation, it may be obtained in crystals. The primitive form of these crystals is, according to Hauy, the octahedron; and that of its integrant particles, the tetrahedron: But it crystallizes most frequently in long four-sided pyramids. It often assumes the form of plumose crystals; the individual crystals of which are long hexahedral pyramids. Its specific gravity is 1.420 †.

It has an acrid, pungent, urinous taste.

It dissolves in about three times its weight of water at the temperature of 60°, and in a much smaller quantity of boiling water.

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* Wiegleb's *Geschichte*, ii. 55.

† Kirwan.

In its common form (which is an opaque mass) it is not affected by the air, but its crystals are liable to deliquesce.

When heated, it sublimes without decomposition in the form of a white smoke, which exhales a peculiar odour.

When this salt is sublimed with gold leaf, there is found in the neck of the retort an amethyst-coloured matter, bordering on purple, soluble in water, and forming a purple solution. When filtered, there remains behind a purple powder. This salt seems from this to be capable of oxidating gold*.

Composition.

According to Kirwan, whether it be sublimed, or in the state of crystals, its component parts are as follows:

42.75	acid
25.00	ammonia
32.25	water
100.00†	

Decomposition.

It is decomposed, according to Fourcroy, by the following salts:

1. Sulphats of glucina, alumina, zirconia.
2. Sulphites of potass, soda.
3. Nitrats of glucina, alumina, zirconia.
4. Phosphats of potass, soda.
5. Fluats of barytes, potass, soda.
6. Borats of potass, soda.
7. Carbonats of potass, soda.

This salt is applied to a great variety of purposes. It is from it that pure ammonia is usually extracted. A

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* Storr, Crell's *New Discoveries*, &c. Part ii. p. 41.

† Nicholson's *Jour.* iii. 215.

considerable portion of sal ammoniac is consumed by the dyers, and perhaps a still greater quantity by coppersmiths, &c. who employ it to prevent the oxidation of the surface of the metals which they are covering with tin.

Sp. 7. *Muriat of Magnesia.*

THOUGH this salt abounds in several mineral waters, it was confounded with muriat of lime, and of course unknown, till Dr Black pointed out the difference between these salts.

It is usually prepared by dissolving carbonat of magnesia in muriatic acid, and evaporating the solution to a proper consistency.

Properties.

It is not easily crystallized. Bergman's method was to evaporate it by a considerable heat to the proper degree of concentration, and then to expose it to a sudden cold. By this method he obtained it in small needles*. Its specific gravity is 1.601†.

It has a very bitter taste. It is soluble in its own weight of water‡, and in five parts of alcohol§.

A saturated solution of it quickly forms a jelly ; on which, if hot water be poured, spongy masses are formed not even soluble in muriatic acid ||.

It deliquesces very speedily when exposed to the air.

A strong heat decomposes it. When dried in a high temperature, it is very caustic ¶.

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[*] Bergman, i. 382.

[†] Hassenfratz, *Ann. de Chim.* xxviii. 12.

[‡] Fourcroy.

[§] Bergman, i. 382.

[||] Bergman, Ibid.

[¶] Westrum, *Ann. de Chim.* ii. 135.

Composition.

According to Bergman, it is composed of
34 acid
41 magnesia
25 water

100 *

According to Kirwan, when evaporated to dryness, its component parts are,
34.59 acid
31.07 magnesia
34.38 water

100.04†

Decomposition.

It is decomposed, according to Fourcroy, by the following salts:

1. Sulphats of ammonia, glucina, alumina, zirconia.
2. Sulphites of potass, soda, ammonia.
3. Phosphats of potass, soda, ammonia.
4. Fluats of strontian, soda.
5. Borats of potass, soda, ammonia.
6. Carbonats of potass, soda, ammonia.

This salt has not been applied to any use.

Sp. 8. *Muriat of Ammonia-and-magnesia.*

This salt was first mentioned by Bergman in 1775‡. It was afterwards described more particularly by Fourcroy in 1790§.

It may be prepared by the same processes as the other triple salts with these two bases, as already described.

Properties.

Its crystals are so exceedingly small and irregular, that their figure has not been determined.

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* *Opusc.* i. 136.

† Nicholson's *Journal*, iii. 215.

‡ *Opusc.* i. 370.

§ *Ann. de Chim.* iv. 222.

Its taste is bitter and ammoniacal. It is soluble in about six parts of cold water, and in a smaller proportion of boiling water.

It is but little altered by exposure to the air. Heat decomposes it.

Composition.

According to Fourcroy, it is composed of

27 muriat of ammonia
73 muriat of magnesia

100*

Hitherto it has been applied to no use.

Sp. 9. *Muriat of Glucina.*

This salt has only been examined by Vauquelin; and little more is known at present concerning its properties than that it resembles nitrat of glucina, but is more easily crystallized. When dissolved in weak alcohol, it forms an agreeably sweet liquid.

Sp. 10. *Muriat of Yttria.*

This salt has been examined by Eckeberg† and Vauquelin‡. It has a strong resemblance to the nitrat of yttria. Like that salt, it dries with difficulty, melts in a gentle heat, and attracts moisture very rapidly from the atmosphere.

Sp. 11. *Muriat of Alumina.*

This salt was first described by Macquer and Margraff. Its properties have been but little examined.

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* Fourcroy, iii. 208.

† Crell's *Annals*, 1799, ii. 70.

‡ *Ann. de Chim.* xxxvi. 157.

It is prepared by dissolving alumina in muriatic acid: It is always in the state of a supermuriat.

Properties.

It is scarcely possible to obtain it in the form of crystals: it is usually either gelatinous, or in the state of white powder.

It is exceedingly soluble in water. When dried, it very soon attracts moisture from the air, and deliquesces.

When heated, it melts and loses its acid, while the alumina remains behind in a state of purity.

The proportion of its component parts has not been ascertained.

According to Fourcroy, it is decomposed by the following salts:

Decomposition.

1. Sulphats of ammonia, zirconia.
2. Sulphites of soda, strontian, ammonia, magnesia, glucina.
3. Nitrat of zirconia.
4. Phospats of potass, soda, ammonia, glucina.
5. Fluats of barytes, strontian, magnesia, potass, soda, ammonia.
6. Borats of magnesia, potass, soda, ammonia.
7. Carbonats of lime, potass, soda, magnesia, ammonia.

This salt has not hitherto been applied to any use; unless perhaps it may be formed during some of the processes employed for dyeing.

Sp. 12. *Muriat of Zirconia.*

This salt was first examined by Klaproth: It was afterwards described more particularly by Vauquelin.

Properties.

It is easily formed by pouring muriatic acid on newly precipitated zirconia. It is colourless; its taste is very astringent: by evaporation it furnishes small transparent crystals in needles, which lose their transparence in the air. Muriat of zirconia is very soluble in water and in alcohol; to the flame of which it does not communicate any particular colour. Heat decomposes it; and it is decomposed likewise by the saliva when taken into the mouth.

When muriat of zirconia contains a little silica, it forms cubic crystals without consistence, and resembling a jelly. These crystals, when exposed to the air, gradually lose their transparency, and diminish in volume, and there are formed in the middle of the salt white silky needle-shaped crystals.

Muriat of zirconia is decomposed by sulphuric acid; part of the sulphat precipitates, and part remains dissolved in the muriatic acid. When this acid is driven off by heat, the remainder of the sulphat is gradually deposited: if the evaporation be stopped before the mass be reduced to dryness, it forms a kind of jelly when cold. It is also decomposed by the phosphoric, citric, tartarous, oxalic, and mucous acids, which form with zirconia insoluble compounds that precipitate in white flakes.

Action of gallic acid.

The gallic acid poured into muriat of zirconia produces a white precipitate; but a green, bordering on grey, if the zirconia contain iron; and this last precipitate becomes, when dry, of a bright black colour, and resembles China ink. The liquid preserves a greenish colour: new portions of gallic acid produce no farther precipitation; but carbonat of ammonia separates in great abundance a flaky matter of a purplish colour, not unlike that of the leys of wine. From these experiments it follows, that gallic acid has a greater affinity for zirconia than muriatic acid has; and that the gallats of zirconia and iron are soluble in muriatic acid.

Carbonat of potass decomposes muriat of zirconia, and part of the carbonic acid combines with the earth, and renders it easily soluble in acids though dried.

Carbonat of ammonia occasions a precipitate, which is mostly dissolved by adding more carbonat.

Prussiat of mercury produces an abundant precipitate, which is soluble in muriatic acid; and which consequently is not muriat of mercury.

A plate of zinc, introduced into a solution of muriat of zirconia, occasions a slight effervescence; the liquor becomes milky, and in a few days assumes the form of a white semitransparent jelly.

Alumina decomposes muriat of zirconia with the assistance of a slight heat; the alumina dissolves, the liquor becomes milky, and assumes the form of a jelly. When the muriat contains iron, it remains in the solution, and the precipitated zirconia is quite pure. Here, then, is a method of freeing zirconia from iron *.

GENUS VI. OXY-MURIATS.

THOUGH the oxy-muriatic acid was discovered by Scheele, it was not till 1786 that Berthollet discovered the possibility of combining it with different bases, and of forming that class of salts now known by the name of oxy-muriats.

Preparation.

These salts cannot be formed by dissolving the different bases in the acid while liquid, in consequence, perhaps, of the strong affinity which it has for water; but

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* Vauquelin, *Ann. de Chim.* xxii. 201.

they may be easily formed by the following process: Dissolve the base which is to be combined with the acid, or its carbonat, in water, or mix it with water if it happens to be insoluble, and putting it into one of Woulfe's bottles, cause oxy-muriatic acid in the state of gas, distilled in the usual manner, to pass through it. The acid combines with the base, and at the same time (if a carbonat be used) an effervescence takes place, owing to the disengagement of the carbonic acid gas. As the base becomes saturated with acid, the oxy-muriat gradually precipitates in the state of crystals.

At the same time with the oxy-muriat a quantity of common muriat is formed; but it may be easily separated by dissolving the salt in a small quantity of boiling water, and allowing it to cool; the greater part of the oxy-muriats falls down in crystals, whereas the other salt remains in solution. The formation of the two salts is thus explained by Berthollet. He supposes that one part of the oxy-muriatic acid is decomposed; that its oxygen combines with the other portion of acid, and forms what he terms a *superoxygenated muriatic acid;* that it is this new formed acid which combines with the base, and of course the salts obtained are superoxygenated muriat and common muriat. This theory is probable, but it has not been completly demonstrated. The quantity of muriat formed is but small, and it may be owing to the decomposition of a small part of the acid by some other cause. It would be necessary to show that the acid contained in the oxy-muriat is not the same with common oxy-muriatic acid; and this, in consequence of the singular properties of these salts, is no very easy task. It must be acknowledged, however, that when oxy-muriat of potass is decomposed by any

Theory.

other acid, the acid disengaged is very heavy, and adheres like oil to those substances on which it falls; but in other respects it agrees exactly with common oxy-muriatic acid.

The oxy-muriats may be distinguished by the following properties:

Characters.

1. When heated moderately, they give out a great quantity of oxygen gas, and are converted into common muriats.

2. When mixed with combustibles, they detonate with much greater violence than the nitrats. This detonation is occasioned not only by heat but by friction and percussion, and often takes place spontaneously.

3. Soluble in water, and capable of crystallizing when the solution cools.

The greater number of them have been but slightly examined; owing probably to the difficulty of forming them rapidly. Some of them, however, have been introduced into the process of bleaching with much advantage. And those of them which are already known, have given rise to some of the most brilliant and astonishing experiments exhibited in chemistry.

Sp. 1. *Oxy-Muriat of Potass.*

Discovery.

THIS extraordinary salt, first formed by Berthollet [*], has been since examined by a great number of chemists. Lavoisier, Dolfuz [†], Van Mons, Fourcroy and Vauque-

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[*] It was in fact first discovered by Dr Higgens, who described the method of forming it and some of its properties some time before Berthollet, under the name of saltpetre. See Higgens on *Acetous Acid*, p. 180.

[†] *Ann. de Chim.* i. 225.

lin *, Hoyle †, &c. have investigated its properties, and discovered many of the singular effects which it produces.

It is prepared by dissolving one part of carbonat of potass in six parts of water, putting the mixture into a Woulfe's bottle, and saturating the potass with oxy-muriatic acid gas. When the saturation is nearly completed the oxy-muriat falls down in crystals. It may be purified by solution in boiling water. As the water cools, the pure oxy-muriat crystallizes. The crystals are to be dried between folds of blotting-paper.

Properties.

According to Hauy, the primitive form of the crystals of oxy-muriat of potass is an obtuse rhomboidal prism. But it is usually obtained in small thin plates, of a silvery whiteness. It is only by allowing an unsaturated solution of it in boiling water to cool slowly, or by exposing a solution in cold water to spontaneous evaporation, that it is obtained in large regular rhomboidal crystals.

Its taste is cooling, austere, and disagreeable, somewhat analogous to that of nitre. Its specific gravity is 1.989‡. When rubbed smartly, it phosphoresces, or rather emits a number of sparks of fire §.

It is soluble in 17 parts of water at the temperature of 60°, and in $2\frac{1}{2}$ parts of boiling water ‖. It is not sensibly altered by exposure to the air.

When heated, it readily undergoes the watery fusion. If the heat be continued, it boils, and gives out about the third of its weight of oxygen gas. It is from this

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* *Ann. de Chim.* xxi. 235.

† *Manchester Memoirs*, v. 221.

‡ Hassenfratz, *Ann. de Chim.* xxviii. 12.

§ Fourcroy, iii. 221.

‖ Hoyle, Nicholson's *Journal*, ii. 292.

salt that oxygen gas can be obtained in the state of the greatest purity. After the effervescence is over, there remains common muriat of potass.

According to Fourcroy, it is composed of

67	muriat of potass
33	oxygen
100 *	

Detonates with combustibles.

The most astonishing of its properties are those which it exhibits when mixed with combustibles. All combustible substances whatever are capable of decomposing it, and in general the decomposition is attended with violent detonations.

When three parts of this salt and one part of sulphur are triturated in a mortar, the mixture detonates violently: the same effect is produced when the mixture is placed upon an anvil, and struck smartly with a hammer. Nay, it even sometimes detonates spontaneously without any perceptible friction, and ought not therefore to be kept ready mixed. Charcoal produces the same effects though not so violent.

This property induced Berthollet to propose it as a subsitute for nitre in the preparation of gunpowder. The attempt was made at Essone in 1788; but no sooner had the workmen begun to triturate the mixture of charcoal, sulphur and oxy-muriat, than it exploded with violence, and proved fatal to Mr Letors and Mademoiselle Chevraud. The force of this gunpowder when it is prepared is much greater than that of the common sort of powder; but the danger of preparing it, and even of using it after it is prepared, is so great, that it can

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* Fourcroy, iii. 221.

hardly ever be substituted with advantage for common gunpowder.

Phosphorus also detonates with this salt either by trituration or percussion. The quantities of each used ought not to exceed half a grain, or at most a grain, otherwise the experiment may be attended with some danger. It detonates also when treated in the same way with almost all the metals, and likewise with cinnabar, pyrites, sugar, gums, oils, alcohol, &c.

When thrown upon platinum heated to whiteness, it does not detonate, but sublimes. The surface of the platinum, however, is oxidated; for acetous acid dissolves a part of it; and when prussiat of lime is poured into the solution, the liquid becomes of a greenish-white colour *.

The acids decompose it and expel the oxy-muriatic acid in a state of such condensation, that it acts instantaneously upon all combustibles which come in its way, and occasions astonishingly rapid and brilliant combustions. When sulphuric acid is poured upon it, a detonation takes place, a red flame is emitted, and a strong odour of oxy-muriatic acid is exhaled †. If sulphuric acid be poured upon a mixture of this salt and sulphur, charcoal, or the metals, or oil of turpentine, or almost any combustible, a very brilliant flame is emitted.

When this salt is triturated in a mortar with a little cotton cloth, small repeated explosions are heard, similar

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* Morveau, *Ann. de Chim.* xxv. 18.

† Mr Hoyle remarks, that at the same time a strong smell of nitrous gas is emitted, the mixture assuming an orange colour (*Manchester Memoirs*, v. 230). He attempted to obtain the gas disengaged, by applying heat to a mixture of sulphuric acid and oxy-muriat of potass, but an explosion took place, which shattered his apparatus to pieces.

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to the crack of a whip, and if the cotton be dry and warm it sometimes takes fire. It always does so when, after the trituration has been continued for some time, sulphuric acid is poured upon the cotton.

When nitric acid is poured upon this salt, the oxy-muriatic acid is disengaged, but without any detonation or flame. When this acid is poured upon a mixture of oxy-muriat of potass and phosphorus, flakes of flame are emitted at intervals for a considerable time *.

The theory of these explosions was first pointed out by Berthollet. The oxygen of the oxy-muriatic acid combines with the combustible, and at the same time lets go a quantity of caloric; and trituration or percussion acts merely by bringing the particles which combine within the sphere of each others attraction.

This salt was employed in bleaching after the discovery of the whitening property of oxy-muriatic acid; but other compounds have been lately substituted in its place.

Sp. 2. *Oxy-muriat of Soda.*

This salt has not hitherto been examined. From the experiments of Dolfuz and Gadolin, we learn that it may be formed by the same process as oxy-muriat of potass; that it crystallizes in prisms; that it detonates on red hot coals, and that it precipitates sulphat of iron brown †.

Sp. 3. *Oxy-muriat of Barytes.*

This salt is still unknown. Fourcroy has ascertained that when oxy-muriatic acid gas is received into a bottle containing water and carbonat of barytes, the barytes is

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* Collier, *Manchester Mem.* v. 229.

† *Ann. de Chim.* i. 227.

gradually dissolved, and the carbonic acid emitted; oxy-muriat of barytes in that case was no doubt formed[*].

Sp. 4. *Oxy-muriat of Strontian.*

Properties.

THIS salt was first formed by Messrs Davy and Clayfield. The combination only succeeds when oxy-muriatic gas is passed through a saturated boiling solution of strontian in water. When the strontian is saturated, the solution has a dusky orange colour. It yields crystals with difficulty, in consequence of the great solubility of the oxy-muriat. By great evaporation and cooling, fine needle-form crystals are obtained. Alcohol dissolves them, and burns with a red flame. They detonate slightly with phosphorus and charcoal. When sulphuric acid is poured into the solution of this salt in water, a vivid light is emitted, and a great increase of temperature takes place; but no light appears when the acid is poured upon the dry salt[†].

Sp. 5. *Oxy-muriat of Lime.*

THIS salt may be prepared by the common process. Its properties have not been examined by chemists; but it has been substituted by Mr Tennant of Glasgow for oxy-muriat of potass in bleaching, and is said to answer the purpose completely. The oxy-muriat of potass had succeeded with the paper-makers, but the bleachers of linen did not find it to answer. The oxy-muriat of lime is prepared in the usual manner, by means of chalk, and is used by the bleachers in a liquid form. It is said, however, to be now prepared for them in considerable quantities and sold in a dry state.

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[*] Fourcroy, iii. 220.

[†] *West Country Contributions*, p. 111.

Sp. 6, 7, 8, 9, 10.

THE oxy-muriats of magnesia, glucina, yttria, alumina, and zirconia, have not been examined. According to some chemists there is no such salt as the oxy-muriat of ammonia, as the acid and alkali have the property of decomposing each other. Others affirm that they are capable of combining together without decomposition below the freezing temperature; and Van Mons even describes the properties of the salt.

GENUS VII. PHOSPHATS.

THIS class of salts was first distinguished by Pott and Margraff. Several of the phosphats were afterwards examined by Haupt*, Schlosser†, Rouelle‡, Proust§, Westrum, and Scheele; but for the most complete account of them we are indebted to Fourcroy and Vauquelin. They may be distinguished by the following properties:

Characters.

1. When heated along with combustibles, they are not decomposed, nor is phosphorus obtained.

2. Before the blow-pipe they are converted into a globule of glass, which in some cases is transparent, in others opaque.

3. Soluble in nitric acid without effervescence, and precipitated from that solution by lime-water.

4. Decomposed, at least partially, by sulphuric acid; and their acid, which is separated, when mixed with charcoal and heated to redness, yields phosphorus.

5. After being strongly heated, they often phosphoresce.

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* *De Sale Mirabile Perlato*, 1740.

† *De Sale Urinæ*, 1760.

‡ *Jour. de Medicine*, 1776.

§ *Jour. de Phys.* xvii. 148.

The phosphats at present known amount to 13; some of which are found native in great abundance.

Sp. 1. *Phosphat of Barytes.*

THIS salt has hitherto been described only by Mr Vauquelin*.

It may be prepared either by saturating phsphoric acid with barytes or carbonat of barytes, or by mixing together an alkaline phosphat and nitrat or muriat of barytes. In either case the phosphat of barytes precipitates immediately in the form of a white powder.

Properties.

This salt is tasteless, incrystallizable by art, insoluble in water, and not altered by exposure to the air. Its specific gravity is 1.2867†.

When strongly heated, it melts into a grey-coloured enamel.

The proportion of its component parts is unknown.

According to Fourcroy, it is decomposed by the following salts:

Decomposition.

1. All the earthy and alkaline sulphats.
2. Sulphite of lime.
3. Nitrats of strontian, lime, alumina.
4. Muriats of lime, glucina, zirconia.
5 Carbonats of potass, soda.

This salt has not been applied to any use.

Sp. 2. *Phosphat of Strontian.*

THIS salt was first formed by Dr Hope; but it was more particularly described by Vauquelin in 1797‡.

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[*] *Jour. de l' Ecole Polytechnique.*

[†] Hassenfratz, *Ann. de Chim.* xxviii. 12.

[‡] *Jour. de Min.* An. vi. p. 13.

Like the former salt it may be formed by dissolving carbonat of strontian in phosphoric acid, or by mixing together nitrat of strontian and phosphat of soda. A white precipitate immediately falls, which is the phosphat of strontian.

Properties.

This salt is tasteless, insoluble in water, and not alterable by exposure to the air. It is soluble in an excess of phosphoric acid; a property which distinguishes it from phosphat of barytes.

Before the blow-pipe it fuses into a white enamel, and at the same time emits a phosphoric light.

It is completely decomposed by sulphuric acid, but by no other.

According to Vauquelin, it is composed of

Composition.

41.24	acid
58.76	strontian
100.00	

Decomposition.

According to Fourcroy, the following salts have the property of decomposing it:

1. Sulphites of barytes, lime.
2. Nitrites of lime.
3. Muriats of lime, zirconia.
4. Phosphites of barytes, potass.
5. Fluats of barytes potass, soda.
6. Carbonats of barytes, lime, potass, soda.

Sp. 3. *Phosphat of Lime.*

THIS interesting salt, which constitutes the basis of bones, was pointed out by Scheele and Gahn in 1774: but for the first precise account of its properties we are indebted to Eckeberg*, Fourcroy, and Vauquelin.

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* Crell's *Annals*, 1798, i. 323.

Preparation.

As this salt constitutes the basis of bones, it is not necessary to prepare it artificially. It may be obtained in a state of purity by the following process: Calcine the bones to whiteness, reduce them to powder, and wash them repeatedly with water, to separate several soluble salts which are present. After this edulcoration, there remains only phosphat of lime and a little carbonat of lime. This last salt may be dissolved by means of weak acetous acid; and the phosphat, after being well washed, remains in a state of purity.

Phosphat of lime, thus prepared, is always in the state of a white powder; but it is found native in regular crystals. In that state it is known by the name of *apetite*. The primitive form of its crystals is, according to Hauy, the regular six-sided prism; and the primitive form of its integrant particles is a three-sided prism, whose bases are equilateral triangles: But it very often assumes other forms.

Properties.

It is destitute of taste, insoluble in water, and not liable to be altered by exposure to the air. It may be exposed to a strong heat without undergoing any change; but in a very violent heat it becomes soft, and is converted into a white semitransparent enamel, or rather porcelain. According to the experiments of Saussure, a heat of 378° Wedgewood is necessary to produce this effect *.

Sulphuric, nitric, muriatic, fluoric, and several vegetable acids, are capable of decomposing phosphat of lime; but the decomposition is only partial. Fourcroy and Vauquelin have ascertained, that these acids are only capable of abstracting 0.40 parts of the lime,

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* *Jour. de Phys.* xlv. 26.

while the remainder continues combined with the phosphoric acid, constituting a *superphosphat of lime.* Hence the reason that phosphoric acid is capable also of decomposing partially the combinations of these acids with lime; it abstracts as much of the lime as is sufficient to convert it into superphosphat.

Composition.

Phosphat of lime, according to Fourcroy and Vauquelin, is composed of . . . . 41 acid
59 lime

100

According to Fourcroy, it is decomposed by the following salts:

1. Fluats of barytes, potass, soda.
2. Borat of barytes.

This salt is employed for making cupels: from it also almost the whole of the phosphorus employed by chemists is extracted. It is employed likewise as a medicine in rickets.

Sp. 4. *Superphosphat of Lime.*

THIS salt was discovered in 1795 by Fourcroy and Vauquelin. It had indeed been often formed before, but chemists had neglected to examine it.

It is this salt which always remains in the aqueous solution when calcined bones are decomposed by means of sulphuric acid; and it may be formed artificially by dissolving phosphat of lime in phosphoric acid, till the acid refuses to take up any more, and afterwards evaporating the solution till the salt crystallizes.

Properties.

Its crystals are usually thin brilliant plates, resembling mother-of-pearl, which easily adhere together, and acquire a kind of gluey consistency.

Its taste is strongly acid. Water dissolves it; and in a greater proportion when boiling hot than when cold: hence a saturated solution of it in boiling water crystallizes on cooling. It attracts a little moisture when exposed to the air.

When heated, it readily undergoes the watery fusion; then swells up and dries. In a high temperature, it melts into a semitransparent glass, which is tasteless and insoluble, and is not altered by exposure to the air.

When this salt is heated to redness along with charcoal, its excess of acid is decomposed, and converted into phosphorus, and phosphat of lime remains behind. It is from this salt that phosphorus is usually obtained: but the process of Fourcroy, which consists in decomposing the superphosphat of lime by means of acetite of lead, and afterwards decomposing the phosphat of lead by means of charcoal, must yield a much greater proportion of phosphorus.

No acid hitherto tried is capable of decomposing this salt except the oxalic, which abstracts its base completely, and precipitates with it in the form of oxalat of lime: but it is decomposed and reduced to the state of phosphat of lime by all the alkaline and earthy bases.

Composition.

It is composed, according to the analysis of Fourcroy and Vauquelin, of . . . 54 acid
46 lime

100

Sp. 5. *Phosphat of Potass.*

THIS salt was first formed by Lavoisier in 1774. It was afterwards examined by Vauquelin.

It is prepared by saturating phosphoric acid with potass, and evaporating the solution to the required consistency.

Properties.

This salt does not crystallize when evaporated sufficiently: it assumes the form of a jelly; and if the evaporation be carried farther, it becomes dry altogether. Its specific gravity, when dry, is 2.8516 *.

It is exceedingly soluble in water; and when dry readily attracts moisture from the atmosphere, and is converted into a viscid liquid. When heated, it first undergoes the watery fusion; then allows its water of crystallization to evaporate, and is reduced to dryness. In a high temperature it melts into a transparent glass, which deliquesces again when exposed to the air.

It is completely decomposed by the sulphuric, nitric, and muriatic acids; and by barytes, strontian, and lime. The following salts, according to Fourcroy, have the property of decomposing it:

Decomposition.

1. Sulphats of soda, strontian, lime, ammonia, magnesia, glucina, alumina, zirconia.
2. Sulphites of barytes, lime, strontian, glucina.
3. Nitrats of barytes, soda, strontian, lime, ammonia, magnesia, glucina, alumina, zirconia.
4. Muriats of barytes, soda, strontian, lime, ammonia, magnesia, glucina, alumina, zirconia.
5. Phosphites of lime, barytes.
6. Fluats, borats, and carbonats of barytes, lime.

Hitherto this salt has not been applied to any use.

Sp. 6. *Phosphat of Soda.*

History.

THIS salt exists ready formed in urine, and was the

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* Hassenfratz, *Ann. de Chim.* xxviii. 12.

first known of all the phosphats. It occupied a good deal of the attention of chemists; and the difficulty of analysing it gave occasion to various hypotheses concerning its nature. Hellot remarked it in urine; and described it, in 1737, as a salt different from those that had usually been observed. Haupt described it in 1740 under the name of *sal mirabile perlatum*, or "wonderful perlated salt." It was called *perlated* from the grey, opaque, pearl-like colour which it assumed when melted by the blow-pipe. Margraff described it in 1745, and found it would not yield phosphorus when treated with charcoal, as the other salts of urine did. Rouelle the Younger analysed it in 1776, and concluded from his experiments that it was a compound of phosphoric acid and soda[*]; but Mr Proust being unable to obtain phosphorus from it, concluded, that it did not contain phosphoric acid, but another acid analogous to the boracic[†]. To this substance, which Mr Proust actually obtained, Bergman gave the name of *perlated acid*, and Morveau afterwards called it *ouretic acid*. But Mr Klaproth soon afterwards analysed it, and proved that it consisted of soda supersaturated with phosphoric acid[‡]. Scheele soon after made the same discovery[§]. The acid of Mr Proust, then, is merely phosphat of soda combined with phosphoric acid, or *superphosphat of soda*.

Dr Pearson afterwards introduced it with great advantage into medicine as a purgative. He gives the following process for preparing it:

Preparation.

Dissolve in a long-necked matrass 1400 grains of cry-

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[*] *Jour. de Med.* 1776, Juillet.

[†] *Jour. de Phys.* 1781, i. 145.

[‡] Crell's *Annals*, 1785, i. 238.

[§] Ibid. ii. 387.

stallized carbonat of soda in 2100 grains of water at the temperature of 150°. Add gradually 500 grains of phosphoric acid of the specific gravity 1.85. Boil the liquor for some minutes; and while it is boiling hot, filtrate it, and pour it into a shallow vessel. Let it remain in a cool place, and crystals will continue to form for several days. From the above quantities of materials he has obtained from 1450 to 1550 grains of crystals.

Apothecaries usually prepare it from the superphosphat of lime, obtained from bones by means of sulphuric acid. An excess of carbonat of soda is added to separate the lime. The liquid is then filtered and evaporated slowly till it crystallizes.

Properties.

Its crystals are rhomboidal prisms, of which the acute angles are 60°, and the obtuse angles 120°, terminated by a three-sided pyramid. Its specific gravity is 1.333*.

Its taste is almost the same with that of common salt.

It is soluble at the temperature of 60° in about four parts of water, and in two parts of boiling water. This solution crystallizes on cooling; but, in order to obtain the salt properly crystallized, the solution should contain a slight excess of alkali.

When exposed to the air, this salt very soon effloresces on the surface. When heated, it undergoes the watery fusion. At a red heat it melts into a white enamel. Before the blow-pipe it melts into a transparent globule, which becomes opaque on cooling, and its surface acquires a polyhedral figure.

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* Hassenfratz, *Ann. de Chim.* xxviii. 12.

It is not altered by combustibles nor metals. With metallic oxides it enters into fusion, and forms a coloured globule of glass.

Sulphuric, nitric, and muriatic acids, decompose it partially, and convert it into *superphosphat of soda.* In this state it is more soluble in water, and not so easily crystallized; but may be obtained by proper evaporation in the state of thin scales, not unlike boracic acid. It was this superphosphat which Proust obtained, and which he considered as a peculiar acid.

The greater number of earths may be fused along with this salt, and converted into glass.

Decomposition.

It is decomposed, according to Fourcroy, by the following salts :

1. Sulphats of lime, strontian, magnesia, alumina, ammonia, glucina, zirconia.
2. Sulphites of barytes, lime, potass, strontian, glucina.
3. Nitrats of barytes, lime, ammonia, magnesia, glucina, alumina, zirconia.
4. Muriats of barytes, strontian, lime, ammonia, magnesia, glucina, alumina, zirconia.
5. Phosphites of lime, barytes, potass.
6. Fluats, borats, and carbonats of lime, barytes, potass.

This salt has been applied to various uses. It has been introduced into medicine as a purgative, and on account of its pleasant taste has of late been much used. It is usually taken in broth, which it is employed to season instead of common salt. It may be subsituted for borax to promote the soldering of metals. Mineralogists employ it very much as a flux when they examine the action of heat on minerals by means of the blow-pipe.

Sp. 7. Phosphat of Ammonia.

This salt also exists in urine, and seems to have been first accurately distinguished by Rouelle. It was afterwards examined by Lavoisier in 1774, and still more lately by Vauquelin [*].

It is usually prepared by saturating with ammonia the superphosphat of lime obtained from bones, and evaporating the solution to such a consistency that when allowed to cool the phosphat of ammonia is obtained in crystals.

Properties.

It crystallizes in four-sided prisms, terminated by equal-sided pyramids. Its taste is cooling, salt, and ammoniacal. Its specific gravity is 1.8051 [†].

It is soluble in four parts of water at the temperature of 60°, and in rather a smaller proportion of boiling water. It is by spontaneous evaporation that it is obtained in the state of regular crystals.

It is not altered by exposure to the air. When heated, it undergoes the watery fusion : it then dries ; but if the heat be continued, it swells up, loses its alkaline base, and the acid melts into a transparent glass. It is the only one of the earthy and alkaline phosphats which can be decomposed by heat: hence the reason that it yields phosphorus when distilled along with charcoal.

It is decomposed by the sulphuric, nitric, and muriatic acids, and by the fixed alkalies and alkaline earths. It is capable of combining with an additional dose of acid, and of passing into the state of a superphosphat.

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[*] *Jour. de l'Ecole Polytechnique.*

[†] Hassenfratz, *Ann. de Chim.* xxviii. 12.

Decomposition.

According to Fourcroy, it is decomposed by the following salts:

1. Sulphats of strontian, lime, magnesia, glucina, alumina, zirconia.
2. Sulphites of barytes, lime, potass, soda, strontian, magnesia, glucina.
3. Nitrats of barytes, strontian, lime, magnesia, glucina, alumina, zirconia.
4. Muriats of barytes, strontian, lime, magnesia, glucina, alumina, zirconia.
5. Phosphats of lime, barytes, strontian, magnesia, potass, soda.
6. Fluats and borats of lime, barytes, strontian, magnesia, potass, soda.
7. Carbonats of barytes, strontian, lime, potass, soda.

This salt is much employed as a flux in experiments with the blow-pipe. It enters also as an ingredient in those coloured glasses called *pastes*, which are made in imitation of precious stones.

Sp. 8. *Phosphat of Soda-and-ammonia.*

THOUGH this salt, known to chemists by the names of *microcosmic salt*, and *fusible salt of urine*, was extracted from urine, and examined much soooner than any of the other phosphats, it was long before philosophers were able to form precise notions concerning its nature, or even to obtain it in a state of purity. This indeed could not be expected till the phosphats of soda and of ammonia had been accurately examined, and their composition ascertained. Fourcroy was the first who gave a precise account of the proportion of its component parts [*]. According to him, it is composed of

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[*] *Ann. de Chim.* vii. 183.

32	acid
24	soda
19	ammonia
25	water
100	

The properties of this salt are nearly those of the two last species joined together. It answers better than the first of them as a flux; because the heat soon drives off the ammonia, and leaves an excess of acid. Its specific gravity is 1.509*. When exposed to the air, this salt effloresces, and gradually loses its ammonia; a fact first observed by the Duke de Chaulnes.

Sp. 9 *Phosphat of Magnesia*

THIS salt was first formed by Bergman in 1775†. It has been lately examined with much precision by the celebrated and indefatigable Vauquelin‡.

Preparation.

It is usually prepared by dissolving carbonat of magnesia in phosphoric acid, and evaporating the solution gradually till the salt crystallizes; but it may be obtained in large regular crystals by a much easier process first pointed out by Fourcroy. Mix together equal parts of the aqueous solutions of phosphat of soda and sulphat of magnesia. No apparent change takes place at first; but in a few hours large transparent crystals of phosphat of magnesia make their appearance in the solution.

Properties.

Its crystals are six-sided prisms, the sides of which are unequal. It has very little taste; however, it leaves

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* Hassenfratz, *Ann. de Chim.* xxviii. 12.

† *Opusc.* i. 390.

‡ *Jour. de l'Ecole Polytechnique.*

a cooling and sweetish impression upon the tongue. Its specific gravity is 1.5489*.

It requires about 15 parts of cold water to dissolve it. It is more soluble in boiling water, but it crystallizes in part as the solution cools. When exposed to the air, it loses its water of crystallization, and falls down in powder.

When heated moderately, it is also reduced to a dry powder. In a high temperature, it melts into a transparent glass.

Decomposition.

According to Fourcroy, it is decomposed by the following salts:

1. Sulphats of glucina, zirconia.
2. Sulphites of barytes, lime, potass, soda, glucina.
3. Nitrats of barytes, strontian, lime.
4. Muriats of barytes, strontian, glucina, zirconia.
5. Phosphites of lime, barytes, strontian, potass, soda.
6. Fluats of lime, barytes, strontian, potass, soda, ammonia.
7. Borats of lime, barytes, strontian, potass, soda.
8. Carbonats of strontian, lime, potass, soda.

This salt has not been applied to any use.

Sp. 10. *Phosphat of Ammonia-and-magnesia.*

This salt was first discovered by Fourcroy, who found it in a calcalous concretion formed in the colon of a horse. Since this discovery Fourcroy and Vauquelin have observed it also in human urine.

It might be prepared by mixing together solutions of the phosphats of ammonia and of magnesia in water; the triple salt immediately precipitates in the state of

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* Hassenfratz, *Ann. de Chim.* xxviii. 12.

a white powder. When urine is allowed to remain a considerable time in close vessels, it often deposites this salt in regular crystals on the sides and bottom of the vessel.

Properties.

These crystals are small four-sided prisms, terminated by irregular four-sided pyramids. This salt is tasteless, scarcely soluble in water, and not liable to be altered by exposure to the air.

When heated, it falls to powder, gives out its ammonia, and in a high temperature melts into a transparent globule. When distilled along with charcoal, phosphorus is obtained.

Fourcroy has ascertained that the phosphat of ammonia-and-magnesia, obtained from the calculous concretions of the horse, is composed of

Composition.

33 phosphat of ammonia
33 phosphat of magnesia
33 water
—
99

Sp. 11. *Phosphat of Glucina.*

This salt has been only examined by Vauquelin. He obtained it by pouring phosphat of soda into the solution of glucina in sulphuric, nitric, or muriatic acids. The phosphat of glucina is precipitated in the state of a white powder.

Properties.

It does not crystallize. It is tasteless, insoluble in water, unless it contains an excess of acid, and not liable to be altered by exposure to the air. When heated strongly, it melts into a transparent glass.

According to Fourcroy, it is decomposed by the following salts ;

Chap. III. Decomposition.

1. Sulphats of alumina, zirconia.
2. Sulphites of barytes, lime, potass, soda, strontian, ammonia, magnesia.
3. Nitrats of alumina, zirconia.
4. Muriats of alumina, zirconia.
5. Phosphites, fluats, and borats of lime, barytes, strontian, magnesia, potass, soda, ammonia.
6. Carbonats of barytes, strontian, lime, potass, soda, ammonia.

Sp. 12. *Phosphat of Yttria.*

THIS salt has only been formed by Vauquelin. When the solution of phosphat of soda is mixed with the sulphat, nitrat, or muriat of yttria, phosphat of yttria precipitates in gelatinous flakes*.

Sp. 13. *Phosphat of Alumina.*

THIS salt has only been examined by Fourcroy. It may be formed by saturating phosphoric acid with alumina. It is a tasteless powder, insoluble in water. Dissolved in phosphoric acid, it yields a gritty powder, and a gummy solution, which by heat is converted into a transparent glass.

Sp. 14. *Phosphat of Zirconia.*

Unknown†.

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* *Ann. de Chim.* xxxvi. 158

† Phosphoric acid and silica, when mixed together and exposed to a strong heat, melt into a beautiful transparent glass, which is not decomposed either by the action of acids or of alkalies. Fourcroy has given this compound the name of phosphat of silica; but it is essentially different from salts, and ought therefore rather to be ranked among some other class of bodies.

GENUS VIII. PHOSPHITES.

THESE salts have been lately examined for the first time, and their properties described, by Fourcroy and Vauquelin†. They may be distinguished by the following properties :

Characters.

1. When heated, they emit a phosphorescent flame.

2. When distilled in a strong heat, they give out a little phosphorus, and are converted into phosphats.

3. Detonate when heated with nitrat or oxy-muriat of potass, and are converted into phosphats.

4. Converted into phosphats by nitric and oxy-muriatic acid.

5. Fusible in a violent heat into glass.

The phosphites at present known amount to seven.

Sp. 1. *Phosphite of Lime.*

THIS salt may be formed by dissolving lime in phosphorous acid ; when the saturation is complete, the salt precipitates in the state of a white powder.

Properties.

It is tasteless and insoluble in water ; but it dissolves in an excess of acid, and forms a superphosphite. This last salt may be obtained in prismatic crystals by evaporating the solution.

This salt is not altered by exposure to the air. When heated, it phosphoresces and emits a little phosphorus. In a violent heat, it melts into a transparent globule.

Composition.

It is composed of 34 acid
51 lime
15 water

100

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* *Jour. de l'Ecole Polytechnique*, I. iv. 655

Sp. 2. *Phosphite of Barytes.*

THIS salt may be formed by pouring phosphorous acid into barytic water, or this last water into a solution of phosphite of soda. In either case phosphite of barytes precipitates in the form of a white powder.

Properties.

It is tasteless, and but very sparingly soluble in water, unless there be an excess of acid. It is not altered by exposure to the air. Before the blow-pipe it melts, and is surrounded with a light so brilliant that the eye can scarcely bear it. The globule which it forms becomes opaque as it cools.

Composition.

It is composed of	
	41.7 acid
	51.3 barytes
	7.0 water
	100.0

Sp. 3. *Phosphite of Strontian.*

Unknown.

Sp. 4. *Phosphite of Magnesia.*

THIS salt is best formed by mixing together aqueous solutions of phosphite of potass or soda and sulphat of magnesia; the phosphite of magnesia gradually precipitates in beautiful white flakes.

Properties.

It has no sensible taste. It is soluble in 400 parts of water, at the temperature of 60°, and scarcely more soluble in boiling water. When its solution is evaporated slowly, a transparent pellicle forms on its surface, flakes are deposited, and towards the end of the process small tetrahedral crystals are precipitated.

When exposed to the air, it effloresces. When heated, it phosphoresces and melts into a glass, which becomes opaque on cooling.

It is composed of	
44	acid
20	magnesia
36	water
100	

Sp. 5. *Phosphite of Potass.*

This salt is formed by dissolving carbonat of potass in phosphorous acid, and evaporating the solution slowly till it deposites crystals of phosphite of potass.

Properties.

It crystallizes in four-sided rectangular prisms, terminated by dihedral summits. Its taste is sharp and saline. It is soluble in three parts of cold water, and still more soluble in boiling water. It is not altered by exposure to the air. When heated, it decrepitates and then melts into a transparent globule, which becomes opaque on cooling. It does not phosphoresce so evidently as the other phosphites, perhaps because it contains an excess of potass, which saturates the phosphoric acid as it forms.

It is composed of	
39.5	acid
49.5	potass
11.0	water
100.0	

Sp. 6. *Phosphite of Soda.*

This salt may be prepared exactly in the same way as phosphite of potass.

Properties.

Its crystals are irregular four-sided prisms or elongated rhomboids. Sometimes it assumes the form of square plates, or of plumose crystals. Its taste is cooling and agreeable. It is soluble in two parts of cold water, and scarcely more soluble in boiling water.

When exposed to the air it effloresces. Before the blow-pipe it emits a beautiful yellow flame, and melts into a globule, which becomes opaque on cooling.

It is composed of . . 16.3 acid
23.7 soda
60.0 water

100.0

It is decomposed by the following salts:

1. Sulphats of lime, barytes, strontian, magnesia.
2. Nitrats and muriàts of lime, barytes, strontian, magnesia.

Sp. 7. Phosphite of Ammonia.

THIS salt may be prepared by the same processes as the two last described phosphites.

It crystallizes sometimes in long transparent needles, and sometimes in four-sided prisms terminated by four-sided pyramids.

Properties.

It has a very sharp saline taste. It is soluble in two parts of water at the temperature of 60°, and still more soluble in boiling water. When exposed to the air, it attracts moisture and becomes slightly deliquescent.

When distilled in a retort, the ammonia is disengaged partly liquid and partly in the state of gas, holding phosphorus in solution, which becomes luminous when mixed with oxygen gas. Before the blow-pipe on charcoal, it boils and loses its water of crystallization; it becomes surrounded with a phosphorescent light, and bubbles of phosphorated hydrogen gas are emitted, which burn in the air with a lively flame, and form a fine coronet of phosphoric acid vapour. This gas is emitted also when the salt is heated in a small glass bulb, the tube belonging to which is plunged under mercury.

This salt is composed of 26 acid
51 ammonia
23 water

100

Sp. 8. *Phosphite of Ammonia-and-Magnesia.*

This salt may be formed by mixing together the aqueous solutions of its two component parts.

It is sparingly soluble in water, and may be obtained in crystals; but its properties have not been examined with precision.

Sp. 9. *and* 10. *Phosphites of Glucina and Yttria.*

Unknown.

Sp. 11. *Phosphite of Alumina.*

This salt may be prepared by saturating phosphorous acid with alumina, and then evaporating the solution to a proper consistence.

It does not crystallize, but forms a glutinous mass, which dries gradually, and does not afterwards attract moisture from the air. Its taste is astringent. It is very soluble in water. When heated, it frothes and gives out phosphorus, but it does not readily melt into a globule of glas.

Sp. 12. *Phosphite of Zirconia.*

Unknown.

GENUS IX. FLUATS.

THESE salts were first made known to the world by Scheele in 1771*, and succeeding chemists have done little more than repeat and confirm his experiments.

Fluats may be distinguished by the following properties:

Characters.

1. When sulphuric acid is poured upon them, they emit acrid vapours of fluoric acid, which have the property of corroding glass.
2. When heated, several of them phosphoresce.
3. Not decomposed by heat, nor altered by combustibles.
4. Combine readily with silica by means of heat.

Sp. 1. *Fluat of Lime.*

THIS salt exists abundantly native. It is from it indeed that fluoric acid is always extracted.

Properties.

It is found frequently crystallized. The primitive form of its crystals, according to Hauy, is the octahedron, but it occurs more frequently in cubes; sometimes the angles, and sometimes the edges of these cubes, are truncated. The form of its integrant particles is the regular tetrahedron.

This salt has no taste. Its specific gravity is 3.15. It is insoluble in water, and not altered by exposure to the air.

Phosphoresces.

When heated, it decrepitates and phosphoresces strongly in the dark. It emits this light even under water, or in the vacuum of an air pump. When kept hot for some time, it ceases to shine, and the phospho-

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[*] Scheele, i. 26.

rescent property cannot be again restored to it by any process known, except by decomposing it altogether by means of sulphuric acid, and forming it anew. Scheele ascertained that new formed fluat of lime is equally phosphorescent with native. The cause of this curious property is not well understood. After being heated, the salt, though it refuses to phosphoresce any more, has not lost any perceptible weight, nor is it altered in any of its other qualities. When strongly heated, fluat of lime melts into a transparent glass. According to Saussure, this takes place at the temperature of 51° Wedgewood *.

It is decomposed by the following salts :

1. Carbonats of potass, soda.
2. The greater number of the phosphats.

Sp. 2. *Fluat of Barytes.*

This salt, as Bergman informs us, may be formed by pouring fluoric acid into nitrat or muriat of barytes. Fluat of barytes precipitates in the form of a white powder, which requires a considerable proportion of water to dissolve it.

Sp. 3. *Fluat of Strontian.*

This salt was formed by Dr Hope; but its properties have not been examined.

Sp. 4. *Fluat of Magnesia.*

This salt may be formed by dissolving carbonat of magnesia in fluoric acid. The salt precipitates in a great measure as the saturation approaches.

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* *Jour. de Phys.* xlv. 16.

It is not soluble in water except there be an excess of acid. In that case, by spontaneous evaporation, it forms hexagonal prisms, terminated by a low pyramid composed of three rhomboidal sides.

These crystals are hardly soluble in water. Alcohol dissolves a small portion of them. Heat does not decompose them; nor are they decomposed by any acid *.

Sp. 5. *Fluat of Potass.*

This salt may be prepared by saturating fluoric acid with potass. It does not crystallize, but forms a gelatinous mass almost without taste, which attracts moisture from the air.

It dissolves readily in water. When exposed to the fire it melts without any ebullition †.

Sp. 6. *Fluat of Potats-and-Silica.*

Preparation.

When fluoric acid is obtained by the common process in glass vessels, it is always combined with a portion of silica. If into this impure acid a quantity of potass, or the carbonat, sulphat, nitrat, or muriat of that alkali, be dropt, a gelatinous precipitate immediately appears, which, when dried, becomes white like chalk, and separates into small loose grains like the sand of an hour-glass. This powder is a combination of fluoric acid, silica, and potass. Its nature was first ascertained by Scheele.

Properties.

It has an acid taste, and is soluble in about 150 parts of boiling water; but is again partly deposited as the solution cools. When strongly heated, it melts into a transparent glass, and loses its acid ‡.

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* Bergman, i. 384.

† Scheele on *Fluor.* i. 26.

‡ Scheele, Crell's *Annals*, i. 214. Engl. Transl.

Mr Scheele has shewn, that a similar triple salt may be formed by using soda, or the salts containing soda, instead of potass.

Lime also is capable of combining with these triple salts, and forming with them quadruple salts composed of fluoric acid, silica, fixed alkali, and lime *.

Sp. 7. *Fluat of Soda.*

This salt may be formed by saturating fluoric acid with soda. When the solution is evaporated till a pellicle forms on its surface, it yields on cooling small cubic crystals of fluat of soda. These crystals have a bitter and astringent taste; they do not deliquesce in the air, and are but sparingly soluble in water. Before the blow-pipe they decrepitate, and melt into a transparent globule †.

Sp. 8. *Fluat of Ammonia.*

This salt may be prepared by saturating fluoric acid with ammonia. The solution yields by evaporation small crystals of fluat of ammonia. When heated, it sublimes in the state of superfluat.

It is decomposed by the following salts:

1. Nitrat and muriat of lime, and sulphat of magnesia.
2. Nitrats of mercury, silver, lead ‡.

Sp. 9. *Fluat of Ammonia-and-magnesia.*

This salt has been formed by Fourcroy, but its properties have not been examined.

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* Scheele, Crell's *Annals*, i. 219. Engl. Transl.

† Fourcroy, iii. 306.

‡ Scheele, i. 28.

Sp. 10. *and* 11. *Fluats of Glucina and Yttria.*

Unknown.

Sp. 12. *Fluat of Alumina.*

This salt does not crystallize; but assumes, when evaporated, the consistence of a jelly. Its taste is astringent, and it contains always an excess of acid. This salt has been lately discovered native, combined with soda.

Sp. 13. *Fluat of Zirconia.*

Unknown.

Sp. 14. *Fluat of Silica.*

Fluoric acid, when obtained by the usual process in glass vessels, contains always a portion of silica, and forms therefore in reality a super-fluat of that earth. If this solution be allowed to remain for a considerable time in a vessel not completely shut, it deposites small brilliant, transparent, rhomboidal crystals. These Fourcroy has ascertained to be fluat of silica. The acid may be separated by means of heat, and by concentrated acids. This salt is soluble in alkalies, and forms with them triple salts *.

Genus X. Borats.

Though some of these salts have been long known, and one of them has been in general use for many years, their nature is still but imperfectly understood, because they have been but superficially examined. Fourcroy

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* Fourcroy, iii. 311.

is the only chemist, if we except Bergman, who has attempted a description of them. They may be distinguished by the following properties :

Characters.

1. Before the blow-pipe they melt into a glass.

2. When their concentrated solutions are boiled with sulphuric acid, and allowed to cool, brilliant scales of boracic acid are deposited.

3. They are not altered by combustible bodies.

4. With most metallic oxides they enter into fusion, and form globules of coloured glass.

Sp. 1. *Borat of Lime.*

THIS salt may be formed by mixing together lime-water and the aqueous solution of boracic acid, or by boiling together lime and pure borax in water. In either case, the borat of lime precipitates in the state of a white powder, tasteless, and difficultly soluble in water *.

Sp. 2. *Borat of Barytes.*

AN insoluble white powder, which has scarcely been examined, formed by the same process as borat of lime.

Sp. 3. *Borat of Strontian.*

THIS salt has only been formed by Dr Hope. It is a white powder, soluble in about 130 parts of boiling water. The solution turns the syrup of violets green †. It is therefore in the state of a sub-borat.

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* Bergman, iii. 363.

† Hope, *Edin. Trans.* iv. 17.

Sp. 4. *Borat of Magnesia.*

Bergman formed this salt by dissolving magnesia in boracic acid. The solution proceeded slowly; and on evaporation, the salt was precipitated in small irregular crystals. It is soluble in acetous and formic acids. Alcohol decomposes it. It melts easily in the fire without being decomposed *.

Sp. 5. *Borat of Lime-and-magnesia.*

This salt, which is found native in the mountain of Kalkberg near Luneburg in Germany, was first analysed by Westrum in 1788.

Properties.

It is in the form of transparent or opaque white crystals, consisting of cubes, having their edges and four of their angles truncated. It is so hard as to scratch glass, and to strike fire with steel. Its specific gravity is 2.566. When heated, it becomes electric; and what is singular, the truncated angles are always positively electric, while the opposite entire ones are negative †.

These crystals are insoluble in water, and not altered by exposure to the air. When heated, they decrepitate: in a red heat they lose their lustre, but do not sensibly diminish in weight. In a white heat they lose 0 005 of their weight. When exposed to the action of a very violent heat, they melt into a yellow-coloured glass.

According to Westrum, they are composed of

Composition.

73.5 acid
14.6 magnesia
11.9 lime
100.0

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* Bergman, i. 386.

† Hauy, *Ann. de Chim.* ix. 59.

Sp. 6. *Borat of Potass.*

This salt, which was first formed by Baron, is very little known. It may be prepared by calcining a mixture of boracic acid and nitre. The heat drives off the nitric acid, and leaves a white saline mass, which, when dissolved in water, yields crystals of borat of potass. It is capable of combining with an excess of base, and forming a sub-borat of potass.

Sp. 7. *Borat of Soda.*

This salt, which may be formed by saturating borax with boracic acid, has never been examined. Bergman informs us, that about half its weight of boracic acid is necessary to saturate borax[*]. Its specific gravity is 1.351[†].

Sp. 8. *Sub-borat of Soda or Borax.*

History.

This salt, the only one of the borats which has been accurately examined, is supposed to have been known to the ancients, and to be the substance denominated *chrysocolla* by Pliny. At any rate, it is mentioned by Geber as early as the ninth century under the name of borax. Its composition was first pointed out by Geoffroy in 1732, and Baron in 1748. Bergman was the first who demonstrated that it has an excess of base, and is therefore in the state of a sub-borat.

This salt is brought from the East Indies in an impure state under the name of *tinkal*, enveloped in a kind

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[*] Bergman, iii. 325. According to Withering, twice its weight is necessary.—Bergman's *Sciagraphia*, p. 26. Engl. Trans.

[†] Hassenfratz, *Ann. de Chim.* xxviii. 12.

of fatty matter, which Vauquelin has ascertained to be a soap with soda for its base. When purified in Europe, it takes the name of *borax*. The purification is performed by the Dutch ; but the process which they follow is not known. Valmont Bomare informs us that they extract 80 parts of pure borax from 100 parts of tinkal. The operations are conducted in leaden vessels, and consist chiefly in repeated solutions, filtrations, and crystallizations. Valmont Bomare suspects that they employ lime-water ; and Fourcroy has shewn that this might be useful in decomposing the soap in which crude borax is enveloped*.

Properties.

Borax, thus purified, may be obtained crystallized in hexangular prisms, of which two sides are much broader than the remainder, terminated by triangular pyramids. It is of a white colour. Its specific gravity is 1.740†. It converts vegetable blues to green. Its taste is styptic and alkaline.

It is soluble in 12 times its weight of water of the temperature of 60°, and 6 times its weight of boiling water.

When exposed to the air, it effloresces slowly and slightly.

When heated, it swells, loses about four-tenths of its weight, becomes ropy, and then assumes the form of a light, porous, and very friable mass, known by the name of *calcined borax ;* in a strong heat it melts into a transparent glass still soluble in water.

When two pieces of borax are struck together in the dark, a flash of light is emitted‡.

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* Fourcroy, iii. 330.

† Kirwan.

‡ Accum, Nicholson's *Jour.* ii. 28.

Composition.

This salt, according to Bergman, is composed of

39 acid
17 soda
44 water

100*

It is decomposed by the following salts, according to Fourcroy:

Decomposition.

1. Sulphats of lime, ammonia, magnesia, glucina, alumina, zirconia.
2. Sulphites of ammonia, magnesia.
3. Nitrats of barytes, strontian, lime, ammonia, magnesia, glucina, alumina, zirconia.
4. Muriats of barytes, strontian, lime, ammonia, magnesia, glucina, alumina, zirconia.
5. Super-phosphat of lime.
6. Phosphats of ammonia, magnesia, glucina, alumina, zirconia.
7. Fluats of barytes, strontian, magnesia, ammonia, glucina, alumina, zirconia.

Uses.

Borax is sometimes used in medicine as an astringent. It is used as a flux for metals, and enters into the composition of some of the coloured glass pastes made in imitation of gems; but its great use is to facilitate the soldering of the more precious metals. It is employed also as a flux by mineralogists in essaying the properties of minerals by the blow-pipe.

Sp. 9. Borat of Ammonia.

This salt may be formed by saturating boracic acid with ammonia. It has scarcely been examined. Four-

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* Bergman's Notes on Scheffer.

croy affirms, that when its solution is evaporated, the ammonia is volatilized, and the acid crystallizes[*].

Sp. 10. *and* 11. *Borats of Glucina and Yttria.*

Unknown.

Sp. 12. *Borat of Alumina.*

THIS salt may be formed by mixing together the solutions of borat of soda and sulphat of alumina. It is said to be scarcely soluble in water, and not to crystallize.

Sp. 13. *Borat of Zirconia.*

Unknown.

Borat of silica.

WHEN boracic acid and silica are exposed to a strong heat, they melt together into a transparent glass. This compound has received the name of *borat* of *silica* from Fourcroy.

GENUS XI. CARBONATS.

THOUGH several of the carbonats were in the hands of chemists, and employed by them in the greater number of their experiments, their nature and composition was entirely unknown till Dr Black discovered it in 1756. Since that time they have been examined with great attention by almost every chemist of eminence; so that at present no family of salts is more accurately understood. The first treatise on the subject was published by Bergman in 1774[†].

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[*] Fourcroy, iii. 336.

[†] *Opusc.* i. 1.

They may be distinguished by the following properties :

Characters.

1. When sulphuric acid is poured upon them, they effervesce violently, emitting carbonic acid gas.

2. When heated strongly, the carbonic acid is driven off, and the base remains in a state of purity. Some carbonats require a very violent heat to be thus decomposed, but the operation is facilitated by mixing them with charcoal, which decomposes the carbonic acid altogether.

3. The alkaline carbonats tinge vegetable blues green, and have an alkaline taste.

4. The alkaline carbonats are soluble in water ; the carbonats with bases of the alkaline earths are insoluble, but dissolve when an excess of acid is added.

Many of these salts exist native ; but they may be all formed artificially by dissolving or diffusing the base in water, and making carbonic acid gas pass into the liquid till it be saturated.

Sp. 1. *Carbonat of Barytes.*

This salt seems to have been first examined by Bergman. Withering first found it native in 1783. Hence it has received the name of *Witherite.* Since that time it has been examined by Kirwan, Klaproth, Hope, Pelletier, Fourcroy, and Vauquelin, and its properties described with great precision.

It may be prepared artificially by exposing barytic water to the open air, or by passing carbonic acid gas into it. In either case the carbonat precipitates in the state of a white powder.

Properties.

It is found native crystallized. Its crystals have been observed to assume four different forms ; double six-sided and double four-sided pyramids, six-sided columns terminated by a pyramid with the same number of faces, and small radiated crystals half an inch in length, and very thin, appearing to be hexagonal prisms, rounded towards the point. It has no sensible taste; yet it is poisonous. Its specific gravity, when native, is 4.331; when prepared artificially, it scarcely exceeds 3.763.

Cold water dissolves $\frac{1}{4304}$ part, and boiling water $\frac{1}{2304}$ part of this salt. Water saturated with carbonic acid dissolves $\frac{1}{830}$ part*.

It is not altered by exposure to the air.

It is decomposed by the application of a very violent heat†, either in a black lead crucible, or when formed into a paste with charcoal powder.

Composition.

According to Dr Withering, native carbonat of barytes is composed of 20 acid
80 barytes
100

According to Pelletier, of 22 acid
62 barytes
16 water
100

Bergman informs us that the artificial carbonat is composed of . . . . 7 acid
65 barytes
28 water
100‡

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[*] Fourcroy, *Ann. de Chim.* iv. 64.

[†] Dr Hope.

[‡] *Opusc.* i. 22.

According to Kirwan, the natural or the artificial ignited is composed of 22 acid
78 barytes
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100*

According to Fourcroy, it is decomposed by the following salts:

Decomposition.

1. Sulphats of ammonia, magnesia, glucina, alumina, zirconia.
2. Sulphites of lime, ammonia, magnesia, glucina, alumina, zirconia.
3. Nitrats of strontian, lime.
4. Muriat of alumina.
5. Super-phosphat of lime.
6. Phosphats of strontian, potass, soda, ammonia, glucina, alumina.

This salt is too scarce at present to be employed for any useful purpose, otherwise it might serve for the preparation of barytes, and might be introduced into manufactures with much advantage.

Sp. 2. *Carbonat of Strontian.*

THIS salt was first pointed out as distinct from the last species by Crawford in 1790; but we are indebted for the first accurate account of it to Dr Hope. His experiments were afterwards confirmed by Klaproth, Pelletier, Fourcroy, and Vauquelin.

Properties.

It has been found native at Strontian in Argyleshire and at Leadhills in Scotland. It is usually in striated semitransparent masses, which have a greenish tinge.

It has no taste. It requires 1536 parts of boiling

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* Nicholson's *Journal*, iii. 215.

water to dissolve it *. Its specific gravity is about 3.66. It is not altered by exposure to the air.

When strongly heated in a crucible, it loses part of its acid; and this decomposition is facilitated by making it into a paste with charcoal powder. According to Saussure, it melts into a transparent glass at the temperature of 226° Wedgewood †. When thrown in powder on burning coals, it produces red sparks.

Composition.

According to the analysis of Dr Hope, it is composed of . . . . 30.2 acid
61.2 strontian
8.6 water
100.0 ‡

According to Pelletier of 30 acid
62 strontian
8 water
100 §

According to Klaproth and Kirwan, of
30.0 acid
69.5 strontian
0.5 water
100.0 ‖

Hitherto it has not been applied to any use.

Sp. 3. *Carbonat of Lime.*

THIS substance, under the names of marble, chalk, lime-stone, &c. exists in great abundance in nature,

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* Hope, *Trans. Edin.* iv. 5.

† *Jour. de Phys.* xlv. 24.

‡ Hope, *Trans. Edin.* iv. 8.

§ *Ann. de Chim.* xxi. 135.

‖ Beytrage, i. 270. and Nicholson's *Journal*, iii. 215.

variously mixed with other bodies. It is perhaps the most important and most generally used of all the salts, unless we except muriat of soda. Its properties of course have been very completely investigated.

Properties.

It is often found crystallized and perfectly transparent. The primitive form of its crystals is the rhomboidal prism with angles of 101½° and 78½°. Its integrant particles have the same form. But, besides the primitive, no less than 42 varieties of its crystals have been discovered and described by mineralogists.

It has scarcely any taste. Its specific gravity is about 2.7.

It is insoluble in pure water; but water saturated with carbonic acid dissolves $\frac{1}{1500}$ part of it; from this solution it gradually precipitates as the acid leaves it in the form of a white powder*.

It suffers little or no alteration by being exposed to the air.

When exposed to heat, it decrepitates and loses its water, and afterwards its acid separates as the heat is increased: But to separate the acid completely, a pretty strong heat is required.

According to Bergman it is composed of

Composition.

34 acid
55 lime
11 water

100 †

According to Kirwan of 45 acid
55 lime

100 ‡

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* Bergman, i. 26.

† *Opusc.* i. 23.

‡ Nicholson's *Jour.* iii. 215.

Decomposition.

According to Fourcroy, it is decomposed by the following salts:

1. Sulphats of ammonia, magnesia, glucina, alumina, zirconia.
2. Sulphites of magnesia, glucina, alumina, zirconia.
3. Phosphats of strontian, potass, soda, ammonia, magnesia, glucina, alumina, zirconia.
4. Fluats of barytes, strontian, magnesia, ammonia, glucina, alumina, zirconia.
5. Borats of magnesia, ammonia, glucina, alumina, zirconia.

Sp. 4. *Carbonat of Potass.*

This salt has been long known to chemists; and before its composition was ascertained by Black, it was characterized by a great variety of names, according to the manner of preparing it; such as fixed nitre, salt of tartar, fossil alkali, &c. Its properties were first described with precision by Bergman in 1774 *.

Formation.

This salt is formed by saturating potass with carbonic acid, which is best done by exposing a solution of potass for a considerable time to carbonic acid gas, or by causing the gas to pass through a solution of potass till it refuses to absorb any more. The potass of commerce is a mixture of this salt and pure potass: by distilling it with solid carbonat of ammonia, it may be also converted into carbonat of potass †.

When potass is saturated with carbonic acid it always lets fall a quantity of silica. Mr Pelletier has proposed this saturation as the best method of purifying potass from that earth.

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* *Opusc.* i. 13.

† Berthollet.

Properties.

It crystallizes, according to Bergman, in quadrangular prisms; the apexes of which are composed of two inverted triangles, converging like the roof of a house [*]. According to Pelletier they are tetrahedral rhomboidal prisms, with dihedral summits. The complete crystal has eight faces, two hexagons, two rectangles, and four rhombs [†].

It has an alkaline, but not a caustic taste. Its specific gravity is 2.012 [‡].

It is soluble at the common temperature in about four times its weight of water [§]. Boiling water dissolves $\frac{5}{6}$ths of its weight [||]. Alcohol, even when hot, does not dissolve above $\frac{1}{1200}$ parts of it. Pelletier has observed, that when the crystallized salt is dissolved in boiling water, bubbles of carbonic acid gas are emitted.

It is not altered by exposure to the air.

Heat deprives it of its water and part of its acid, but does not decompose it completely.

According to Bergman, this salt is composed of

Composition.

20	acid
48	potass
32	water
100	

According to Kirwan, of

43	acid
41	potass
16	water
100 [**]	

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[*] Bergman, i. 13.

[†] *Ann. de Chim.* xv. 29.

[‡] Hassenfratz, *Ann. de Chim.* xxviii. 12.

[§] Bergman, i. 13.

[||] Pelletier.

[**] Nicholson's *Journal*, iii. 215.

According to Pelletier of 43 acid
40 potass
17 water

100

Bergman seems to have under-rated the quantity of acid, from not observing that the salt loses part of its acid when heated. Even solution in hot water produces a separation of some acid.

Decomposition.

It is decomposed by the following salts:

1. Almost all salts with earthy bases.
2. Almost all salts with metalline bases.
3. All ammoniacal salts.

The uses to which this salt is applied are very numerous. Indeed it is in this state, or at least partly in this state, that potass is employed by manufacturers.

Sp. 5. Carbonat of Soda.

Formation.

This salt has been also very long known. It is usually obtained by burning and lixiviating marine plants, or by decomposing common salt. In commerce it is usually called *barrilla* or *soda*. In that state, however, it is never perfectly pure, containing always a mixture of earthy bodies, and usually common salt; but it may be purified by dissolving it in a small portion of water, filtrating the solution, and evaporating it at a low heat, skimming off the crystals of common salt as they form on its surface.

Properties.

It crystallizes in decahedrons composed of two four-sided pyramids applied base to base, and having their apexes truncated *. It is often obtained also in large transparent flat rhomboidal prisms.

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* Bergman, i. 19.

Its taste is precisely the same with that of the carbonat of potass. Its specific gravity is 1.3591 *.

It is soluble in two parts of cold water, and in rather less than its weight of boiling water. So that when dissolved in boiling water it crystallizes as the solution cools.

When exposed to the air, it very soon effloresces and falls to powder.

When heated, it very soon undergoes the watery fusion, and the soda of commerce sometimes contains so much water of crystallization, that when once melted, it remains permanently liquid. If the heat be continued, the water gradually evaporates, and the salt becomes dry. In a red heat it melts into a transparent liquid. A very violent heat drives off the greater part of its acid. This salt melts rather more easily than carbonat of potass, and for that reason it is preferred by glass manufacturers.

Composition.

According to Bergman, it is composed of

16	acid
20	soda
64	water
100 †	

According to Kirwan, when crystallized, it is composed of . . . . . .

14.42	acid
21.58	soda
64.00	water
100.00	

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* Hassenfratz, *Ann. de Chim.* xxviii. 12.

† Bergman, i. 18.

And when dry of . .	40.05 acid
	59.86 soda
	99.91 [*]

It is decomposed by the same salts which decompose the carbonat of potass.

Sp. 6. *Carbonat of Magnesia.*

This salt has been long known. Its composition was first discovered by Dr Black: afterwards its properties were investigated by Bergman and Butini, and more lately by Fourcroy [†].

Preparation.

It is usually prepared by mixing together the solutions of sulphat of magnesia and carbonat of potass, and applying heat. The carbonat of magnesia precipitates in the state of a white powder. Such is the state in which it occurs in commerce; but Fourcroy has shown that in that state it does not contain a maximum of acid. It is therefore only a sub-carbonat; but it may be saturated with acid by diffusing it in water, and making carbonic acid gas to pass through it till it be saturated and dissolved. It then forms by evaporation crystals, which are transparent hexagonal prisms, terminated by a hexagonal plane: these are partly in groups and partly solitary: their length is about six lines, their breadth two [‡]. But it may be obtained in more regular crystals, by mixing together 125 parts of sulphat of magnesia and 136 parts of carbonat of soda, both dissolved in water, filtering the solution, and then setting it aside. In two or three days the carbonat of magnesia crystallizes.

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[*] Nicholson's *Jour.* iii. 215.

[†] *Ann. de Chim.* ii. 278.

[‡] Butini, *sur la Magnesie.*

Book II. Division II.

Properties.

This salt has little taste. Its specific gravity, when in powder, is only 0.2941 according to Hassenfratz [*].

It is soluble, when crystallized, in 48 parts of cold water; but when in powder, it requires at least ten times as much; and what is very remarkable, it is more soluble in cold than in hot water, impregnated with carbonic acid [†].

When exposed to the air, it effloresces, and falls into powder [‡].

When heated, it decrepitates, falls into powder, and is decomposed.

Composition.

According to Fourcroy and Kirwan, it is composed of

50	acid
25	magnesia
25	water
100	

The sub-carbonat is composed of

48	acid
40	magnesia
12	water
100	

Bergman and Butini, on the other hand, found the component parts in the following proportions:

Bergman.	Butini.	
30	36	acid
45	43	magnesia
25	21	water
100	100	

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[*] *Ann. de Chim.* xxviii. 12.

[†] Butini.

[‡] Fourcroy, *Ann. de Chim.* ii. 298.

But their carbonat does not seem to have been fully saturated with acid. The magnesia of commerce, according to Kirwan, is composed of 34 acid
45 magnesia
21 water

100 *

According to Fourcroy, carbonat of magnesia is decomposed by the following salts :

Decomposition.

1. Sulphats of ammonia, glucina, alumina, zirconia.
2. Sulphites of glucina, alumina, zirconia.
3. Nitrats and muriats of glucina, alumina, zirconia.
4. Super-phosphat of lime.
5. Phosphats of alumina, zirconia.

This salt is employed in medicine to remove acidity in the stomach.

Sp. 7. Carbonat of Ammonia.

THIS salt has been also long known. It is often obtained by distilling animal substances ; but for chemical purposes it is best to extract it from sal ammoniac by means of chalk. Two parts of chalk and one part of sal ammoniac, both as dry as possible, are mixed together and put into an earthen retort. On the application of a sufficient heat, carbonat of ammonia sublimes, and is obtained in the state of a white crystallized mass.

Properties.

Its crystals are so small and so irregular, that it is difficult to ascertain their form. According to Bergman, they may be obtained in octahedrons, having, for the most part, their two opposite apexes truncated †.

The taste and smell of this salt, though much weaker,

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* Nicholson's *Journal*, iii. 215.

† Bergman, i. 21.

are the same with those of pure ammonia. Like all the alkaline carbonats it converts vegetable blues to green, precisely as pure alkalies do. Its specific gravity is 0.966[*].

It is soluble in rather less than twice its weight of cold water. Hot water dissolves its own weight of it. Boiling water cannot be employed, because at that heat the carbonat is volatilized.

It is not altered by exposure to the air. When heated it evaporates very speedily.

Varieties.

Mr Davy has shown that the component parts of this salt vary exceedingly, according to the manner of preparing it. The lower the temperature at which it is formed the greater is the proportion of acid and water which it contains; and, on the other hand, the higher the temperature the greater is the proportion of alkali. Thus carbonat of ammonia, formed at the temperature of 300°, contained more than 50 per cent. of alkali, while carbonat formed at 60°, contained only 20 per cent.[†]

Composition.

According to Bergman, it is composed of 45 acid
43 ammonia
12 water

100[‡]

According to Kirwan, it is composed of about 13 parts of acid combined with six of alkali[§].

It is decomposed, according to Fourcroy, by the following salts.

Decomposition.

1. Sulphats of lime, glucina, alumina, zirconia.

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[*] Hassenfratz, *Ann. de Chim.* xxviii. 12.

[†] Davy's *Researches*, p. 75.

[‡] Bergman, i. 21.

[§] Nicholson's *Journal*, iii. 215.

2. Sulphites, muriats, and fluats of barytes, lime, strontian, magnesia, glucina, alumina, zirconia.
3. Nitrat of barytes.
4. Super-phosphat of lime.

This salt is employed in medicine, and in the manufacture of sal ammoniac.

Sp. 8. *Carbonat of Ammonia-and-magnesia.*

THIS salt has been formed by Fourcroy by mixing together aqueous solutions of its two component parts; but its properties have not been examined.

Sp. 9. *Carbonat of Glucina.*

THIS salt has only been examined by Vauquelin It may be prepared by precipitating glucina from its solution in acids by an alkaline carbonat, and washing the precipitate sufficiently with pure water.

It is in the state of a white soft powder, which has a greasy feel. It has no taste, and is exceedingly light.

It is insoluble in water, not altered by exposure to the air, easily decomposed and its acid driven off by the application of heat.

Sp. 10. *Carbonat of Alumina.*

THE greater number of chemists have agreed in admitting the existence of this salt. Bergman could not form it artificially; but he allows its existence, because when alum is mixed with an alkaline carbonat, part of the alumina remains in solution till the carbonic acid be driven off*. Saussure has shown lately, that water,

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* Bergman, i. 32.

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saturated with carbonic acid, is capable of dissolving alumina; but this combination is destroyed by simple exposure to the air. Carbonat of alumina, then, cannot exist in a dry state. What had been considered formerly as a dry carbonat is a triple compound of alumina, carbonic acid, and the alkali employed in precipitating the alumina[†].

Sp. 11. *Carbonat of Zirconia.*

THIS salt was formed by Vauquelin by precipitating zirconia from its solution in acids by alkaline carbonats. It is a tasteless white powder, composed of

44.5 acid and water
55.5 zirconia
———
100.0

When heated the carbonic acid is driven off.

This salt is soluble in the three alkaline carbonats, and seems to form with them triple salts.

GENUS XII. ARSENIATS.

THE existence of this genus of salts was first discovered by Macquer; but their nature and composition was first pointed out by Scheele in his Dissertation on Arsenic, published in 1775. Since the researches of these two illustrious chemists, scarcely any addition has been made to our knowledge of the arseniats, if we except a few observations on some of these salts by Pelletier.

They may be distinguished by the following property:

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[*] *Jour. de Phys.* lii, 28.

When heated along with charcoal powder, they are decomposed, and arsenic sublimes.

Character.

Sp. 1. *Arseniat of Barytes.*

THIS salt was formed by Scheele by dissolving barytes in arsenic acid. When the saturation was nearly completed, the salt precipitated in the state of an insoluble powder. It may be formed also by mixing arseniat of potass with nitrat or muriat of barytes. This salt is insoluble in water except there be an excess of acid. When exposed to a violent heat, it shows a tendency to melt, but is not decomposed*.

Sp. 2. *Arseniat of Strontian.*

Unknown.

Sp. 3. *Arseniat of Lime.*

WHEN arsenic acid is dropt into lime-water, arseniat of lime is precipitated; but if an excess of acid be added, the salt is redissolved, and yields when evaporated small crystals of arseniat of lime, which are soluble in water, and decomposed by sulphuric acid. This salt may be formed also by dissolving chalk in arsenic acid, or by mixing the alkaline arseniats with the the nitrat, muriat or acetite of lime. Arseniat of lime, when heated, exhibits the same phenomena as the first species †.

Sp. 4. *Arseniat of Magnesia.*

MAGNESIA dissolves in arsenic acid; but when the acid is nearly saturated, the solution becomes thick and

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* Scheele, i. 163.

† Ibid. p. 157.

coagulates. The coagulum redissolves in an excess of acid, and yields when evaporated an incrystallizable gummy mass. This salt may be obtained also by mixing the alkaline arseniats with nitrat, muriat, and acetite of magnesia. When heated, it exhibits the same phenomena as the first species *.

Sp. 5. *Arseniat of Potass.*

When arsenic acid is saturated with potass, it forms an incrystallizable salt, which deliquesces in the air, renders syrup of violets green, but does not alter the infusion of turnsole. When heated in a clay crucible, it is partly converted into a white glass, and partly changed into super-arseniat of potass. When mixed with one-eighth of its weight of charcoal-powder, and distilled in a retort, it swells and bubbles up violently, evidently in consequence of the disengagement of carbonic acid gas, and at the same time a quantity of arsenic is sublimed: the residuum is merely carbonat of potass and charcoal. This salt is decomposed by

1. Nitrat, muriat, and acetite of barytes.
2. Nitrat, muriat, and acetite of lime and of magnesia*.

Sp. 6. *Super-arseniat of Potass.*

This salt was first formed by Macquer; and for that reason was long distinguished by the name of *arsenical neutral salt of Macquer*. He obtained it by distilling in a retort a mixture, consisting of equal parts of white oxide of arsenic and nitre. After the distillation the white saline mass, which remained in the retort, was dissolved in hot water and filtered. When properly eva-

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* Scheele, i. 159.

† Ibid. p. 142.

porated, beautiful transparent crystals of super-arseniat of arsenic are obtained[*].

Scheele first ascertained the composition of this salt, by discovering that it was obtained by adding arsenic acid to the arseniat of potass, till the solution ceases to alter the colour of syrup of violets. It then reddens the infusion of turnsole, and yields by evaporation fine crystals of Macquer's neutral salt.

Properties.

This salt crystallizes in four-sided prisms, terminated by four-sided pyramids, the edges of which correspond with those of the prism. It is soluble in water, and gives a red colour to vegetable blues. This salt is not decomposed by salts with base of lime or magnesia, as is the case with arseniat of potass[†].

Sp. 7. *Arseniat of Soda.*

WHEN arsenic acid is saturated with soda, it yields by evaporation crystals of arseniat of soda, which, according to Scheele, are similar to those of the super-arseniat of potass: but, according to Pelletier, are regular six-sided prisms, not terminated by any pyramids. Its properties, when heated as far as they have been examined, coincide with those of arseniat of potass. When an excess of acid is added, this salt does not crystallize; and when evaporated to dryness, attracts moisture again from the air[‡].

Sp. 8. *Arseniat of Ammonia.*

WHEN arsenic acid is saturated with ammonia, the solution yields by evaporation crystals of arseniat of am-

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[*] *Mem. Par.* 1746 and 1748.

[†] Macquer and Scheele.

[‡] Scheele, i. 144.

monia in rhomboidal prisms, which give a green colour to syrup of violets. With an excess of acid, it yields needle-formed crystals of super-arseniat of ammonia, which deliquesce when exposed to the air.

When arseniat of ammonia is gently heated, it loses its transparency and part of its alkali. In a strong heat, a portion of the ammonia is decomposed, water is formed, arsenic sublimed, and azotic gas disengaged. This was one of the experiments which first led Scheele to the discovery of the component parts of ammonia*.

Sp. 9. *Arseniat of Glucina.*

Unknown.

Sp. 10. *Arseniat of Yttria.*

When yttria is dissolved in arsenic acid, and the solution boiled, arseniat of yttria precipitates in the state of a white powder†.

Sp. 11. *Arseniat of Alumina.*

Arsenic acid readily dissolves newly precipitated alumina. When the solution is evaporated, it gives a thick mass insoluble in water. This salt may be formed by mixing the alkaline arseniats with sulphat, nitrat, muriat, or acetite of alumina‡.

Sp. 12. *Arseniat of Zirconia.*

Unknown.

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* Scheele, i. 145.

† Eckeberg, Crell's *Annals*, 1799, ii. 70.

‡ Scheele, i. 160.

GENUS XIII. ARSENITES.

FOURCROY has given this name to the combinations formed between white oxide of arsenic or arsenious acid as he calls it, and the alkalies and earths. They were formerly termed *livers* of arsenic, from some fancied resemblance which was traced between arsenic and sulphur. The alkaline arsenites may be prepared by dissolving the white oxide in alkaline solutions. They form a thick viscid yellow-coloured liquid, with a very nauseous odour. They do not crystallize: heat decomposes them, by subliming the oxide, and almost all the acids precipitate the arsenic in the form of a white powder *.

Properties.

The earthy arsenites, as far as they have been examined, are insoluble powders. Hence the reason that white oxide of arsenic occasions a precipitate when dropt into lime, barytic, or strontian water.

These salts have been but very superficially examined, and are by no means sufficiently known to admit of a detailed description.

GENUS XIV. MOLYBDATS.

Super-molybdat of potass.

THESE salts, composed of molybdic acid combined with the alkalies and earths, were formed by Scheele; but their properties are still almost completely unknown. The super-molybdat of potass alone has been described with some detail. It is formed by detonating one part of sulphuret of molybdenum and three parts of nitre in a crucible. By dissolving the reddish mass which

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* Macquer's *Dictionary*.—Bergman, ii. 296.

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remains after this operation and filtering, a solution of sulphat of potass and molybdat of potass is obtained. By evaporating the solution, the sulphat of potass is separated; when sulphuric acid is dropt into the remaining liquid, super-molybdat of potass is precipitated. This salt is soluble in water. Its solution crystallizes by evaporation in small rhomboidal plates inserted into each other. They are bright, and have a metallic taste. When exposed to the blow-pipe upon charcoal, they melt without swelling, and are converted into small globules, which are quickly absorbed by the charcoal. When melted with a mixture of phosphat of soda and of ammonia (or microcosmic salt), they communicate a green tinge. Hot water dissolves them completely, and prussiat of potass occasions in this solution a reddish brown precipitate. When a solution of muriat of tin is poured upon them, they acquire a blue colour *.

Genus XV. Tungstats.

Though Scheele first announced the existence of these salts, we owe the first observations concerning their properties to the De Luyarts; and the indefatigable Vauquelin, assisted by Mr Hecht, has lately given a detailed description of them from his own experiments †. These salts are combinations of the yellow oxide of tungsten with the alkalies and earths.

Sp. 1. *Tungstat of Potass.*

This salt may be formed by dissolving oxide of

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* Klaproth, *Ann. de Chim.* viii. 106.

† *Jour. de Min.* No. 19. p. 20.

tungsten in the solution of potass or carbonat of potass. The solution always retains an excess of potass, refusing to dissolve the oxide before the alkali be completely neutralized. By evaporation the tungstat of potass precipitates in the state of a white powder.

This salt has a metallic and caustic taste; it is soluble in water, and very soon deliquesces when exposed to the air. Its solution in water is decomposed by all the acids: they occasion a precipitate composed of the oxide, potass, and the acid employed. This precipitate or triple salt is the molybdic acid of Scheele[*].

Sp. 2. Tungstat of Soda.

This salt may be formed by the same process as the last. When the solution is evaporated, the tungstat of soda crystallizes in elongated hexahedral plates.

It has an acrid and caustic taste; it is soluble in four parts of cold water, and in two parts of boiling water. Sulphuric, nitric, muriatic, acetous, and oxalic acids, occasion a precipitate in its solution, which is a triple salt, varying according to the acid employed. Phosphoric acid occasions no precipitate, nor is any precipitate produced when sulphuric acid is dropt in after phosphoric acid, No precipitate is occasioned by the sulphats of potass and of magnesia; but a white precipitate is occasioned by the following salts:

1. Muriats of lime and barytes; alum.
2. Almost all metallic salts[†].

Sp. 3. Tungstat of Ammonia.

This salt may be formed by the same process as the

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[*] Vauquelin and Hecht, *Jour. de. Min.* No. xix. p. 20.

[†] Ibid.

others. By evaporating the solution, the tungstat of ammonia crystallizes, sometimes in small scales resembling boracic acid, and sometimes in four-sided prismatic needles. Its taste is metallic; it is soluble in water, does not deliquesce in the air, and is decomposed completely by heat. It is composed of

78 oxide
22 ammonia and water

100*

Sp. 4. *Tungstat of Barytes.*

An insoluble powder, not examined[†].

Sp. 5. *Tungstat of Lime.*

This salt is found native, and is known to mineralogists by the name of *tungsten*. It was first described, and gave its name to the metallic oxide and to the whole genus.

It is of a yellowish grey colour, and sometimes crystallized, and always somewhat transparent. The primitive form of its crystals, according to Hauy, is the octahedron. Its specific gravity is about 6, and its hardness is generally considerable. It is insoluble in water, and is not sensibly altered by exposure to heat. According to the analysis of Scheele, it is composed of

70 oxide of tungsten
30 lime

100

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[*] Vauquelin and Hecht, *Jour. de Min.* No. xix. p. 20.

[†] Scheele, ii. 90.

Sp. 6. Tungstat of Magnesia.

When the yellow oxide of tungsten is boiled with carbonat of magnesia, the liquid yields, when evaporated, tungstat of magnesia in small brilliant scales. It is soluble in water, not altered by exposure to the air, and has a taste similar to that of the other species of tungstats. When an acid is dropt in, a white powder or triple salt precipitates.

Sp. 7. Tungstat of Alumina.

This salt is an insoluble powder.

Sp. 8. Nitrated Tungstat of Potass.

These tungstats are capable of combining with a number of acids, and forming with them a particular kind of neutral salts which have not been particularly examined, if we except *nitrated tungstat of potass*, which is the salt originally described by Scheele under the name of *acid of tungsten*.

This salt is obtained in the form of a white powder; it has an acid and bitter taste, reddens the infusion of turnsole, and is soluble in 20 parts of boiling water. The De Luyarts first showed it to be a compound of nitric acid, oxide of tungsten, and potass.

Genus XVI. Chromats.

This genus of salts is still almost entirely unknown. The alkaline chromats are capable of crystallizing, and are easily distinguished by the beautiful orange colour of the crystals, and of their solution in water. The earthy chromats seem to be nearly insoluble in water.

GENUS XVII. ACETITES.

THIS genus of salts has been known almost since the commencement of chemistry. They may be distinguished by the following properties :

Characters.

1. Decomposed by the action of heat ; the acid being either driven off or destroyed.

2. All very soluble in water.

3. When mixed with sulphuric acid and distilled in a moderate heat, acetous acid is disengaged.

4. When they are dissolved in water, and exposed to the open air, their acid is gradually decomposed.

Sp. 1. *Acetite of Barytes.*

THIS salt may be formed by dissolving barytes or its carbonat in acetous acid, or by decomposing the sulphuret of barytes by that acid. By spontaneous evaporation the acetite crystallizes in fine transparent prismatic needles. Its specific gravity is 1.828 *.

It has an acid and somewhat bitter taste ; it is soluble in water, and does not deliquesce when exposed to the air, but rather effloresces.

It is decomposed by the alkaline carbonats and by almost all the sulphats. Hence it is often employed to detect the presence of sulphuric acid in solutions.

Sp. 2. *Acetite of Potass.*

PLINY is supposed, but probably without any reason, to have been acquainted with this salt, because he recommends a mixture of vinegar and vine ashes as a cure for a particular species of tumor †. It was first

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* Hassenfratz, *Ann. de Chim.* xxviii. 12.

† *Plinii*, lib. xxiii. *proœmium*.

clearly described by Raymond Lully. It has received a great number of names; as, for instance, *arcanum tartari. secret foliated earth of tartar, essential salt of wine, regenerated tartar, diuretic salt, digestive salt of Sylvius.*

Properties.

It is usually formed by dissolving carbonat of potass in acetous acid, and evaporating the solution to dryness in a moderate heat. By this process it is obtained in fine white plates. By a well-managed evaporation it may be procured in regular prismatic crystals.

This salt has a sharp warm taste. At the temperature of 60°, 100 parts of it are soluble in 102 parts of water. It is soluble also in alcohol. When exposed to the air, it very soon deliquesces. When heated, it readily melts, and in a high temperature its acid is decomposed, and there remains behind a mass composed chiefly of the potass and charcoal, which, when the experiment is made in close vessels, often takes fire when exposed to the air. When distilled along with white oxide of arsenic, it yields a white smoke, which has an odour intolerably offensive, and takes fire when it comes into contact with the air.

Composition.

According to Wenzel, 240 parts of acetous acid require for saturation $241\frac{4}{9}$ths of potass. And from the experiments of Dr Higgins, it appears that acetite of potass is composed of

38.5 acid and water
61.5 potass
———
100*

It is decomposed by the greater number of metallic salts.

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* *On Acetous Acid.* p. 8.

Sp. 3. *Acetite of Soda.*

This salt, which seems to have been first examined by Baron, was formerly known by the absurd name of *crystallized foliated earth.*

It is usually prepared by saturating acetous acid with carbonat of soda, and evaporating the solution till a thin pellicle appears on its surface. When the solution is allowed to cool, the acetite of soda crystallizes in striated prisms, not unlike those of sulphat of soda. It has a sharp taste, approaching to bitter. It is soluble in 2.86 parts of water at the temperature of 60°[*]. Its specific gravity is 2.1[†].

It is not affected by exposure to the air. When heated, it first loses its water of crystallization; in a strong heat it melts; and in a still stronger its acid is destroyed. This salt can only be obtained in crystals when there is an excess of alkali in the solution.

According to Wenzel, 440 parts of acetous acid require for saturation 175$\frac{3}{7}$ of soda.

Sp. 4. *Acetite of Strontian.*

This salt, which was first examined by Dr Hope, and afterwards by Vauquelin, is easily formed by dissolving strontian or its carbonat in acetous acid. By evaporation it is obtained in small crystals, which are not affected by exposure to the atmosphere. 49 parts of it are soluble in 120 parts of boiling water: It seems to be nearly as soluble in cold water. It renders vegetable colours green[‡].

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[*] Bergman, v. 78.

[†] Hassenfratz, *Ann. de Chim.* xxviii. 12.

[‡] Hope, *Trans. Edin.* iv. 14.

Its taste is not unpleasant. When heated, its acid is decomposed, as happens to all the other acetites.

Sp. 5. *Acetite of Lime.*

THIS salt was first described accurately by Crollius. The ancients, however, used a mixture of lime and vinegar in surgery [*].

It is easily formed by dissolving chalk in acetous acid. When the solution is evaporated till a pellicle forms on its surface, it yields, on cooling, the acetite of lime in fine prismatic needles of a glossy appearance like satin. Its specific gravity is 1.005 [†].

Its taste is bitter and sour, because it has an excess of acid. It is soluble in water. It is not altered by exposure to the air; at least Morveau kept some of it for a whole year merely covered with paper, and even quite uncovered for a month, without its undergoing any alteration [‡].

Heat decomposes it by disengaging and at the same time partly decomposing its acid.

Composition.

According to Wenzel, 240 parts of acetous acid require for saturation 125 of lime; according to Maret, 100 parts of acetite of lime contain 50 of lime [||]. From the experiments of Dr Higgins, it follows, that acetite of lime is composed of 35.7 parts of lime and 64.3 of acetous acid and water [§].

Sp. 6. *Acetite of Ammonia.*

THIS salt was formerly called *spirit of Mindererus.*

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[*] *Plinii* lib. xxxvi. c. 24.

[†] Hassenfratz, *Ann. de Chim.* xxviii. 12.

[‡] Morveau, *Encycl. Method.* i. 9.

[||] Ibid.

[§] *On Acetous Acid*, p. 47.

It may be prepared by the same process as the other acetites.

Properties.

It is too volatile to be easily crystallized: It may, however, by gentle evaporation, be made to deposite needle-shaped crystals. Mr de Lassone crystallized it by sublimation[*]. When the sublimation is slow, it forms long, slender, flatted crystals, terminating in sharp points, of a pearl-white colour, and about an inch and eight-tenths in length[†].

It impresses the tongue at first with a sense of coldness, and then of sweetness, which is followed by a taste resembling that of a mixture of sugar and nitre, in which the sweet does not predominate over the mawkish taste of the nitre[‡].

It is very deliquescent. It melts at 170°, and sublimes at about 250°[‖].

When a watery solution of this salt is distilled, there comes over first a quantity of ammonia, next a quantity of acetous acid, and at last of the neutral salt itself. No such decomposition takes place when the crystals are distilled by a moderate heat[§].

According to Wenzel, 240 parts of acetous acid require for saturation 244 of ammonia. This salt is often used in medicine as a sudorific.

Sp. 7. Acetite of Magnesia.

This salt may be formed by dissolving magnesia or its carbonat in acetous acid.

It is not crystallizable; but forms by evaporation a

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[*] *Mem. Par.* i. 775.

[†] Higgins *On Acetous Acid*, p. 188.

[‡] Higgins, Ibid. p. 192.

[‖] Ibid.

[§] Ibid.

viscid mass[*]. It has a sweetish taste; leaving, however, a sense of bitterness[†]. Its specific gravity is 1.378[‡]. It is very soluble both in water and alcohol[‖]. When exposed to the air, it deliquesces. Heat decomposes it.

According to Wenzel, 240 parts of acetous acid require for saturation $123\frac{3}{4}$ths of magnesia.

Sp. 8. *Acetite of Glucina.*

ACETOUS acid readily dissolves glucina; but the solution, as Vauquelin informs us, does not crystallize, but is converted by evaporation into a gummy mass, which becomes slowly dry and brittle. Its taste is sweet and astringent.

Sp. 9. *Acetite of Yttria.*

YTTRIA dissolves readily in acetous acid, and the solution yields by evaporation crystals of acetite of yttria. These crystals have most commonly the form of thick six-sided plates, and are not altered by exposure to the air[**].

Sp. 10. *Acetite of Alumina.*

THIS salt can only be formed by digesting acetous acid on alumina recently precipitated. By evaporation needle-shaped crystals are obtained, which are very deliquescent. According to Wenzel, 240 parts of acetous acid require $20\frac{5}{7}$ths of alumina for saturation. This salt has an astringent taste. Its specific gravity is 1.245[††].

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[*] Bergman, i. 388.

[†] Morveau, *Encycl. Method.* i. 9.

[‡] Hassenfratz, *Ann. de Chim.* xxviii. 12.

[‖] Bergman, i. 388.

[**] Eckeberg, Crell's *Annals*, 1799. ii. 69.

[††] Hassenfratz, *Ann. de Chim.* xxviii. 12.

Sp. 11. *Acetite of Zirconia.*

This salt may be formed by pouring acetous acid on newly precipitated zirconia. It has an astringent taste. It does not crystallize; but when evaporated to dryness, it forms a powder, which does not attract moisture from the air as acetite of alumina does *. It is very soluble in water and in alcohol. It is not so easily decomposed by heat as nitrat of zirconia, probably because it does not adhere so strongly to water †.

Genus XVIII. Oxalats.

This genus of salts was first made known by Bergman, who described the greater number of them in his dissertation on oxalic acid, published in 1776 ‡. These salts may be distinguished by the following properties:

Characters.

1. When exposed to a red heat, their acid is decomposed and driven off, and the base only remains behind.

2. Lime water precipitates a white powder from their solutions, which is soluble in acetous acid, after being exposed to a red heat.

3. The earthy oxalats are in general nearly insoluble in water: the alkaline oxalats are capable of combining with an excess of acid, and forming super-oxalats much less soluble than the oxalats.

Sp. 1. *Oxalat of Lime.*

Oxalic acid does not readily dissolve lime, on ac-

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* Klaproth, *Jour. de Phys.* xxxvi. 188.

† Vauquelin, *Ann. de Chim.* xxii. 206.

‡ *Opusc.* i. 260.

count of the insolubility of the oxalat of that base; but the salt may be readily formed by dropping oxalic acid into any of the acid solutions of lime. The oxalat of lime immediately precipitates in the state of a white insipid powder, insoluble in water, and communicating a green colour to the syrup of violets.

Composition.

According to Bergman's analysis, it is composed of

48	acid
46	lime
6	water
100 [*]	

No acid decomposes this salt, nor any alkaline or earthy body; but the acid may be easily decomposed and driven off by the action of heat.

Sp. 2. *Oxalat of Barytes.*

OXALIC acid readily dissolves barytes, and the solution, when saturated, lets fall small transparent crystals of oxalat of barytes, because that salt is but little soluble in water. These crystals contain an excess of acid. When boiled in water, they lose this excess, and in consequence fall down in the state of an insoluble powder [†].

Sp. 3. *Oxalat of Strontian.*

THIS salt, first examined by Dr Hope and afterwards by Vauquelin, may be readily formed by mixing together a solution of oxalat of potass and nitrat of strontian. The oxalat of strontian immediately precipitates. It is a white insipid powder; soluble in 1920 parts of

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[*] Bergman, i. 262.

[†] Ibid. 263.

Composition.

boiling water. Heat decomposes it by destroying the acid *. According to the calculation of Mr Vauquelin, it is composed of . . . 40.5 acid
59.5 strontian

100.0 †

Sp. 4. *Oxalat of Magnesia.*

This salt may be obtained by saturating oxalic acid with magnesia, and evaporating the solution. It is in the form of a white powder. It is scarcely soluble either in water or alcohol. Heat decomposes it. It is composed of 65 acid and water
35 magnesia

100 ‡

Sp. 5. *Oxalat of Potass.*

This salt is easily formed by dissolving potass in oxalic acid; but the solution does not readily crystallize unless there be a slight excess either of the acid or the base. A solution, composed of two parts of carbonat of potass, dissolved in one part of acid, yields six-sided prisms, not unlike the crystals of oxalic acid.

These crystals fall to powder when heated. They give a green tinge to litmus paper, but they redden tincture of litmus and syrup of violets §.

Sp. 6. *Super-oxalat of Potass.*

History.

This salt exists ready formed in *oxalis acetosella* or wood-sorrel, and in the *rumex acetosa*; from which it is

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* Hope, *Edin. Trans.* iv. 14.

† *Jour. de Min.* An. vi. p. 14.

‡ Bergman, i. 262. and 387.

§ Ibid. p. 260.

extracted in some parts of Europe in great quantities. Hence it is known by the name of *salt of wood sorrel*, and in this country is sold under the name of *essential salt of lemons*. It is mentioned by Duclos in the Memoirs of the French Academy for 1668. Margraff first proved that it contained potass; and Scheele discovered its acid to be the oxalic. A great many interesting experiments had been previously made on it by Wenzel and Wiegleb.

Formation.

It may be formed, as Scheele has shown, by dropping potass very gradually into a saturated solution of oxalic acid in water: as soon as the proper quantity of alkali is added, the super-oxalat is precipitated. But care must be taken not to add too much alkali, otherwise no precipitation will take place at all *.

Properties.

Its crystals are small opaque parallelopipeds †. It has an acid, pungent, bitterish, taste. It is soluble in about ten times its weight of boiling water, but much less soluble in cold water. It is not altered by exposure to the air. Heat decomposes it.

This salt is capable of combining with most of the alkalies and earths, and of forming with them triple salts, which have not been accurately examined.

Sp. 7. Oxalat of Soda.

WHEN two parts of crystallized carbonat of soda are dissolved in one part of oxalic acid, the oxalat of soda partly precipitates, because it is but sparingly soluble in water. The remaining solution yields by evaporation crystalline grains, which give a green tinge to syrup of violets, and are perfectly soluble in hot water ‡.

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* Crell's *Annals*, i. 107. Eng. Trans.

† Romé de Lisle.

‡ Bergman, i. 261.

This salt is also capable of combining with an excess of acid, and forming a super-oxalat sparingly soluble in water; but the properties of this triple salt have not been much examined.

Sp. 8. *Oxalat of Ammonia.*

When oxalic acid is saturated with ammonia, the solution yields by evaporation oxalat of ammonia crystallized in four-sided prisms, terminated by dihedral summits. They are soluble in water, but insoluble in alcohol. When distilled, carbonat of ammonia is disengaged, a little of the salt is sublimed, and a residuum of charcoal remains behind. This salt is much used as a reactive to detect the presence of lime *.

It is capable of combining with an excess of acid, and forming a super-oxalat.

Sp. 9. *Oxalat of Alumina.*

Oxalic acid readily dissolves alumina, and forms a salt which is uncrystallizable; but furnishes on evaporation a yellowish pellucid mass. It is sparingly soluble in alcohol. It has a sweet astringent taste. It is composed of . . . . 44 alumina

56 acid and water

100

When exposed to the air it deliquesces; and if it has been previously well dried, its weight is increased by $\frac{2}{3}$. It reddens turnsole †.

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* Bergman, i. 261.

† Ibid. ii. 387.

Sp. 10, 11, and 12.

THE oxalats of glucina, yttria, and zirconia, are still unknown.

GENUS XIX. TARTRITES.

THOUGH tartarous acid was first obtained by Scheele in a separate state, several of the tartrites had been previously examined, having been formed, partly by decomposing tartar, and partly by combining it with other bases. Since the discovery of pure tartarous acid, they have been examined by Retzius, by Von Packen, and more lately by Thenart. They may be distinguished by the following properties:

Characters.

1. When exposed to a red heat, the acid is decomposed and the base remains, generally in the state of a carbonat.

2. The earthy tartrites are nearly insoluble in water; the alkaline are soluble; but they combine with an excess of acid, and are converted into super-tartrites, which are much less soluble than the tartrites.

3. When boiled with sulphuric acid, the tartarous acid is separated, and may be detected by dropping in a solution of potass. Tartar precipitates in small gritty crystals like sand.

4. All the tartrites are capable of combining with another base, and forming triple salts.

Sp. 1. *Tartrite of Lime.*

THIS salt may be formed by dissolving lime in tartarous acid, or more economically by dissolving tartar in boiling water, and adding to the solution lime in powder till it ceases to produce any effervescence, and to redden vegetable blues. Tartrite of lime precipitates in the state of a white powder, tasteless, insoluble in water, but soluble in an excess of tartarous acid.

It is decomposed by sulphuric, nitric, and muriatic acids, but by none of the earths or alkalies.

Sp. 2. *Tartrite of Barytes.*

This salt may be formed by the same processes as the tartrite of lime; and, like it, is an insoluble white powder.

Sp. 3. *Tartrite of Strontian.*

This salt, first examined by Dr Hope, and afterwards by Vauquelin, may be formed by dissolving strontian in tartarous acid, or by mixing together solutions of nitrat of strontian and tartrite of potass. Its crystals are small regular triangular tables, having the edges and angles sharp and well defined. It is insipid. It dissolves in 320 parts of boiling water. It is composed of

47.12	acid and water
52.88	strontian
100.00*	

Sp. 4. *Tartrite of Potass.*

This salt, formerly distinguished by the name of *soluble tartar*, is usually prepared by adding at intervals tartar in powder to a hot solution of carbonat of potass till all effervescence ceases. The solution is then boiled for some time, and afterwards evaporated till a pel-

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* Vauquelin, *Jour. de Min.* An. vi. p. 15.

licle forms on its surface. On cooling, the tartrite of potass crystallizes in flat four-sided rectangular prisms, terminated by dihedral summits.

This salt has an unpleasant bitter taste. Its specific gravity is 1.5567 *. It is soluble in four parts of cold water, and still more soluble in hot water. When heated it melts, swells up, blackens, and is decomposed.

Sp. 5. *Tartar, or Super-tartrite of Potass.*

History.

THIS salt is obtained, in a state of impurity, incrusted on the bottom and sides of casks in which wine has been kept. It is afterwards purified by dissolving it in boiling water, and filtering it while hot. On cooling, it deposites the pure salt in very irregular crystals. In this state it is sold under the name of *crystals*, or *cream of tartar*. This salt attracted the peculiar attention of chemists, probably in consequence of the extravagant encomiums and invectives bestowed on it by Paracelsus. It is called *tartar*, says he, because it produces the oil, water, tincture, and salt, which burn the patient as *hell* does. According to him, it is the principle of every disease and every remedy, and all things contain the germ of it. This ridiculous theory was combated by Van Helmont, who gives a pretty accurate account of the formation of tartar in wine casks †.

It was known to Van Helmont, and even to his predecessors, that potass could be obtained from tartar: but it was long a disputed point among chemists, whether that alkali existed in it ready formed. Duhamel, Margraff, and Rouelle, at last established that point be-

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* Hassenfratz, *Ann. de Chim.* xxviii. 12.

† *Tartari Vini Historia*, Van Helmont, p. 224.

yond a doubt; but the other component part of tartar was unknown, or very imperfectly known, till Scheele pointed out the method of extracting it.

Properties.

The crystals of tartar are very small and irregular. According to Montet, they are prisms, somewhat flat, and mostly with six sides.

Tartar has an acid, and rather unpleasant taste. It is very brittle, and easily reduced to powder. Its specific gravity is 1.953[*]. It is soluble in about 60 parts of cold water, and in about 30 parts of boiling water. It is not altered by exposure to the air; but when its solution in water is allowed to remain for some time, the salt is gradually decomposed, a mucous matter is deposited, and there remains in solution carbonat of potass coloured with a little oil. This decomposition was first accurately described by Berthollet in 1782[†].

When tartar is heated, it melts, swells, blackens, and the acid is entirely decomposed. The same changes take place when the salt is distilled in close vessels. The phenomena of this distillation have been described with great care, and its products very attentively examined by chemists; because, before the discovery of the tartarous acid by Scheele, distillation was the only method thought of for obtaining any knowledge of the acid part of tartar. These products are an enormous quantity of gas consisting of carbonic acid and carbonated hydrogen, an oil, and an acid; and, according to some chemists, *carbonat of ammonia*. The acid obtained was long considered as a peculiar body, and was denominated *pyro-tartarous* acid by the French chemists in 1787: But Fourcroy and Vauquelin have lately de-

Pyro-tartarous acid.

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[*] Hassenfratz, *Ann. de Chim.* xxviii. 12.

[†] *Mem. Par.*

monstrated, that it is no other than acetous acid contaminated with a little empyreumatic oil [*].

Composition.

Tartar, according to Bergman, is composed of

77 acid
23 potass
100 [†]

Or of . . . . 56 tartrite of potass
44 tartarous acid
100

According to the late analysis of Thenart, its component parts are
57 acid
33 potass
7 water
97 [‡]

Sp. 6. *Tartrite of Potass-and-lime.*

This salt was first pointed out by Thenart. It may be formed by pouring lime-water into the solution of tartrite of potass till a precipitate begins to appear, and then allowing the liquid to evaporate spontaneously. The triple salt gradually attaches itself to the sides of the vessel in crystals [§].

Sp. 7. *and* 8. *Tartrite of Potass-and-barytes, and Tartrite of Potass-and-strontian.*

These two triple salts may be formed in the same way. They have been pointed out by Thenart; but,

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[*] *Ann. de Chim.* xxxv. 161.

[†] Bergman, iii. 368.

[‡] *Ann. de Chim.* xxxviii. 39.

[§] Ibid. p. 31.

like the preceding salt, their properties are still undescribed *.

Sp. 9. *Tartrite of Soda.*

This salt may be formed by dissolving soda in tartarous acid. It crystallizes in fine needles. Its specific gravity is 1.7437 †. This salt is also capable of combining with an excess of acid, and forming a *super-tartrite* of soda, which is nearly as insoluble in water as tartar ‡.

Sp. 10. *Tartrite of Potass-and-soda.*

Preparation.

This salt is usually prepared by putting one part of tartar in five parts of boiling water, and adding gradually carbonat of soda in powder as long as it continues to produce an effervescence. The tartar gradually dissolves. When the saturation is complete, the solution is filtered and evaporated to the consistence of a syrup. On cooling, the tartrite of potass-and-soda crystallizes.

History.

This salt has been distinguished by the name of *salt of Seignette*, because it was first formed and introduced into medicine by Mr Seignette, an apothecary at Rochelle. This gentleman recommended it in a tract published in 1672. It was soon after introduced into practice in Paris by Lemery; and, becoming a fashionable medicine, made the fortune of the discoverer. For some time its composition was kept secret; but Boulduc and Geoffroy discovered its component parts in 1731.

Its crystals are prisms of eight or ten unequal sides, having their ends truncated at right angles. They are

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* *Ann. de Chim.* xxxviii. 32.

† Hassenfratz, Ibid. xxviii. 12.

‡ Thenart, Ibid.

generally divided into two in the direction of their axes; and the base on which they stand is marked with two diagonal lines, so as to divide it into four triangles. It has a bitter taste. It is almost as soluble as tartrite of potass. It effloresces when exposed to the air. Heat decomposes it.

According to the analysis of Vauquelin, it is composed of . . . . 54 tartrite of potass
46 tartrite of soda

100*

Sp. 11. *Tartrite of Ammonia.*

The crystals of this salt are polygonous prisms, not unlike those of the last described salt. It has a cooling bitter taste like that of nitre. It is very soluble in water. Heat decomposes it. This salt also, as Retzius first observed, combines with an excess of acid, and forms a super-tartrite almost as insoluble in water as tartar.

Sp. 12. *Tartrite of Potass-and-ammonia.*

This triple salt may be formed by pouring ammonia into acidulous tartrite of potass. Its crystals, according to Macquer, are prisms with four, five, or six sides: according to the Dijon academicians, parallelopipeds, with two alternate sloping sides.

It has a cooling taste. It is soluble enough in water. It effloresces in the air. Heat decomposes it.

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* Fourcroy, vii. 246.

Sp. 13. *Tartrite of Magnesia.*

THIS salt is insoluble in water except there be an excess of acid present. It then affords by evaporation small crystals in the form of hexangular truncated prisms *. It has a more saline taste, and is more fusible than tartrite of lime †. Heat first melts and afterwards decomposes it.

Sp. 14. *Tartrite of Potass-and-magnesia.*

THIS triple salt, first examined by the Dijon academicians, may be formed by dissolving magnesia or its carbonat in tartar. The solution, according to them, yields, by evaporation, needle-form crystals: but, according to Thenart, this triple salt does not crystallize; and when evaporated to dryness, it deliquesces ‡.

Sp. 15. *Tartrite of Alumina.*

THIS salt does not crystallize, but forms by evaporation a clear transparent gummy mass. Its taste is astringent. It is soluble in water. It does not deliquesce in the air §.

Sp. 16. *Tartrite of Potass-and-alumina.*

THIS triple salt is formed by saturating tartar with alumina. It bears a very striking resemblance to the last described salt. Thenart has observed, that no precipitate is produced in this salt, either by the addition of alkalies or their carbonats ||.

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[*] Bergman, i. 388.

[†] Von Packen *de Sale essent. acid. Tartar.*

[‡] *Ann. de Chim.* xxxviii. 32.

[§] Von Packen.

[||] *Ann. de Chim.* xxxviii. 33.

Chap. III.

GENUS XX. CITRATS.

As the citric acid was first obtained in a state of purity by Scheele, we may consider him as the author of the first accurate remarks on the citrats. Several of them have been lately examined with considerable attention by Vauquelin; but they are still very imperfectly known.

The citrats may be distinguished by the following properties:

Characters.

1. The solution of barytes forms a precipitate in the alkaline citrats.
2. They are decomposed by the stronger mineral acids.
3. They are decomposed by the oxalic and tartarous acids, which occasion an insoluble precipitate in their solutions.
4. When distilled, they yield traces of acetous acid.
5. Their solution in water is gradually decomposed, depositing mucous flakes.

Sp. 1. *Citrat of Barytes.*

WHEN barytes is added to a solution of citric acid, a flocky precipitate appears, which is at first dissolved again by agitation; but remains permanent when the saturation is complete. The citrat of barytes, thus formed, is precipitated in the state of a white powder; but it gradually assumes the appearance of silky flakes, or forms a kind of vegetation very brilliant and beautiful. It requires a great quantity of water to dissolve it. This ſalt, according to Vauquelin, is composed of

50 acid crystallized
50 barytes

100[*]

Sp. 2. *Citrat of Lime.*

This salt is formed by dissolving carbonat of lime in citric acid. It is usually in the state of a white powder, scarcely soluble in water; but it is soluble in an excess of acid, and may be obtained from that solution in crystals. According to Vauquelin, it is composed of

62.66 acid
37.34 lime

100.00[†]

Sp. 3. *Citrat of Strontian.*

This salt was obtained by Vauquelin by mixing a solution of citrat of ammonia with nitrat of strontian. No precipitate appears; but when the liquid is slowly evaporated, small crystals of citrat of strontian are gradually formed. This salt is soluble in water, and exhibits nearly the same properties as the oxalat or tartrite of strontian[‡].

Sp. 4. *Citrat of Potass.*

This salt may be formed by dissolving carbonat of potass in citric acid, and evaporating the solution to the requisite consistency. It is very soluble in water; does not crystallize easily; and readily deliquesces

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[*] Fourcroy, vii. 207.

[†] Ibid.

[‡] *Jour. de Min.* An. vi. p. 16.

when exposed to the air. It is composed, according to Vauquelin of . . . . 55.55 acid
44.45 potass
100.00*

This salt, or rather its solution in water, is often employed in this country as a medicine to allay sickness, and put a stop to vomiting.

Sp. 5. *Citrat of Soda.*

THIS salt may be formed by the same process as the last species. By proper evaporation, it is obtained crystallized in six-sided prisms, not terminated by pyramids. Its taste is salt and cooling, but mild. It is soluble in 1$\frac{2}{3}$ parts of water. When exposed to the air, it effloresces slightly. When heated, it melts, swells, bubbles up, blackens, and is decomposed. According to Vauquelin, it is composed of

60.7 acid
39.3 soda
100.0†

Sp. 6. *Citrat of Ammonia.*

THIS salt, formed by dissolving carbonat of ammonia in citric acid, does not crystallize till its solution be evaporated to the consistency of a thick syrup. Its crystals are elongated prisms. It is very soluble in water. Its taste is cooling and moderately saline ‡. The ammonia is separated by the application of heat §.

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* Fourcroy, vii. 207.

† Ibid.

‡ Dobson.

§ Scheele.

According to Vauquelin, it is composed of

62 acid
38 ammonia

100[*]

Sp. 7. Citrat of Magnesia.

This salt may be formed by dissolving carbonat of magnesia in citric acid. This solution, though evaporated to a thick syrup, does not crystallize; but it gradually assumes the form of a white opaque soft mass, which rises in the vessel like a mushroom. According to Vauquelin, it is composed of

66.66 acid
33.34 magnesia

100.00[†]

The remaining citrats have not been examined, and are therefore still unknown.

GENUS XXI. MUCITES OR SACCHOLATS.

THESE salts, hitherto examined only by Scheele, are almost entirely unknown. The following are all the facts mentioned by that illustrious discoverer.

1. Mucite of potass. Small crystals, soluble in eight times their weight of boiling water[‡].

2. Mucite of soda. The same; soluble in five times their weight of boiling water[§].

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[*] Fourcroy, vii. 208.

[†] Ibid.

[‡] Scheele on *Sugar of Milk.*

[§] Ibid.

3. Mucite of ammonia. A salt which has a sourish taste. Heat separates the ammonia *.
4. Mucite of barytes.
5. Mucite of lime.
6. Mucite of magnesia.
7. Mucite of alumina.

These salts are insoluble in water †.

GENUS XXII. MALATS.

THESE salts are no better known than the last genus, never having been examined except superficially by Scheele. The following are all the properties mentioned by that philosopher ‡.

1. Malat of potass.
2. Malat of soda.
3. Malat of ammonia.

These salts are deliquescent.

4. Malat of lime. Small irregular crystals. They require a large quantity of boiling water for their solution. With excess of acid they are readily soluble in cold water. They are insoluble in alcohol.
5. Malat of barytes. The properties of this salt resemble pretty much those of malat of lime.
6. Malat of magnesia. Deliquescent.

GENUS XXIII. LACTATS.

THIS genus also is scarcely known. The few observations of Scheele, the only chemist who examined them, are the following ‡.

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[*] Scheele, on *Sugar of Milk*.

[†] Ibid.

[‡] Crell's *Annals*, ii. 9. Eng. Trans.

[§] Scheele, ii. 64.

1. Lactat of potass. A deliquescent salt, soluble in alcohol.

2. Lactat of soda. This salts does not crystallize. It is soluble in alcohol.

3. Lactat of ammonia. Crystals which deliquesce. Heat separates a great part of the ammonia before destroying the acid.

4. Lactat of barytes.
5. Lactat of lime.
6. Lactat of alumina.

These salts deliquesce. The lactat of lime is soluble in alcohol.

7. Lactat of magnesia. Small deliquescent crystals.

Genus XXIV. Gallats.

This genus is still less known if possible than the three last, not one of the species having been examined by a single chemist. All that is known is, that gallic acid, when united with the earths, forms yellow-coloured powders, but sparingly soluble in water, unless there be an excess of acid or of base.

Genus XXV. Benzoats.

Though these salts have been long known, their properties hitherto have been but superficially examined. Lichtenstein [*] and Tromsdorff [†] are the only chemists who have attempted any thing like a detailed description of them. To them we are chiefly indebted for the following facts.

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[*] Crell's *Neu. Entdeck.* 1782. iv. 9.

[†] Crell's *Annals*, 1790, ii. 303.

Sp. 1. *Benzoat of Barytes.*

This salt crystallizes, is soluble in water, not altered by exposure to the air, but decomposed by heat and by the stronger acids.

Sp. 2. *Benzoat of Lime.*

This salt forms white, shining, pointed crystals, of a sweetish taste, much more soluble in hot than cold water. It exists in abundance in the urine of cows *.

Sp. 3. *Benzoat of Potass.*

This salt forms pointed feathery crystals. It has a saline sharp taste. It is very soluble in water. It deliquesces when exposed to the air.

Sp. 4. *Benzoat of Soda.*

The crystals of this salt are larger, but its taste is the same with that of benzoat of potass. It is also very soluble in water. It effloresces in the air.

Sp. 5. *Benzoat of Ammonia.*

This salt crystallizes with difficulty. Its crystals are feather-shaped. It deliquesces. It is very soluble in water.

Sp. 6. *Benzoat of Magnesia.*

This salt forms feather-shaped crystals of a sharp bitter taste, and easily soluble in water.

Sp. 7. *Benzoat of Alumina.*

This salt forms dendritical crystals. It has a sharp

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* Fourcroy and Vauquelin.

bitter taste, is soluble in water, and deliquesces when exposed to the air.

The other benzoats are entirely unknown.

Genus XXVI. Succinats.

This genus of salts is as imperfectly known as the preceding. For the few experiments that have been made, we are indebted to Stockar, Wenzel[*], Leonhardi[†], and Bergman[‡].

Sp. 1. *Succinat of Barytes.*

This salt, according to Bergman, is difficultly soluble in water.

Sp. 2. *Succinat of Lime.*

This salt forms oblong, pointed, non-deliquescent salts, which are difficultly soluble even in boiling water. It is not altered by exposure to the air. It is decomposed by muriat of ammonia, and by the fixed alkaline carbonats.

Sp. 3. *Succinat of Potass.*

This salt, according to Leonhardi and Stockar, crystallizes in three-sided prisms. It has a bitter saline taste, is very soluble in water, and deliquesces when exposed to the air. When exposed to heat, it decrepitates and melts; and in a strong heat is decomposed.

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[*] Wenzel's *Verwandschaft der Korper*, 1777.

[†] *De Salibus Succinatis*, 1775.

[‡] *On Elective Attractions*, *Opusc.* iii. 291.

Sp. 4. *Succinat of Soda.*

When pure succinic acid is saturated with soda, the solution by spontaneous evaporation yields beautiful transparent crystals of succinat of soda; some of which are four-sided prisms with dihedral summits; others six-sided prisms, terminated by an oblique face *. This salt has a bitter taste, is less soluble in water than common salt, and does not deliquesce when exposed to the air.

This salt is decomposed completely when exposed to a sufficient heat in close vessels.

Sp. 5. *Succinat of Ammonia.*

This salt forms needle-shaped crystals. It has a sharp, bitter, and cooling taste; when exposed to heat, it sublimes without decomposition.

Sp. 6. *Succinat of Magnesia.*

This salt has the form of a white, glutinous, frothy mass, which when dried by the fire attracts moisture from the air, and deliquesces.

Sp. 7. *Succinat of Alumina.*

This salt, according to Wenzel, crystallizes in prisms, and is easily decomposed by heat.

Genus XXVII. Camphorats.

These salts have been examined by Bouillon La Grange with much care. They possess the following properties:

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* Morveau, *Ann. de Chim.* xxix. 166.

Characters.

1. A taste which is usually bitterish.
2. Decomposed by heat: the acid sublimes, and the base remains in a state of purity.
3. Before the blow-pipe they burn with a blue flame.

Sp. 1. *Camphorat of Lime.*

This salt may be prepared by dropping into lime-water crystallized camphoric acid. The mixture is then to be made boiling hot, passed through a filter, and evaporated to about $\frac{3}{4}$ths of its volume. On cooling camphorat of lime is deposited.

Properties.

It has no regular shape; but if the evaporation has been properly conducted, it is in plates lying one above another. It is of a white colour, and has a taste slightly bitter.

Water at the temperature of 60° dissolves very little of this salt; boiling water is capable of dissolving about $\frac{1}{200}$th part of its weight of it. It is insoluble in alcohol.

When exposed to the air, it dries and falls into powder. When exposed to a moderate heat, it melts and swells up; when placed on burning coals, or when heated in close vessels, the acid is decomposed and volatilized, and the lime remains pure.

When sulphuric acid is poured into a solution of this salt, it produces an insoluble precipitate; nitric and muriatic acids precipitate the camphoric acid.

Composition.

It is composed of 50 acid
43 lime
7 water
100

It is decomposed by the following salts:

1. Carbonat of potass.
2. Nitrat of barytes.
3. Muriat and sulphat of alumina.
4. Phosphat of soda[*].

Sp. 2. *Camphorat of Potass.*

To prepare this salt carbonat of potass is to be dissolved in water, and the solution saturated with camphoric acid. When the effervescence is over, the liquor is to be evaporated by a gentle heat to the proper consistence, and crystals of camphorat of potass will be deposited when the liquor cools.

Properties.

Camphorat of potass is white and transparent; its crystals are regular hexagons. Its taste is bitterish and slightly aromatic.

Water at the temperature of 60° dissolves $\frac{1}{100}$th part of its weight of this salt; boiling water dissolves $\frac{1}{4}$th part of its weight. It is soluble in alcohol, and the solution burns with a deep blue flame. When exposed to moist air, it loses a little of its transparency, but in dry air it suffers no change.

When exposed to heat it melts, swells, and the acid is volatilized in a thick smoke, which has an aromatic odour. Before the blow-pipe it burns with a blue flame, and the potass remains behind in a state of purity.

Decomposition.

It is decomposed by the following salts:

1. Nitrats of barytes, silver.
2. All the salts whose base is lime.
3. Sulphat of iron.
4 Muriats of tin, lead[†].

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[*] *Ann. de Chim.* xxvii. 21.

[†] Bouillon La Grange, Ibid. p. 24.

Sp. 3. *Camphorat of Soda.*

This salt may be formed precisely in the same manner as the camphorat of potass.

Properties. It is white and transparent; its taste is somewhat bitter; its crystals are irregular.

Water at the temperature of 60° dissolves less than $\frac{1}{200}$th part of its weight of this salt; boiling water dissolves $\frac{1}{8}$th of its weight. It is also soluble in alcohol.

When exposed to the air it loses its transparency, and effloresces slightly, but is never completely reduced to powder.

Heat produces the same effect upon it as on camphorat of potass: the acid burns with a blue flame, which becomes reddish towards the end.

It is decomposed by the following salts:

Decomposition.
1. Nitrats of lime, silver.
2. Muriats of magnesia, barytes, alumina, lime, iron.
3. Sulphats of alumina, iron; and many other salts with metallic bases †.

Sp. 4. *Camphorat of Barytes.*

In order to prepare this salt, barytes is to be dissolved in water, and camphoric acid added to the solution; the mixture is then to be boiled, and afterwards filtered and evaporated to dryness.

Properties. Camphorat of barytes does not crystallize; when the evaporation is conducted slowly, the salt is deposited in thin plates one above another, which appear transparent while immersed in the liquor, but become opaque whenever they come into contact with the air.

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* *Ann. de Chim.* xxvii. 26.

It has very little taste, though it leaves at last upon the tongue a slight impression of acidity mixed with bitterness. Water dissolves only a very small quantity of this salt: boiling water being capable of taking up only $\frac{1}{600}$th part of it. It is not altered by exposure to the air.

When exposed to heat, it melts easily, and the acid is volatilized. When the heat is considerable, the acid burns with a lively blue flame, which becomes red and at last white.

Decomposition.

It is decomposed by

1. Nitrats of potass, soda, lime, ammonia, and magnesia.
2. Muriats of lime, potass, alumina, and magnesia.
3. All the sulphats.
4. Carbonats of potass and soda.
5. Phosphats of potass, soda, and ammonia *.

Sp. 5. *Camphorat of Ammonia.*

This salt may be prepared by dissolving carbonat of ammonia in hot water, and adding camphoric acid slowly till the alkali is saturated. It must then be evaporated with a very moderate heat, to prevent the disengaging of the ammonia.

Properties.

It is very difficult to obtain this salt in regular crystals. When evaporated to dryness, there is obtained a solid opaque mass of a sharp and bitterish taste.

Water at the temperature of about 60° dissolves nearly $\frac{1}{100}$th part of its weight of this salt; boiling water dissolves $\frac{1}{3}$d of its weight: But all the alkaline camphorats are much more soluble when there is excess of base.

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* *Ann. de Chim.* xxvii. 28.

It is completely soluble in alcohol.

When exposed to the air it attracts moisture, but not in sufficient quantity to enable it to assume a liquid form. When exposed to heat it swells, melts, and is converted into vapour. Before the blow-pipe it burns with a blue and red flame, and is entirely volatilized.

Most of the calcareous salts form triple salts with camphorat of ammonia.

It decomposes in part all the aluminous salts, except the sulphat of alumina*.

Sp. 6. Camphorat of Magnesia.

THIS salt may be prepared by mixing water with carbonat of magnesia, and adding crystallized camphoric acid: heat is then applied, the solution is filtrated, and evaporated to dryness. The salt obtained is dissolved in hot water, passed through a filter, and evaporated by means of a moderate heat till a pellicle forms on the surface of the solution. On cooling the salt is deposited in thin plates. The second solution is intended to remove any excess of magnesia that may happen to be present.

Properties.

This salt does not crystallize. It is white, opaque, and has a bitter taste. It is scarcely more soluble in water than camphorat of lime. Alcohol has no action on it while cold, but when hot it dissolves the acid and leaves the magnesia; and the acid precipitates again as the alcohol cools.

When exposed to the air, it dries and becomes covered with a little powder; but this effect is produced slowly, and only in a warm place. When this salt is

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* *Ann. de Chim.* xxvii. 31.

placed on burning coals, the acid is volatilized, and the magnesia remains pure. Before the blow-pipe it burns, like the other camphorats, with a blue flame.

The nitrats, muriats, and sulphats, do not completely decompose this salt, if we except the nitrat of lime and muriat of alumina *.

Sp. 7. Camphorat of Alumina.

To prepare this salt, alumina, precipitated by means of ammonia, and well washed, is to be mixed with water, and crystals of camphoric acid added. The mixture is then to be heated, filtered, and concentrated by evaporation.

Properties.

This salt is a white powder, of an acid bitterish taste, leaving on the tongue, like most of the aluminous salts, a sensation of astringency.

Water at the temperature of 60° dissolves about $\frac{1}{200}$th part of its weight of this salt. Boiling water dissolves it in considerable quantities; but it precipitates again as the solution cools. Alcohol, while cold, dissolves it very sparingly; but when hot it dissolves a considerable quantity of it, which precipitates also as the solution cools. This salt undergoes very little alteration in the air; but it rather parts with than attracts moisture. Heat volatilizes the acid; and when the salt is thrown on burning coals it burns with a blue flame.

It is decomposed by the nitrats of lime and barytes †.

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* *Ann. de Chim.* xxvii. 21.

† Ibid. p. 34.

Book II. Division II.

GENUS XXVIII. SUBERATS.

THESE salts have been described with a good deal of detail by Bouillon la Grange. They have in general a bitter taste, and are decomposed by heat.

Sp. 1. Suberat of Barytes.

THIS salt does not crystallize. Heat makes it swell up, and melts it. It is scarcely soluble in water except there be an excess of acid. It is decomposed by most of the neutral salts except the barytic salts and the fluat of lime*.

Sp. 2. Suberat of Potass.

THIS salt ought to be formed by means of crystallized carbonat of potass.

It crystallizes in prisms, having four unequal sides. It has a bitter saltish taste, and it reddens vegetable blues. It is very soluble in water. Caloric melts it, and at last volatilizes the acid. It is decomposed by most of the metallic salts, and by sulphat of alumina, muriat of alumina and of lime; nitrat of alumina and of lime; and phosphat of alumina †.

Sp. 3. Suberat of Soda.

THIS salt does not crystallize. It reddens the tincture of turnsole. Its taste is slightly bitter. It is very soluble in water and in alcohol. It attracts moisture from the air. Caloric produces the same effect on it that it does on suberat of potass. It is decomposed by the calcareous, aluminous, and magnesian salts ‡.

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* *Ann. de Chim.* xxiii. 52.

† Ibid.

‡ Ibid. p. 53.

Sp. 4. *Suberat of Lime.*

THIS salt does not crystallize. It is perfectly white: it has a saltish taste: it does not redden the tincture of turnsole. It is very sparingly soluble in water except when hot; and as the solution cools most of the salt precipitates again. When placed upon burning coals it swells up, the acid is decomposed, and there remains only the lime in the state of powder.

It is decomposed by the following salts:

1. Muriat of alumina.
2. Carbonats of potass and soda.
3. Fluat of magnesia.
4. Phosphats of alumina and soda.
5. Borat of potass.
6. All the metallic solutions*.

Sp. 5. *Suberat of Ammònia.*

THIS salt crystallizes in parallelopipeds. Its taste is saltish, and it leaves an impression of bitterness. It reddens vegetable blues. It is very soluble in water. It attracts moisture from the air. When placed upon burning coals, it loses its water of crystallization, and swells up; and before the blow-pipe it evaporates entirely. It is decomposed by the aluminous and magnesian salts †.

Sp. 6. *Suberat of Magnesia.*

THIS salt is in the form of a powder: it reddens the tincture of turnsole. It has a bitter taste: it is soluble in water, and attracts some moisture when exposed to

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* *Ann. de Chim.* xxiii. 54.

† Ibid. p. 55.

the air. When heated it swells up and melts: before the blow-pipe the acid is decomposed, and the magnesia remains in a state of purity.

It is decomposed by the following salts:

1. Muriat and phosphat of alumina.
2. Nitrats of lime and alumina.
3. Borat of potass.
4. Fluat of soda*.

Sp. 7. *Suberat of Alumina.*

This salt does not crystallize. When its solution is evaporated by a moderate heat in a wide vessel, the salt obtained is of a yellow colour, transparent, having a styptic taste, and leaving an impression of bitterness on the tongue. When too much heat is employed, it melts and blackens. It reddens the tincture of turnsole, and attracts moisture from the air. Before the blow-pipe it swells up, the acid is volatilized and decomposed, and nothing remains but the alumina.

It is decomposed by the following salts:

1. Carbonats of potass and soda.
2. Sulphat and muriat of iron.
3. Nitrats of silver, mercury, and lead†.

GENUS XXIX. PRUSSIATS.

The salts formed by the prussic acid have scarcely any permanency unless they be united with a little of some metallic oxide, and therefore in the state of triple salts. Mere exposure to the air, or to a heat of 120°, is sufficient to decompose them. This want of perma-

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* *Ann. de Chim.* xxiii. 55.

† Ibid.

nency rendering the pure prussiats of little importance, has prevented chemists from paying much attention to their properties. The only person, indeed, who has examined them at all is Scheele. But the triple prussiats, not being liable to spontaneous decomposition, have been employed with success as chemical re-agents, and have excited a good deal of interest in consequence of the important purposes to which they may be applied.

Sp. 1. *Prussiat of Barytes.*

THIS salt is but sparingly soluble in water. The barytes is precipitated by sulphuric acid, and even by carbonic acid *.

Sp. 2. *and* 3. *Prussiats of the Fixed Alkalies.*

THESE salts, formed by dissolving the fixed alkalies in prussic acid, are very soluble in water, tinge vegetable blues green, and are partly decomposed by a very moderate heat †.

Sp. 4. *Prussiat of Lime.*

THIS salt may be formed by dissolving lime in prussic acid, filtrating the solution, and separating the uncombined lime, which it still retains, by adding as much liquid carbonic acid as is just sufficient to precipitate all the lime from the same bulk of lime-water. It is then to be filtered again, and preserved in close vessels. It is decomposed by all the other acids, and by the alkalies. When distilled, the prussic acid is separated, and the pure lime remains ‡.

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* Scheele, ii. 167.

† Ibid. p. 166.

‡ Ibid. p. 168.

Sp. 5. *Prussiat of Ammonia.*

This salt has the odour of pure ammonia; when heated it evaporates completely [*].

Sp. 6. *Prussiat of Magnesia.*

This salt may be formed by putting pure magnesia into prussic acid. In a few days the earth is dissolved, and the compound formed. The magnesia is precipitated by the alkalies and lime, and by exposure to the air [†].

Sp. 7. *Prussiats of Iron.*

As the prussiats of iron enter as ingredients into the triple salts formed by the prussic acid, it will be necessary to give some account of them before entering upon the consideration of these triple salts.

It has been demonstrated by chemists, that there are no fewer than four prussiats of iron; namely,

1. White prussiat,	3. Yellow prussiat,
2. Blue prussiat,	4. Green prussiat.

The white prussiat discovered by Mr Proust is composed of prussic acid and *green oxide* of iron. It becomes gradually blue when exposed to the atmosphere, because the oxide absorbs oxygen, and is converted into brown oxide [‡].

Blue prussiat, or prussian blue, is composed of prussic acid and brown oxide of iron. It is a deep blue powder, insoluble in water, and scarcely soluble in acids. It is composed, according to the most accurate

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[*] Scheele, ii. 166.

[†] Ibid. p. 167.

[‡] Nicholson's *Journal*, i. 453.

experiments hitherto made, of equal parts of oxide of iron and prussic acid. It is not affected by exposure to the air. Heat decomposes it by destroying the acid, and the oxide of iron remains behind. The prussian blue of commerce, besides other impurities, contains mixed with it a great quantity of alumina.

Yellow prussiat is composed of prussic acid combined with an excess of brown oxide of iron: it is therefore a sub-prussiat of iron. This prussiat is soluble in acids. It may be obtained by digesting the alkalies or alkaline earths with prussian blue. Part of the acid is carried off by these bodies, and the yellow prussiat remains in the state of a powder.

Green prussiat, first discovered by Mr Berthollet, is composed of oxy-prussic acid and brown oxide of iron. It is therefore in fact an oxy-prussiat.

Sp. 7. *Prussiat of Barytes-and-iron.*

For the first accurate description of this salt we are indebted to the ingenious Mr William Henry. It may be formed by adding prussian blue to hot barytic water till it ceases to be discoloured. The solution, when filtered and gently evaporated, yields crystals of prussiat of barytes-and-iron.

These crystals have the figure of rhomboidal prisms; they have a yellow colour, and are soluble in 1920 parts of cold water, and in about 100 parts of boiling water. In a red heat they are decomposed, the acid being destroyed. They are soluble in nitric and muriatic acids; sulphuric acid occasions a precipitate of sulphat of barytes *.

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* Nicholson's *Journal*, iii. 170.

Sp. 8. *Prussiat of Strontian-and-iron.*

This salt was also first examined by Mr Henry. It may be formed by the same process as the last species; but the solution does not crystallize nearly so readily. When evaporated to dryness, it does not deliquesce, and is again soluble in less than four parts of cold water [*].

Sp. 9. *Prussiat of Lime-and-iron.*

This salt was perhaps first mentioned by Mr Hagen [†]; but we are indebted to Morveau for the first accurate account of its properties and preparation [‡].

Preparation.

Upon two parts of Prussian blue of commerce, previously well washed with a sufficient quantity of boiling water to separate all the foreign salts, about 56 parts of lime water are to be poured, and the mixture must be boiled for a short time till the lime is saturated with the prussic acid, which is known by its no longer altering paper stained with turmeric: it is then to be filtered.

This liquid, which contains the triple prussiat of lime in solution, has a greenish-yellow colour; its specific gravity is 1.005; and it has an unpleasant bitterish taste. When evaporated to dryness, it yields small crystalline grains, soluble without alteration in water. It is insoluble in alcohol.

This triple prussiat may be used with advantage as a test to ascertain the presence of metals held in solution. The only impurity which it contains is a little sulphat of lime.

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[*] Nicholson's *Journal*, iii. 171.

[†] Crell's *Annals*, 1784, i. 291.

[‡] *Ency. Method. Chim.* i. 242.

Sp. 10. *Prussiat of Potass-and-iron.*

Importance.

This salt, known also by the names of *prussian alkali*, *phlogisticated alkali*, *prussian test*, *triple prussiat of potass*, &c. has been chosen by chemists as the best combination of prussic acid for detecting the presence of metals, and more especially for detecting the existence of iron. To chemists and mineralogists it is one of the most important instruments ever invented; as, when properly prepared, it is capable of indicating whether any metallic substance (platinum excepted) be present in any solution whatever, and even of pointing out the particular metal, and of ascertaining its quantity. This it does by precipitating the metals from their solution in consequence of the insoluble compound which it forms with them. And the colour of the precipitate indicates the particular metal, while its quantity enables us to judge of the proportion of metallic oxide contained in any solution.

In order to be certain of the accuracy of these results, it is necessary to have a prussian alkali perfectly pure, and to be certain before-hand of the quantity, or rather of the proportions of its ingredients. To obtain a test of this kind has been the object of chemists ever since the discoveries of Macquer pointed out its importance. It is to the use of impure tests that a great part of the contradictory results of mineralogical analyses by different chemists is to be ascribed.

The great object of chemists at first was to obtain this prussiat entirely free from iron; but their attempts uniformly failed; because the oxide of iron is one of its necessary component parts. This was first properly pointed out by Morveau.

Often impure.

There are two * ways in which this test may be rendered impure, besides the introduction of foreign ingredients, which it is needless to mention, because it is obvious that it must be guarded against. 1. There may be a superabundance of alkali present, or, which is the same thing, there may be mixed with the prussian test a quantity of pure alkali; or, 2. There may be contained in it a quantity of yellow prussiat of iron, for which prussiat of potass has also a considerable affinity.

If the prussian test contain a superabundance of alkali, two inconveniences follow. This superabundant quantity will precipitate those earthy salts which are liable to contain an excess of acid, and which are only soluble by that excess: Hence alumina and barytes will be precipitated. It is to the use of impure tests of this kind that we owe the opinion, that barytes and alumina are precipitated by the prussian alkali, and the consequent theories of the metallic nature of these earths. This mistake was first corrected by Meyer of Stetin *.

Another inconvenience arising from the superabundance of alkali in the prussian test is, that it gradually decomposes the blue prussiat which the test contains, and converts it into yellow prussiat. In what manner it does this will be understood, after what has been said, without any explanation.

On the other hand, when the prussian alkali contains a quantity of yellow prussiat of iron, as great inconveniences follow. This yellow prussiat has an affinity for

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* See Kirwan's *Min.* i. 487.

† Crell's *Annals*, 1786, ii. 142.

prussic acid, which, though inferior to that of the potass, is still considerable; and, on the other hand, the potass has a stronger affinity for every other acid than for the prussic. When, therefore, the test is exposed to the air, the carbonic acid, which the atmosphere always contains, assisted by the affinity between the yellow prussiat and the prussic acid, decomposes the prussiat of potass in the test; and the yellow prussiat is precipitated in the form of prussian blue: and every other acid produces the same effect. A test of this kind would indicate the presence of iron in every mixture which contains an acid (for a precipitation of prussian blue would appear); and could not, therefore, be employed with any confidence.

To describe the various methods proposed by chemists for preparing this salt would be unnecessary, as the greater number do not answer the purpose intended*. The method practised by Klaproth, first made known to chemists by Westrum†, and afterwards described in our language by Kirwan‡, is considered as one of the best. It is as follows:

Preparation.

Prepare pure potass, by gradually projecting into a large crucible heated to whiteness a mixture of equal parts of purified nitre and crystals of tartar; when the whole is injected, let it be kept at a white heat for half an hour, to burn off the coal.

Detach the alkali thus obtained from the crucible,

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* A historical account of these different preparations, with their properties and defects, may be seen in Westrum's Treatise (Crell's *Neu Entd. in d. Chem.* Th. xii.), in Morveau's Dissertation on the Prussic Acid (*Encycl. Method. Chim.* i. 225.), and Kirwan's Treatise on the Method of Analysing Minerals (Kirwan's *Min.* i. 487.)

† Crell's *Annals*, 1785. i. 405.

‡ *Mineralogy*, i. 494.

reduce it to powder, spread it on a muffle, and expose it to a white heat for half an hour.

Dissolve it in six times its weight of water, and filter the solution while warm.

Pour this solution into a glass receiver, placed in a sand furnace, heated to 170° or 180°, and then gradually add the best prussian blue in powder, injecting new portions according as the former become grey, and supplying water as fast as it evaporates; continue until the added portions are no longer discoloured, then increase the heat to 212°, and continues it for half an hour.

Filter the ley thus obtained, and saturate it with sulphuric acid moderately diluted; a precipitate will appear: when this ceases, filter off the whole, and wash the precipitate.

Evaporate the filtered liquor to about one quarter, and set it by to crystallize: after a few days, yellowish crystals of a cubic or quadrangular form will be found mixed with some sulphat of potass and oxide of iron; pick out the yellowish crystals, lay them on blotting paper, and redissolve them in four times their weight of cold water, to exclude the sulphat of potass.

Essay a few drops of this solution with barytic water, to see whether it contains any sulphuric acid, and add some barytic water to the remainder if necessary: filter off the solution from the sulphat of barytes, which will have precipitated, and set it by to crystallize for a few days; that the barytes, if any should remain, may be precipitated. If the crystals now obtained be of a pale yellow colour, and discover no bluish streaks when sprinkled over with muriatic acid, they are fit for use; but if they still discover bluish or green streaks, the solutions and crystallizations must be repeated.

These crystals must be kept in a well-stopped bottle, which to preserve them from the air should be filled with alcohol, as they are insoluble in it.

Before they are used, the quantity of iron they contain should be ascertained, by heating 100 grains to redness for half an hour in an *open* crucible: the prussic acid will be consumed, and the iron will remain in the state of a reddish brown magnetic oxide, which should be weighed and noted. This oxide is half the weight of the prussian blue afforded by the prussian alkali: its weight must therefore be subtracted from that of metallic precipitates formed by this test. Hence the weight of the crystals, in a given quantity of the solution, should be noted, that the quantity employed in precipitation may be known. Care must be taken to continue the calcination till the oxide of iron becomes brown; for while it is black it weighs considerably more than it should.

Another good method of preparing this salt has been lately given by Mr Henry; but it is rather too expensive for general use. It consists in first forming a triple prussiat of barytes, and adding it in crystals to a solution of carbonat of potass till the solution no longer restores the colour of reddened litmus paper. After digesting the mixture for half an hour, filter the liquid and evaporate it gently. The triple prussiat of potass crystallizes [*].

The triple prussiat of potass when pure forms fine transparent crystals of a yellow colour; they have the form of cubes or parallelopipeds, and contain, when prepared according to Klaproth's method, 0.24 parts of oxide of iron.

[†] Nicholson's *Jour.* iv. 31.

Sp. 11. *Prussiat of Soda-and-iron.*

The only discernible difference between this salt and the last is, that it crystallizes differently*.

Sp. 12. *Prussiat of Ammonia-and-iron.*

This triple salt has also been employed as a test; but it is not so easy to obtain it in a state of purity as the other two. It was discovered by Macquer, and first recommended by Meyer.

It forms flat hexangular crystals, soluble in water, and deliquesces in the air. Heat decomposes it like the other prussiats†.

Sp. 13. *Prussiat of Magnesia-and-iron.*

This triple salt was first examined by Hagen in 1782; but since that time scarcely any attention has been paid to it.

GENUS XXX. SEBATS.

For our knowledge of this class of salts we are chiefly indebted to the celebrated Crell, who published a dissertation on the sebacic acid and its combinations in the Philosophical Transactions for 1780 and 1782. Their properties are still but imperfectly known. Crell has ascertained the following facts:

Properties.

1. Sebat of potass. This salt is of a white colour. Its crystals are quadrangular pyramids, of which two opposite sides are narrower than the others. It has a sharp saline taste like muriat of ammonia, but milder.

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* Berthollet.

* Woulfe, *Jour. de Phys.* xxxiv. 101.

It is soluble in water, insoluble in alcohol, and does not deliquesce when exposed to the air. Heat decomposes it.

2. Sebat of soda. This salt is white. Its crystals are pyramids, with three or four sides: a very moderate heat melts them.

3. Sebat of lime. The crystals of this salt are hexagons, terminated by a plane surface: they have a sharp acrid taste; are very soluble in water, but not in alcohol: they do not deliquesce.

4. Sebat of ammonia. This salt in taste and solubility resembles muriat of ammonia, but it differs from it in not being capable of subliming iron.

5. Sebat of magnesia. A gummy, saline, uncrystallizable mass.

6. Sebat of alumina. A gummy saline mass, which does not crystallize, and has an austere astringent taste.

SECT. II.

OF METALLINE SALTS.

THE action of the acids on metallic bodies, and the saline compounds formed by their combination with them, were some of the first objects to which the earlier chemists directed their attention. The facility with which several of these compounds change their state; the activity and corrosive nature of many of them, owing in a great measure to that facility; the permanency of others; and the apparent conversion of one metallic salt into another—were so many anomalies which remained long inexplicable: But they were of too interesting a nature not to excite attention; and to the successive researches of chemists into the properties of metallic salts must be ascribed a great part of the progress which chemistry has made. Many apparent anomalies have been happily explained by the successive labours of Bergman, Scheele, Bayen, Lavoisier, Proust, &c.; but there still remain a sufficient number of difficulties in this part of this science to exercise the sagacity of the most acute philosophers, and discoveries to be made in it which will fully compensate the most laborious investigation.

Number of metallic salts.

As there are 21 metallic bases from which these bodies derive their characteristic properties, this class of salts may be divided into 21 genera. Since there are 32 acids with which each base has to combine, it would seem at first sight that the number of species belonging to each genus ought to amount to 32, which would make the metallic salts amount in all to 672. But it is not the metals which combine with acids, it is their oxides, or the compounds which they form with oxygen: the metals themselves, as far as is known at present, are not capable of combining with any acid. Now as most metals form more than one oxide, and as each of the oxides of a metal is often capable of combining with acids, it is evident that the number of metallic salts must greatly exceed 672. Thus iron being capable of forming two oxides, the species of salts of iron, instead of 32, must amount to 64, provided each of these oxides be capable of combining with all acids: the contrary of which has not been proved.

It has been shown formerly that the difference between the oxides of the same metal consists in the proportion of oxygen which they contain. Now, in general, all oxides which do not contain a maximum of oxygen have a tendency to absorb that principle, whenever it is presented to them, till they are completely saturated. This tendency displays itself with most energy when the oxides are combined with acids and in a state of solution; consequently all those metallic salts, whose bases do not contain a maximum of oxygen, are liable to absorb that principle, and by that means to change into a different salt. Thus *green vitriol* is a salt composed of sulphuric acid and black oxide of iron. When dissolved in water and exposed to the air, it very soon absorbs oxygen, the black oxide is changed into the red, and thus a new salt is formed composed of sulphuric acid and red oxide of iron. This is a change exactly the reverse of what happens to those earthy and alkaline salts, which contain an acid with a minimum of oxygen; as the *sulphites* and *phosphites*. They also absorb oxygen indeed, and are converted into other salts; but the oxygen combines with the acid, whereas in the metallic salt it combines with the base. These different earthy and alkaline salts have been very happily distinguished by different terminations. Thus the sulph*ite* of potass contains the acid of sulphur with a minimum of oxygen; the sulph*at* of potass contains the acid of sulphur with a maximum of oxygen. No attempt has hitherto been made to distinguish the different metallic salts of the same base with different doses of oxygen by any similar plan. Yet such a distinction is absolutely necessary, if we wish to speak intelligibly about these salts. It is true the distinction is not so easily made in this case as in the other, on account of the indefinite number of

Nomenclature of metalline salts.

oxides belonging to some of the metals; but this very number makes some distinction still more necessary.

It is only of late that chemists began to attend to the different salts which the same metallic base combined with different portions of oxygen is capable of forming with the same acid. Bergman, indeed, and Scheele, had given some striking instances; but Proust has since carried the subject much farther. It is to the newness of this branch of the science that we must ascribe the want of a nomenclature for the metallic salts. The French chemists seem to have been nearly strangers to it when they formed their chemical nomenclature in 1787. And even at present the subject is too imperfectly known to admit of a regular treatise; but I shall in this Section give a very full view of all the facts which have been discovered.

I do not recollect at present any instance of more than two metallic salts with one acid and base, differing merely in the proportion of oxygen, if we except the prussiats. It will be sufficient then for the present to generalize a mode of naming metallic salts which has been adopted in one class, I mean the metallic muriats. In these salts the compound, consisting of muriatic acid and a metal with a minimum of oxygen, is called a *muriat*; the compound of the acid and the same metal, with a maximum of oxygen, is called an *oxy-muriat*. This mode of naming will apply very well to all those genera in which the metal is only capable of forming two oxides, and likewise to all those whose oxides are only capable of forming two salts with the same acid. Thus we may call the compound of sulphuric acid and black oxide of iron *sulphat of iron*, and the compound of the same acid and red oxide of iron, *oxy-sulphat*, or *oxygenated sulphat* *of iron*. In the present state of the science, I shall satisfy myself with arranging these different bodies as varieties of the same species.

Their genera and species.

We have then 21 genera of metallic salts, 32 species belonging to each, and many of these species containing several varieties. We have likewise a very considerable number of triple salts, consisting of combinations of earthy or alkaline with the metallic salts. All these must swell the number of metallic salts to a very considerable amount. But we are very far from being fully acquainted with all these bodies; many of them are still unknown, and many have been merely pointed out without being described. It is even exceedingly probable that not a few of those combinations, which may be stated theoretically, cannot be formed at all. For as the oxides containing a minimum of oxygen have a strong affinity for that principle, it is clear, that instead of combining with those acids which part with their oxygen easily, they will decompose them altogether. This point can only be decided by experiment, as we have no other method of deciding the affinities which different bodies exert upon one another.

GENUS I. SALTS OF GOLD.

THOUGH gold was tortured with the most persevering industry by the alchymists and metallurgists, and has been an interesting object of examination to chemists in every period of the science, there is no genus of salts with which we are at present so little acquainted as those which have for their basis the oxides of that metal. This is not owing to the expence necessarily attending such investigations, but to the peculiar properties of gold itself. As that metal is not acted on by any of the acids except the nitric, oxy-muriatic, and nitro-muriatic, none of the salts of gold can be formed directly, except the nitrat and muriat: all the rest must be composed by precipitating the oxide of gold from its solution in nitro-muriatic acid, and afterwards dissolving it in the other acids. But this method was not thought of till the nature of the oxides of gold was known; and since that point was ascertained, no chemist has considered these salts as worth investigating. It is true, indeed, that they do not hold out those brilliant discoveries which attract adventurers to other parts of the science: yet it must be admitted that an accurate examination of the metallic salts requires as much address, ingenuity, and sagacity, and would contribute as much to the advancement of the science, as any other investigation whatever. It would throw a new light on mineralogy, and even on geology; it would enable us to develope with more precision the nature of affinity than has hitherto been done; and it would serve also as a touchstone to try the truth of certain chemical theories which are at present in vogue.

There are two oxides of gold known, the purple and the yellow; but as far as is known at present, the first of these does not combine with acids at all. Consequently all the salts of gold are, strictly speaking, *oxygenated;* that is, composed of gold combined with a maximum of oxygen. We are only acquainted at present with two species of these salts, namely, the *muriat* and the *nitrat.*

The salts of gold may be ascertained by the following properties:

Characters.

1. They are soluble in water, and the solution has a yellow colour.

3. Triple prussiat of potass occasions a white or yellowish-white precipitate when poured into these solutions.

3. Gallic acid or the infusion of nutgalls gives these solutions a green colour, and a brown powder is precipitated, which is gold reduced.

4. A plate of tin occasions the precipitation of a purple coloured powder.

Sp. 1. *Muriat of Gold.*

Formation.

THIS salt, which was well known to the alchymists, and much valued by them, may be formed by dissolving gold in a mixture composed of equal parts of nitric and muriatic acids. The metal is attacked instantly, and dissolves with a strong effervescence occasioned by the emission of nitrous gas. The liquid, when saturated, which is known by its refusing to dissolve more gold, forms a solution of a deep yellow colour, exceedingly caustic, and of a very astringent metallic taste. It tinges the skin indelibly of a deep purple colour, and produces the same effect upon almost all animal and vegetable bodies, and even upon marble. The colour is owing to the partial reduction of the yellow oxide of gold, and its permanency to the strong affinity between metallic oxides and the epidermis.

When this solution, which consists chiefly of muriat of gold, is evaporated, nitric acid is disengaged, and the muriat is obtained in small crystals of a fine yellow colour, having the form of four-sided prisms or truncated octahedrons. They are obtained more readily if the solution be evaporated to half its bulk, and a little alcohol be afterwards added to it.

This salt is very soluble in water. When exposed to the air, it soon attracts moisture, and runs into a liquid. In a very strong light it acquires a red colour; in consequence, as is supposed, of the partial reduction of its oxide *. When its solution is heated gradually in a retort, there passes over muriatic acid; and muriat of gold is also carried along with it undecomposed †.

It is decomposed by all the alkalies and earths hitherto tried, the yellow oxide of gold being separated. But ammonia redissolves this oxide; and so do the fixed alkalies if added in sufficient quantity, forming probably triple salts, which have not been examined.

Decomposed by combustibles,

It is decomposed also while liquid by hydrogen gas, phosphorus, and sulphurous acid; and the gold is precipitated in the metallic state, being deprived of its oxygen by these combustible bodies: but when dry this decomposition does not happen. For these very interesting facts we are indebted to the ingenious Mrs Fulhame. She found, that when a piece of silk, dipt in a solution of gold in nitro-muriatic acid, is exposed to hydrogen gas while moist, the gold is instantly reduced; but if the silk be dried previously, the reduction does not take place. The same reduction takes place when the silk is dipt into phosphorated ether. If a bit of silk, moistened with phosphorated ether, be dipt into the nitro-muriatic solution, its surface is immediately gilt with a fine coat of gold, which adheres very strongly.

Mrs Fulhame ascertained, that this reduction of the gold does not happen in any case unless the salt be mois-

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* A proof that both the oxides of gold are capable of combining with acids, though all those formed with the purple oxide are unknown.

† To the liquid obtained by distilling over the solution of gold in nitro-muriatic acid, the alchymists gave the name of *leo rubeus*, "red lion."

tened with water: when perfectly dry, it is not altered. This is not peculiar to the action of combustibles: on metallic salts, it holds also, as we shall see afterwards, with respect to the metals. But it is by no means easy to see what makes water so indispensably necessary. It is not, as is commonly supposed, in order to secure the fluidity of the mixture: for Mrs Fulhame has shewn that ether, though a liquid, has no effect in reducing gold unless water be present. She accounts very ingeniously for the phenomena, by supposing that the water is decomposed. The combustible combines with its oxygen, while its hydrogen combines with the oxygen of the gold, and reproduces water. This theory accounts very well for the phenomena; but it would require some direct proof to establish it completely.

And by metals.

The greater number of the metals, when plunged into the solution of muriat of gold, occasion a precipitate either of gold in the metallic state, or of its purple oxide; while at the same time a portion of the precipitating metal is oxidated and dissolved by the acid. Zinc, iron, bismuth, copper, mercury, precipitate it in the metallic state. Lead, silver, and tin, precipitate it in the state of purple oxide. The sulphat of iron precipitates it in the metallic state, and is at the same time converted into the oxy-sulphat by the oxygen which it has absorbed: whereas the oxy-sulphat of iron produces no effect at all. The same thing happens with tin. The muriat of that metal precipitates the gold in the state of purple oxide, combined with oxide of tin; a precipitate well known by the name of *precipitate of Cassius*, and used to give a red colour to porcelain and glass: But the oxy-muriat of tin, which is already at a maximum of oxygen, produces no such effect; because it does not absorb oxygen from the gold.

These precipitations have been long known to chemists; but a satisfactory explanation of them was till lately considered as hopeless; and even at present, notwithstanding the progress which the science has made, there are several particulars attending them which are not fully understood. Bergman first threw light upon the subject, by showing that the precipitating metal absorbed oxygen from the other *. Berthollet has since rendered it probable that, in most cases, when the precipitate is in the metallic state, it is combined with a portion of the precipitating metal, and therefore in the state of an alloy; and that when precipitated in the state of an oxide, it retains a portion of the acid with which it was combined, and is therefore in the state of a *sub-salt*†. But the full discussion of this subject belongs to the succeeding Book. Even the theory of that acute philosopher will not account for every thing. The precipitation does not succeed equally well in all circumstances. Every person must have observed, that in many cases, when the liquid is very much concentrated, a plate of metal produces no change in several hours; but the moment it is diluted, the dissolved metal is precipitated in abundance.

Sp. 2. *Nitrat of Gold.*

BRANDT first observed, that nitrous acid has the pro-

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* See his Dissertation, *De Precipitatis Metallicis*, *Opusc.* ii. 349. His explanation, when translated into the modern language, is, in effect, that given above.

† *Ann. de Chim.* xxxvii. 221.

perty of dissolving gold, especially when assisted by heat; and this observation has been confirmed by the subsequent experiments of several other philosophers. Fourcroy has ascertained, that this effect is produced only when the acid contains a large portion of nitrous acid; and when the gold is very much divided, as in the state of gold leaf. The solution has an orange colour, and always retains an excess of acid. It cannot be evaporated to dryness without decomposition, as the nitrat of gold which it contains is decomposed by light and by heat. It is decomposed by muriatic acid*.

GENUS II. SALTS OF PLATINUM.

As platinum agrees with gold in its power of resisting all the acids except the oxy-muriatic and nitro-muriatic, the same obstacles lie in the way of an examination of the salts of platinum, which have prevented us from getting acquainted with the last genus. Indeed the scarcity of this metal, and the great difficulty of procuring it in a state of purity, render it still less easy to examine the salts which it forms. We need not be surprised, therefore, that this genus is scarcely farther advanced than the last.

The salts of platinum may be distinguished by the following properties:

Characters.

1. Their solution in water has a brown, or yellowish-brown, colour.

2. Triple prussiat of potass occasions no precipitate in these solutions.

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* Fourcroy, vi. 379.

3. Neither is any precipitate produced by gallic acid or the infusion of nutgalls.

4. Potass and ammonia occasion the precipitation of small red-coloured crystals.

Sp. 1. *Muriat of Platinum.*

Formation.

THIS salt may be formed by dissolving platinum in oxy-muriatic acid; but it is more easily obtained by means of nitro-muriatic acid. Sixteen parts of a mixture, composed of one part of nitric and three parts of muriatic acids, when boiled upon platinum previously reduced to powder, gradually dissolve it with an effervescence occasioned by the emission of nitrous and azotic gas. This solution assumes at first a yellow colour, which gradually deepens as the platinum dissolves; and when the solution is finished, it is of a very deep red or brown *. It is exceedingly acrid and caustic, and tinges the skin indelibly of a dark brown colour. When it is sufficiently concentrated by evaporation, very small irregular crystals of muriat of platinum are deposited of a reddish brown colour; and when properly edulcorated and dried, less soluble in water than sulphat of lime †. It has a disagreeably astringent metallic taste. Heat decomposes it by driving off the acid. The earths, as far as they have been tried, decompose the solution of this salt by precipitating its oxide; and the same effect, as Bergman first demonstrated, is produced by a sufficient quantity of soda ‡.

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* During the action of the acid on the metal, a great quantity of gas is evolved; which Lametherie first remarked to be oxy-muriatic acid; and with this conclusion the experiments of Mr Davy accord. See Davy's *Researches*, p. 222.

† Bergman, ii. 167.

‡ Ibid. p. 172.

But the other two alkalies combine with the muriat of platinum, and form triple salts, which deserve attention.

Sp. 2. *Muriat of Platinum-and-Potass.*

When potass is added to the solution of platinum in nitro-muriatic acid, small heavy crystals, of a red colour and octahedral form, are deposited, composed of muriatic acid, oxide of platinum, and potass. The same triple salt is obtained if, instead of potass, the sulphat, nitrat, muriat, or acetite of that alkali be employed. It is sometimes obtained also in the form of a yellow powder. It is soluble in water, and decomposed with difficulty by soda *.

Sp. 3. *Muriat of Platinum-and-ammonia.*

For the discovery of the nature of this salt we are likewise indebted to Bergman. When ammonia is added to the solution of platinum in nitro-muriatic acid, small crystalline grains are deposited, which have an octahedral form, a red or yellow colour, and are soluble in water. These crystals are composed of muriatic acid, oxide of platinum, and ammonia. They are obtained equally, though not in such abundance, if sulphat, nitrat, or muriat of ammonia, be employed instead of the pure alkali or its carbonat. Soda dissolves them; and when the solution is evaporated to dryness, the ammonia is volatilized, and the oxide of platinum separated †. When this or the preceding salt is exposed to a violent heat, the platinum is reduced.

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* Bergman, ii. 168.

† Ibid. p. 174.

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Sp. 4. *Nitrat of Platinum.*

Nitric acid, as far as is known, is not capable of dissolving platinum, not even when combined with nitrous gas; but the oxide of platinum dissolves readily in this acid, and forms with it a nitrat, the properties of which have not been examined.

Sp. 5. *and* 6. *Triple Nitrats of Platinum.*

Bergman has ascertained that potass and ammonia, or their saline compounds, produce the same effect upon the solution of nitrat of platinum that they do on the muriat; that is to say, they occasion a precipitate in crystals, constituting a triple salt; composed, in the first case, of nitric acid, oxide of platinum, and potass; and in the second, of the same acid and oxide, combined with ammonia *.

Sp. 7. *Sulphat of Platinum.*

Though sulphuric acid has no action on platinum, it dissolves its oxide; but the properties of the salt formed have not been examined.

Sp. 8. *and* 9. *Triple Sulphats of Platinum.*

Bergman has proved, that when potass, or ammonia, or their compounds, are dropt into the solution of sulphat of platinum, a triple salt is also precipitated; composed, in the first case, of sulphuric acid, oxide of platinum, and potass; and in the second, of the same bodies combined with ammonia †. It appears, then, that the oxide of platinum, with what acid soever it be uni-

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* Bergman, ii. 175.

† Ibid.

ted, has the property of combining with potass and ammonia, and of forming with them triple salts. In this respect the oxide of platinum agrees with the yellow oxide of tungsten; and it is not probable that the property is confined to these two metallic bodies.

Sp. 10. *Oxalat of Platinum.*

PLATINUM is not acted on by any acid except the oxy-muriatic and nitro-muriatic; but its oxide is soluble in oxalic acid, and yields by evaporation yellow crystals of oxalat of platinum, the properties of which have not been examined*.

Sp. 11. *Benzoat of Platinum.*

ONLY a small proportion of the oxide of platinum is dissolved by benzoic acid. The liquid, by evaporation, yields yellow crystals of benzoat of platinum, which are not altered by exposure to the air, are difficultly soluble in water, and not at all in alcohol. When exposed to the action of heat, the acid is driven off, and the oxide left behind †.

Sp. 12. *Sebat of Platinum.*

SEBACIC ACID dissolves the oxide of platinum, and yields brownish yellow crystals of sebat of platinum. This acid also precipitates platinum from its solution in nitro-muriatic acid in the state of a salt ‡.

Sp. 13. *Prussiat of Platinum.*

SCHEELE ascertained, that prussic acid has no action either on platinum or its oxide; neither is any precipi-

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[*] Bergman, i. 266.

[†] Trommsdorf, *Ann. de Chim.* xi. 315.

[‡] Crell.

tate occasioned by pouring the prussiats into a solution of platinum in nitro-muriatic acid. Consequently either these two bodies are incapable of combining, or the prussiat of platinum is very soluble in water*.

GENUS III. SALTS OF SILVER.

SEVERAL of the acids are capable of oxidating silver; but it resists the action of the greater number. The nitric dissolves it with great facility; hence it is the nitrat of silver with which we are best acquainted. Most of the other acids form with it compounds scarcely soluble in water. All the salts of silver, as far as is known, are decomposed by the alkalies and earths, except the muriat. Vauquelin has ascertained that the alkalies have no effect upon this salt, and that oxide of silver is capable of decomposing the alkaline muriats. The salts of silver may be easily ascertained by the following properties:

Characters.

1. When exposed to the action of the blow-pipe upon charcoal, they are reduced, and a globule of silver obtained.

2. The prussiats, when dropt into a solution of a salt of silver, occasion a white precipitate.

3. Hydrosulphuret of potass occasions a black precipitate.

4. Muriatic acid or the alkaline muriats occasion a white heavy fleaky precipitate resembling curd.

5. Gallic acid and the infusion of nutgalls occasion a brown precipitate, at least in several of the solutions of silver.

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* Scheele, ii. 172.

6. When a plate of copper is put into a solution of silver, that last metal precipitates in the metallic state, retaining, however, a little of the copper alloyed with it.

Sp. 1. *Sulphat of Silver.*

Formation.

SULPHURIC ACID does not act on silver while cold; but when boiled upon that metal in the state of powder, an effervescence is produced, occasioned by the escape of sulphurous acid gas, and the silver is reduced to a white mass soluble in diluted sulphuric acid. This solution is limpid and colourless, and yields on evaporation crystals of sulphat of silver. These crystals are white and brilliant, and have the form of very fine prisms.

Properties.

This salt is but very sparingly soluble in water; hence the reason that it is generally precipitated in the state of a white powder when sulphuric acid is dropt into a solution containing silver. It is soluble in nitric acid without decomposition*. When heated, it melts, and in a dry heat is decomposed; the silver is reduced, and sulphurous acid and oxygen gas are disengaged. When exposed to the light, it is also slowly decomposed. It is decomposed also by the following bodies:

1. Alkalies and alkaline earths, and their carbonats.
2. Muriats, phosphats, fluats.

According to Bergman†, 100 parts of silver, precipitated from its solution by sulphuric acid, yield 134 of sulphur. Now allowing, with Proust, 9 parts of the increase for oxygen, this would give us the component

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[*] Klaproth.

[†] *Opusc.* ii. 391.

parts of sulphat of silver as follows:

18 acid
82 oxide of silver

100

Sp. 2. *Sulphite of Silver.*

Sulphurous acid does not attack silver, but it combines readily with its oxide. The sulphite assumes the form of small brilliant white grains. It has an acrid metallic taste. Water dissolves only a very minute portion of it; accordingly sulphurous acid occasions a white precipitate of sulphite in solutions of silver. When exposed to the light, it assumes a brown colour. When strongly heated, the silver is reduced, and sulphurous and sulphuric acids exhaled.

This salt may be obtained also by mixing together the solutions of sulphite of ammonia and nitrat of silver; but if too much sulphite of ammonia be added, the salt is redissolved and a triple salt formed, composed of sulphurous acid, oxide of silver, and ammonia. The fixed alkalies are also capable of dissolving the sulphite of silver, and forming with it triple salts *.

Sp. 3. *Nitrat of Silver.*

Formation.

Nitric acid attacks silver with considerable violence, and dissolves about half its weight of it. The effervescence is occasioned by the disengagement of nitrous gas. The acid employed must be pure; if it contains any muriatic acid, as is always the case with the nitrous acid of commerce, a white insoluble muriat

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* Fourcroy, vi. 323.

of silver falls to the bottom of the vessel. If the silver contain gold, that metal is also precipitated in the form of a black or very deep purple powder.

The solution is nearly limpid, exceedingly heavy, and astonishingly caustic. It gives the skin, hair, and almost all animal substances, an indelible black colour. Hence it is often used to dye hair, &c. When evaporated till a pellicle begins to form on its surface, it deposites, on cooling, transparent crystals of nitrat of silver. These crystals are brilliant and very irregular; sometimes assuming the form of six-sided, sometimes of four-sided, and sometimes of three-sided, thin plates. Their taste is intensely bitter and metallic.

Properties.

This salt is very soluble in water; it does not deliquesce in the air; but when exposed to a strong light, it becomes brown; and the silver is partly reduced. When heated, it readily melts, swells up, and loses its water of crystallization, and then remains liquid. When allowed to cool, it forms a grey-coloured mass crystallized internally in needles. In that state it is cast in moulds by apothecaries, and formed into small cylinders, often employed by surgeons under the names of *lapis infernalis* and *lunar caustic,* to open ulcers and destroy fungous excrescences.

When this salt is exposed to a red heat, as when it is put upon burning coals, it detonates, and the silver remains pure, attached to the surface of the coal. The same reduction takes place when the salt is distilled in a retort, and nitrous gas, oxygen gas, and azotic gas, are disengaged.

Action of combustibles on it.

Mrs Fulhame has shewn, that when this salt is dissolved in water, it is decomposed, and the silver reduced by means of hydrogen gas and phosphorus. A bit of silk moistened with this solution, and exposed to the action of hydrogen gas, is almost immediately covered with a thin layer of silver, which adheres strongly. The same effect is produced by phosphorus and by sulphurous acid gas.

This salt, both in crystals and after being melted, has the property of fulminating violently when mixed with phosphorus, and struck smartly with a hammer. This was first observed by Brugnatelli. To the same ingenious chemist we are indebted for the two following facts: When three grains of sulphur and nine grains of nitrat of silver, mixed together, are struck with a cold hammer, the sulphur inflames, but no detonation takes place; whereas if the hammer be hot, the mixture detonates, and the silver is reduced. If charcoal be substituted for sulphur, only a faint detonation is heard though the hammer be hot *.

The silver is precipitated from the solution of this salt in water in a metallic state by the greater number of the metals, especially by mercury and copper, which at the same time combine with it.

Decomposition.

This salt is decomposed by all the alkalies and alkaline earths, and by the sulphuric, sulphurous, muriatic, phosphoric, and fluoric acids. It is decomposed also by the following salts:

1. Sulphats,
2. Sulphites,
3. Muriats,
4. Phosphats,
5. Fluats,
6. Borats,
7. Carbonats.

The salt which has been thus described under the name of *nitrat* of silver, is in reality an *oxy-nitrat*, like

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* *Ann. de Chim.* xxvii. 72.

all the other known salts of silver; for its base is silver combined with a maximum of oxygen. Mr Proust has observed, that the other oxide of silver is capable also of combining with nitric acid, and forming a solution containing what ought to be called *nitrat of silver*: But that salt cannot be obtained in a solid form; because, whenever the solution is evaporated, the oxide takes oxygen from the acid; and of course *oxy-nitrat*, or what is commonly called *nitrat of silver*, is formed*.

Chap. III.

Sp. 4. *Muriat of Silver.*

MURIATIC ACID does not attack silver, even when assisted by heat; but the muriat of silver is easily formed by dropping muriatic acid, or any of its combinations with alkalies or earths, into the solution of silver in nitric acid. A white flaky precipitate immediately forms, which is muriat of silver, or *hornsilver* as it was formerly called.

Properties.

This salt is scarcely soluble in water; according to Monnet, it requires no less than 3072 parts of that liquid to dissolve it. When exposed to the air, it gradually acquires a black colour, owing to the escape of part of its acid, and the consequent reduction of part of the oxide of silver. When exposed to a very gentle heat, it melts, and assumes, on cooling, the form of a grey-coloured semitransparent mass, having some resemblance to horn, and for that reason called *luna cornea*. When heated strongly in an earthen crucible, it passes through altogether, and is lost in the fire; but when mixed with about four times its weight of fixed alkali, formed into a ball with a little water, and melt-

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* *Jour. de Phys.* xlix. 223.

ed rapidly in a crucible well lined with alkali, the silver is reduced, and obtained in a state of complete purity.

Composition.

Muriat of silver, according to the analysis of Proust, is composed of . . . . . 18 acid
82 oxide of silver

100*

This oxide of silver, according to the experiments of the same acute philosopher, contains 8.5 per cent. of oxygen†.

The muriat of silver is soluble in ammonia. The alkaline carbonats decompose it, but not the pure alkalies: neither is it decomposed by any of the acids. Several of the metals, when fused along with it, separate the silver in its metallic state; but it is always alloyed with a little of the metal employed. Copper, iron, lead, tin, zinc, antimony, and bismuth, have been used for that purpose.

Muriat of silver is formed also when silver is exposed to the action of oxy-muriatic acid.

Sp. 5. Phosphat of Silver.

Phosphoric acid does not act upon silver, but it combines readily with its oxide. Phosphat of silver is

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[*] With this the analysis of Bergman coincides almost exactly (See Bergman, ii. 391.), and those of Kirwan very nearly. According to him, muriat of silver, dried in a heat of 130°, is composed of

16.54 acid
83.46 oxide

100.00

[†] *Jour. de Phys.* xlix. 221.

precipitated in the state of a white powder when phosphoric acid is poured into liquid nitrat of silver. It is insoluble in water, but soluble in an excess of phosphoric acid. When heated strongly in a crucible, a little phosphorus comes over, and phosphuret of silver remains in the retort *.

Sp. 6. *Fluat of Silver.*

Fluoric acid does not attack silver; but its oxide is partly dissolved by that acid, and partly forms with it an insoluble salt †. This acid precipitates the fluat of silver from the liquid nitrat in the form of a white heavy powder, which is supposed by some to resemble the appearance of muriat of silver. This salt is decomposed by the sulphuric acid.

Sp. 7. *Borat of Silver.*

Boracic acid has no action on silver whatever; but the borat may be formed by pouring a solution of borax into liquid nitrat of silver. The salt falls to the bottom in the form of an insoluble white powder, which has not been examined.

Sp. 8. *Carbonat of Silver.*

Carbonic acid has no action whatever upon silver; but it is absorbed readily by the oxide of that metal. The carbonat may be obtained by precipitating silver from its acid solutions by means of a carbonated alkali. A white insoluble powder is obtained, which is carbonat of silver. This salt becomes black when exposed to the light; and, when heated, the acid is driven off,

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* Fourcroy, vi. 340.

† Scheele, i. 32.

and the silver reduced. According to Bergman, when this salt is obtained by precipitating 100 parts of silver from its solution, by means of carbonat of soda, it weighs 129 *. According to this experiment, if we allow, with Proust, nine parts of the increase of weight to be oxygen, carbonat of silver is composed of about

15 acid
85 oxide of silver

100

Sp. 9. *Arseniat of Silver.*

For the only account of this salt hitherto given we are indebted to Scheele, the discoverer of arsenic acid. This acid does not attack silver at the common temperature; but when the two bodies are heated together pretty strongly, arsenic is sublimed, the silver oxidated, and the mixture melts into a transparent glass. Water carries off from this glass arsenic acid, holding silver in solution; and leaves a brown insoluble powder, which is arseniat of silver. When this salt is exposed to a heat sufficient to melt the silver, that metal is reduced.

The arseniat of silver may be obtained also by dropping arsenic acid into a solution of silver in nitric acid. The salt precipitates in the state of a brown powder. It may be obtained equally by using, instead of arsenic acid, the alkaline arseniats †.

Scheele has observed, that a mixture of arsenic and muriatic acids oxidate silver in a digesting heat, and convert it into muriat, though neither of these acids has

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* Bergman, ii. 391.

† Scheele. i. 167.

any effect on it separately. During the process the arsenic acid loses its oxygen, and is converted into arsenic [*].

Sp. 10. *Chromat of Silver.*

When chromat of potass is dropt into liquid nitrat of silver, a powder precipitates of a beautiful crimson, which becomes purple when exposed to the action of light. This powder is chromat of silver. When heated, it melts and becomes blackish. Before the blow-pipe, when exposed to the action of the blue flame of the candle, it acquires a green colour, and the silver is reduced [†].

Sp. 11. *Acetite of Silver.*

Acetous acid has no action whatever on silver; but it readily dissolves its oxide, and forms with it acetite of silver. The properties of this salt are but imperfectly known. It may be formed easily by putting acetite of potass into a solution of nitrat of silver, or by saturating hot acetous acid with the oxide of silver. On cooling, the solution yields, according to Margraff, small prismatic crystals of an acrid metallic taste, and easily dissolved in water [‡]. When heated, it swells up, the acid is dissipated, and the oxide of silver remains behind.

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[*] Scheele, i. 169.

[†] Vauquelin.

[‡] This has been denied by Monnet, but found accurate by Kirwan. The saturated solution, filtered while hot, yielded him very speedily acicular crystals. He supposes that Monnet failed by evaporating the solution.—Kirwan on *Mineral Waters*, p. 81.

Sp. 12. *Oxalat of Silver.*

OXALIC ACID does not attack silver, but it dissolves a small portion of its oxide. The oxalat of silver, which was first examined by Bergman, may be formed by pouring oxalic acid into a solution of nitrat of silver. It is a white powder scarcely soluble in water, and not at all in alcohol; but soluble in nitric acid. It becomes black by being exposed to the air, owing to the reduction of the oxide *.

Sp. 13. *Tartrite of Silver.*

TARTAROUS ACID does not attack silver; but it dissolves its oxide, and forms with it a saline mass, which becomes black by exposure to the air †. Tartarous acid does not occasion a precipitate in liquid nitrat of silver.

Sp. 14. *Triple Tartrite of Silver.*

THENARD has shown, that when tartar is poured into liquid nitrat of silver, a triple salt is formed, composed of tartarous acid, potass and oxide of silver. This salt is decomposed by the alkalies and their carbonats, and by the sulphats and muriats ‡.

Sp. 15. *Citrat of Silver.*

SILVER is not attacked by the citric acid; but its oxide combines with it, and forms with it a salt insoluble in water, of a harsh metallic taste, which blackens when exposed to the light, and yields, when distilled, acetous acid, while the silver is revived. This salt is

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* Bergman, i. 386.

† Wenzel's *Verwand*, p. 309.

‡ *Ann. de Chim.* xxxviii. 36.

decomposed by nitric acid. According to Vauquelin, to whom we are indebted for these facts, it is composed of . . . . 36 acid
64 oxide of silver

100 *

Sp. 16. *Malat of Silver.*

SCHEELE ascertained, that malic acid occasions a precipitate in nitrat of silver. But the nature of that precipitate has not been examined †.

Sp. 17. *Mucite of Silver.*

MUCOUS acid occasions a white precipitate when dropt into nitrat of silver ‡.

Sp. 18. *Benzoat of Silver.*

BENZOIC acid does not attack silver, but it dissolves its oxide, and forms with it a salt easily soluble in water, but in a very small proportion in alcohol. It does not deliquesce in the air; but when exposed to the rays of the sun, it becomes brown. Heat volatilizes the acid and revives the silver §.

Sp. 19. *Succinat of Silver*

THE succinic acid does not act on silver, but it dissolves its oxide, and forms with it a salt which crystallizes in thin oblong radiated prisms ||.

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* Fourcroy, vii. 209.

† Crell's *Annals*, ii. 11. Engl. Trans.

‡ Scheele, ii. 80.

§ Trommsdorf, *Ann. de Chim.* xi. 315.

|| Wenzel's *Verwand.* p. 338.

Book II.
Division II.

GENUS IV. SALTS OF MERCURY.

THERE is no genus of metallic salts which has been subjected to a longer or more varied examination than this. Mercury was the metal from which the alchymists conceived the greatest hopes, and which they exposed to every possible torture during their researches after the philosopher's stone. The introduction of mercurial salts into medicine occasioned a scrutiny no less varied and obstinate, after the paroxysm of the alchymists was over. The important cures performed by their means, especially in cases of the venereal disease, were early seen by physicians: but the energy with which they acted, and the ravages which they sometimes made on the constitutions of those who used them, were equally visible. These deleterious effects were ascribed to a certain acrid *something* which was supposed to constitute a component part of mercury. The object of chemical physicians was long directed towards discovering a method of removing, neutralizing, or destroying this acrid something, without impairing the good effects of the medicine. Hence the numerous preparations of mercury which were one after another introduced into practice; some of which have in a great measure answered the purposes for which they were intended; while the greater number, after continuing fashionable for a time, have gone one after another out of use.

Mercurial salts have lately engaged the attention of philosophical chemists, because, from the peculiar nature of the metal, the changes which take place during their information are more easily traced. To them we are indebted for the discovery of the composition of sulphuric acid, of metallic oxides, and for the first decisive proofs of the nonexistence of phlogiston : to them we owe the discovery of oxygen gas, and perhaps also of nitrous gas.

Mercurial salts are distinguished by the following properties :

Characters.

1. When strongly heated, they are volatilized and dissipated ; and traces of mercury may be sometimes observed.

2. Triple prussiat of potass or lime occasions a whitish precipitate, which becomes yellow when exposed to the air.

3. Hydrosulphuret of potass occasions a black precipitate.

4. Muriatic acid, when poured into their solution in water, usually occasions a white precipitate.

5. Gallic acid, or the infusion of nutgalls, occasions an orange-yellow precipitate.

6. A plate of copper plunged into a liquid mercurial salt gradually precipitates running mercury.

Sp. 1. *Sulphated Mercury.*

THE action of sulphuric acid on mercury had been observed by chemists in the very infancy of the science, but the phenomena of that action were first explained by Lavoisier in 1777 *, and the different compounds obtained were first examined with precision by Fourcroy in 1791 †. There are no fewer than three different combinations of sulphuric acid and oxide of mercury, which may be distinguished by the names of *super-sulphat*, *sulphat*, and *oxy-sulphat* of mercury.

Three varieties.

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* *Mem. Par.* 1777.

† *Ann. de Chim.* x. 293.

1. *Super-sulphat of mercury.* Sulphuric acid has no action on mercury while cold; but when heat is applied, an effervescence ensues, and sulphurous acid gas is emitted. This indeed is the method usually ſollowed for obtaining that gas in a state of purity. At the same time the mercury is gradually oxydated and converted into a white mass. If the process be stopped before the whole of the sulphuric acid is evaporated to dryness, the white mass obtained, after being washed with a little water, is *super-sulphat of mercury.* This salt has an acrid taste, it reddens vegetable blues, and does not become yellow when exposed to the air. As it contains different proportions of acid, according to the process, its solubility of course is different. When the excess of acid amounts to about the twelfth of its weight, it is soluble in 157 parts of cold water, and in about 33 parts of boiling water *.

2. *Sulphat of mercury.* If the super-sulphat of mercury be washed successively with very small portions of cold water till it ceases to redden the tincture of turnsole, the excess of acid is carried off along with a portion of the oxide, and there remains behind a white salt much less corrosive and acrid than the super-sulphat. This salt, first discovered by Fourcroy, is *sulphat of mercury.* It has been mentioned already, that super-sulphat of mercury, containing a twelfth part of acid in excess, is soluble in 157 parts of cold water: now, if only the fourth of this quantity of water, or 39 parts, be poured upon the salt, the whole excess of acid, together with a considerable portion of the oxide, is car-

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* *Ann. de Chim.* x. 298.

ried off, and there remains behind pure sulphat of mercury.

This salt is very white. It is soluble in 500 parts of cold water, and in 287 parts of boiling water. It is not altered by exposure to the air; but heat decomposes it. According to Fourcroy, it is composed of

12	acid
83	white oxide of mercury
5	water
100	

The alkalies and lime water precipitate the mercury in the state of black oxide. Sulphuric acid combines with it, and converts it into super-sulphat of mercury *.

3. *Oxy-sulphat of mercury.* When three parts of sulphuric acid are boiled upon two parts of mercury, the whole is gradually converted into super-sulphat. If the heat be continued, the excess of acid is slowly decomposed, sulphurous acid gas is disengaged, the mercury combines with an additional dose of oxygen, and there remains a salt composed of sulphuric acid and yellow oxide, or more probably mercury oxidated to a maximum. This salt, according to the rules laid down formerly, ought to be called *oxy-sulphat of mercury.* When water is poured upon it, part of the acid is separated, and the salt assumes the form of a yellow powder, formerly known by the name of *turpeth mineral.* It is oxy-sulphat with an excess of base, as Rouelle and Fourcroy have proved. It is soluble in 2000 parts of cold water, and in 600 parts of boiling water. The solution is colourless †.

Turpeth mineral.

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* *Ann. de Chim.* x. 299.

† Fourcroy, Ibid.

The name *turpeth mineral* seems to have been given to this salt by Crollius, who boasted of its medicinal virtues, but kept the preparation a secret. He attempted to moderate the violent action of this substance by a long digestion, but without success. The process for preparing it was afterwards made public. Kunkel published a set of experiments on it in 1700, in his *Laboratorium Chymicum*. The name *turpeth* was no doubt given from some resemblance which it was supposed to have either in its colour or effects to the root of the *convolvolus turpethum*, a plant formerly used in medicine.

Sp. 2. *Sulphat of Ammonia-and-mercury.*

THIS triple salt, discovered by Fourcroy, may be formed by pouring ammonia into a solution of sulphat of mercury. If only a small quantity of ammonia be used, a copious blackish precipitate takes place, part of which is converted into running mercury by exposure to light, and consequently is black oxide of mercury; the remaining part is the triple salt. If a large quantity of ammonia be used, only the black oxide is precipitated; for the triple salt is rendered much more soluble by an excess of ammonia. As this excess evaporates, the salt crystallizes. Properties. The crystals are polygons, very brilliant and hard. The salt has a sharp, austere, metallic taste. It has no peculiar odour. It is scarcely soluble, except with excess of ammonia. Heat decomposes it. The products obtained by distilling it are, a little ammonia, azotic gas, a little pure mercury, some *sulphite of ammonia;* and there remains yellow sulphat of mercury *.

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* Fourcroy, *Ann. de Chim.* x. 299.

This triple salt may be formed also by pouring ammonia upon super-sulphat of mercury, or on oxy-sulphat of mercury *. According to Fourcroy's analysis, it is composed of . . . 18 acid

Composition.

39 oxide of mercury
33 ammonia
10 water

100†

Sp. 3. *Nitrated Mercury.*

The action of nitric acid on mercury has been long known to chemists, and indeed is described minutely by the alchymists; but it was Bergman who first pointed out the different compounds which that acid forms with the mercurial oxides‡. These are two in number; namely, the *nitrat* and *oxy-nitrat*; the last of which contains mercury oxidated to a maximum. To these two Fourcroy has added a third, the *super-nitrat*, consisting of the first of these salts combined with an excess of acid. So that we have three varieties of nitrated mercury corresponding to the same number of sulphated mercurial salts.

Varieties.

1. *Nitrat of Mercury.* When nitric acid is poured upon mercury, an effervescence takes place, and nitrous gas is disengaged; the metal is gradually oxidated, and dissolved in that portion of the acid which remains un-

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* Fourcroy, *Ann. de Chim.* x. 299.

† As sulphurous acid does not attack mercury, and is converted into sulphuric acid by the oxides of that metal, there seems to be scarcely any such salt as *sulphite of mercury*, at least capable of assuming a solid form.

‡ *Opusc.* i. 102.

decomposed. Nitric acid without the assistance of heat is capable of dissolving almost its own weight of mercury, and the solution is colourless, very heavy, and exceedingly caustic. It tinges the skin indelibly black, and gives the same colour to almost all animal substances. By spontaneous evaporation it yields transparent crystals composed of two four-sided pyramids applied base to base, having their apexes and the four solid angles at their bases truncated. This solution does not yield a precipitate when water is poured into it, and the crystals of nitrat of mercury are soluble without decomposition.

Nitrous turpeth.

When exposed to the air, it gradually absorbs oxygen, and acquires the yellow colour and appearance of turpeth mineral. In this state it has been called by Monnet *nitrous turpeth*. Nitrat of mercury is decomposed by the fixed alkalies, which precipitate the oxide of mercury of a white colour; by ammonia, which precipitates it black; and by muriatic acid and the muriats, which occasion a heavy precipitate of muriat of mercury resembling curd.

2. *Super-nitrat of mercury*. This is merely the last salt with an excess of acid. It is always in the state of super-nitrat when first formed, previous to its crystallization. In that state it is not so apt to absorb oxygen from the air, and to acquire a yellow colour.

3. *Oxy-nitrat of mercury*. When nitric acid is made to dissolve mercury with the assistance of heat, it acts with much more energy, a much greater quantity of nitrous gas is emitted, and the metal combines with a greater proportion of oxygen; and if the heat be continued, it passes at last into a white mass. In this solution the acid is combined with mercury oxidated nearly

to a maximum. It is more acrid than the first solution; and when diluted with water a precipitate appears, consisting of the salt combined with a great excess of base. This precipitate is white if the solution be diluted with cold water, but yellow or greenish-yellow if hot water be used.

Hitherto the difference between these three nitrats has not been much attended to by chemists, if we except Bergman and Scheele. This last chemist has shewn, that when nitric acid is made to act upon a greater portion of mercury than it is capable of dissolving, even when assisted by heat, both the nitrat and oxy-nitrat are formed, but by far the greatest proportion of the first. The reason of which probably is, that the new portions of mercury, as they are dissolved, deoxidate part of the oxy-nitrat already formed, and convert it into nitrat *.

When the nitrat of mercury is placed upon burning coals, it detonates feebly, emitting a lively white flame. When mixed with a little phosphorus, and struck with a hot hammer, it detonates violently, and the mercury is reduced †.

Sp. 4. *Muriated Mercury.*

THE compounds formed by the combination of muriatic acid with the oxides of mercury have, on account of their very great importance, attracted the peculiar attention of chemical philosophers. There is scarcely a single writer on the science who has not either attempted to vary the processes for making them, or to ascertain their properties, or to explain

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* Scheele, i. 221.

† Brugnatelli, *Ann. de Chim.* xxvii. 74.

their nature and composition. In 1769 Bergman published a treatise on the mercurial muriats, in which he collected the more important labours of his predecessors, and gave us also his own experiments*; but that illustrious philosopher failed in his attempts to explain the cause of the different properties exhibited by these salts. It was only after the discovery of the oxy-muriatic acid, and of the nature of the different oxides of mercury, that this difficult problem could receive a satisfactory solution: and for the first complete solution we are indebted to Berthollet.

There are two mercurial muriats; one of them is composed of muriatic acid and mercury combined with a maximum of oxygen; it is of course an *oxy-muriat*; the other, containing mercury oxidated to a less degree, is only a *muriat*.

Action of muriatic acid on mercury.

Muriatic acid has no action whatever upon mercury; but it combines very readily with its oxides, and its affinity for these bodies is so strong that it separates them from the sulphuric and nitric acids. When muriatic acid is dropt into a solution of mercury in sulphuric or nitric acid, a white precipitate appears, consisting of the muriatic acid combined with the oxide. This compound is *muriat* of mercury, if the solution consisted of the sulphat or nitrat of that metal; but it is *oxy-muriat* of mercury if the acid was dropt into an oxy-sulphat or oxy-nitrat. Oxy-muriatic acid also has the property of dissolving mercury very readily, and it forms with it either a muriat or an oxy-muriat, according as the proportion of mercury acted upon is great or small. These, however, are not the usual methods of preparing the muriated mercurial salts.

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* *Opusc.* iv. 279.

Chap. III.
History.

1. *Oxy-muriat of mercury.* This salt is usually denominated *corrosive sublimate*, or *corrosive muriat of mercury*. The original discoverer of it is unknown. It is mentioned by Avicenna, who died before the middle of the eleventh century; and was even known to Rhases, who lived in the century before him. The Chinese have been acquainted with it also for a long time [*]. The alchymists appear all to have been acquainted with it, and to have reckoned it among their secrets; and some of them, Albertus Magnus for instance, describe it with a good deal of precision [†]. Berg-

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[*] Bergman, iv. 281.

[†] It constituted one of the grand ingredients in the composition of the philosophers stone. Albertus Magnus gives the following directions for preparing a liquor by which, says he, *omnia corpora calcinata in primam materiam reducuntur.* "Recipe aquam secundam *(nitro-muriatic acid)* unam libram et mercurii sublimati a vitriolo Romano et sale communi bene preparati clarissimi lotones undecim, et ponatur ad aquam secundam paulatim et successive; sigilletur orificium vitri bene, ne virtus mercurii immissi subito exhâletur, et ponatur vitrum in cineres calidos temperatos, et incipiet ista aqua statim operari in mercurium, ipsum dissolvendo et incorporando. Et sic permittas vitrum stare in cineribus calidis et in dissolutione aquæ, donec ipsa aqua de cetero non appareat, sed ipsum mercurium sublimatum ex toto dissolvet. Agit autem ipsa aqua semper in mercurium per modum imbibitionis donec ex toto solvat ipsum. Sed nota, si ista aqua ex toto non posset solvere mercurium impositum, tunc quicquid dissolutum fuerit per istam aquam de mercurio, hoc deponatur, et non solutum in fundo exsiccetur lento igne, et conteratur, et cum nova aqua iterum dissolvatur ut prius; et sic reiteretur iste ordo, donec totius mercurius sublimatus sit solutus in aquam. Et tunc omnes solutiones istius tertiæ aquæ in unum conjunge in vitrum mundum, et claude orificium ejus cum cera bene et serva diligenter. Hæc est aqua tertia philosophica spissa qualificata in tertio gradu perfectionis, et est mater aquæ vitæ, quæ omnia corpora in primam materiam dissolvit.

"Recipe tertiam aquam clarificatam, mercurialem, tertio gradu perfectionis qualificatam, et ponas eam in putrefactionem in ventrem equi bene digestam, in uno vitro claro bene sigillato cum longo collo per quatuor, man has enumerated no less than 14 different processes recommended by Chemists for preparing this salt; and since that time several new methods have been proposed.

Formation.

The process most commonly followed is to mix together equal parts of dry oxy-nitrat of mercury, decrepitated common salt, and calcined sulphat of iron. One-third of a matrass is filled with this mixture; the vessel is placed in a sand-bath, and gradually heated to redness. When the apparatus is cold, oxy-muriat of mercury is found sublimed in the upper part of the matrass. The theory of this process is obvious. The heat expels the sulphuric acid from the sulphat, which in its turn decomposes the common salt, and leaves the muriatic acid at liberty to act upon the mercurial oxy-nitrat, from which it separates the oxide, and sublimes with it in the state of oxy-muriat.—Another process, first proposed by Kunkel, is to expose, in a similar vessel, a mixture of equal parts of oxy-sulphat of mercury and dry common salt to a strong heat: oxy-muriat of mercury is equally sublimed. It may be formed likewise by passing oxy-muriatic acid into a solution of

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decim dies, et fac eam putrefieri et feces in fundo residere, tunc ista aqua transmutabitur de colore citrino in flaveum; quo facto excipe vitrum, et pone inter cineres lentissimo igne, et suppone alembicum cum suo receptaculo, et incipias distillare paulatim aquam vitæ clarissimam mundam ponderosam, lac virginum, acetum acerrimum guttatim et semper lento modo continuando ignem donec totam aquam vitæ serene distillaveris, tunc cessa cum igne et fac furnum infrigidari, et diligenter serva præter ad partem. Ecce ista est aqua vitæ, acetum philosophorum, lac virginis, per quam copora in primam materiam resolvuntur. Quod infinitis nominatur nominibus. Signa istius aquæ sunt ista: si gutta una projiciatur super laminam ignitam cupream statim penetrabit, et vestigium relinquet album, fumigat super ignem, coagulatur in acre ad modum glaciei."——*Compositum de Compositis. Theatrum Chemicum*, iv. 938.

nitrat of mercury, and evaporating the solution till the salt crystallizes [*]. But it would be tiresome and useless to enumerate all the different processes.

Properties.

Oxy-muriat of mercury, when obtained by sublimation, is in the form of a beautiful white semitransparent mass, composed of very small prismatic needles. By evaporation, it yields cubes or rhomboidal prisms, or more commonly quadrangular prisms with their sides alternately narrower, and terminated by dihedral summits [†]. Its specific gravity is 5.1398 [‡].

Its taste is excessively acrid and caustic, and it leaves for a long time a very disagreeable styptic metallic impression on the tongue. When swallowed, it is one of the most virulent poisons known, producing violent pain, nausea, and vomiting, and corroding in a very short time the stomach and intestines [§].

It is soluble in about 20 parts of cold water. Boiling water, according to Macquer, dissolves half its weight of it. Alcohol, according to the same philosopher, at the temperature of 70°, dissolves $\frac{3}{8}$ of its weight, and 100 parts of boiling alcohol dissolve 88 parts of it. It is not altered by exposure to the air. When heated, it sublimes very readily; and while in the state of vapour, it is exceedingly dangerous to those who are obliged to breathe it.

It is soluble in sulphuric, nitric, and muriatic acids; and may be obtained again by evaporation unaltered. It is decomposed by the fixed alkalies, and its oxide precipitated of a yellow colour, which soon becomes

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[*] Fourcroy, v. 337.

[†] Bergman, iv. 295.

[‡] Hassenfratz, *Ann. de Chim.* xxviii. 12.

[§] Hence it was called by the alchymists the *dragon* brick-red. This decomposition renders oxy-muriat of mercury a useful test for ascertaining the presence of alkalies in solution. If liquid oxy-muriat of mercury be dropt into a solution containing the smallest portion of alkali, the brick-red precipitate appears. The alkaline earths also decompose this salt, and ammonia forms with it a triple compound. Several of the metals, or their sulphurets, decompose it also by the assistance of heat. This is the case in particular with arsenic, bismuth, antimony, and tin. These metals are oxidated and combined with muriatic acid, while the mercury is reduced, and combined with sulphur if it be present.

Composition.

According to Bergman, oxy-muriat of mercury is composed of . . . . . 75.5 mercury
24.5 acid and oxygen

100.0 [*]

History.

2. *Muriat of mercury*. The discoverer of this important salt, commonly known in this country by the names of *calomel* and *mercurius dulcis*, is altogether unknown. It seems to have been prepared by the alchymists; but Crollius, so late as the beginning of the 17th century, speaks of it as a grand secret and mystery: But Beguin made the process public in 1608 in his *Tirocinium Chemicum*, in which he describes the salt under the name of *draco mitigatus* [†].

Formation.

The processes for preparing it, which are numerous, have been described by Bergman. The most usual was

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[*] *Opusc.* ii. 423.

[†] It has been known also by a variety of other names; such as, *sublimatum dulce*, *aquila alba*, *aquila mitigata*, *manna metallorum*, *panchymogogum minerale*, *panchymogogus quercetanus*.

to triturate oxy-muriat of mercury with running mercury in a glass mortar, till the mercury was *killed*, as the apothecaries term it; that is to say, till no globules of the metal could be perceived; and the whole was converted into a homogeneous mass. This mixture was put into a matrass, and exposed to a strong heat in a sand bath. The muriat sublimed; mixed, however, with a little oxy-muriat, which was either removed by repeated sublimations and triturations, or by washing the salt well with water. Scheele has given a much simpler process, but it has not been followed.

His method is to form a nitrat of mercury by dissolving as much mercury as possible in a given quantity of nitric acid. A quantity of common salt, equal to half the weight of the mercury used, is then dissolved in boiling water, and the boiling nitrat is cautiously poured into it. A white precipitate falls, which is to be edulcorated with water till the liquid comes off without any taste, and then dried upon a filter. This powder is muriat of mercury *.

The theory of the formation of this salt is obvious. By the first process, the mercury, combined with the oxy-muriat, which amounts to $\frac{3}{4}$ths of its weight, deprives the oxide of part of its oxygen, and of course the salt is converted into a muriat, which combines at the same time with an additional dose of oxide. In Scheele's process, the mercury is not oxidated to a maximum, or only a small portion of it is so; and the oxy-muriat formed is mostly dissolved by the solution of common salt, which is added in excess on purpose, and afterwards completely removed by the water with which the muriat is washed.

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* Scheele, i. 221.

Properties.

Muriat of mercury is usually in the state of a dull white mass; but when slowly sublimed, it crystallizes in four-sided prisms, terminated by pyramids. It has very little taste, is not poisonous, but only slightly purgative. Its specific gravity is 7.1758*. It is scarcely soluble, requiring, according to Rouelle, 1152 parts of boiling water to dissolve it.

When exposed to the air, it gradually becomes deeper coloured. When rubbed in the dark, it phosphoresces, as Scheele discovered. A stronger heat is required to sublime it than is necessary for the sublimation of oxy-muriat. Oxy-muriatic acid converts it into oxy-muriat of mercury; and the same change is produced by subliming it with one part of common salt and two parts of sulphat of iron.

The proportion of the component parts of the salt is unknown; but it evidently contains a very great excess of oxide. It is more used in medicine than all the other preparations of mercury put together.

Sp. 5. *Oxy-muriat of Mercury-and-ammonia.*

When ammonia is poured into a solution of oxy-muriat of mercury, a white precipitate falls, consisting of the oxy-muriat of mercury-and-ammonia with excess of base. It has a taste at first earthy, afterwards metallic: It is scarcely soluble in water. According to Fourcroy, it is composed of 16 acid

16	acid
81	oxide
3	ammonia
100	

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* Hassenfratz, *Ann. de Chim.* xxviii. 12.

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Sulphuric and nitric acids decompose it, and convert it into oxy-muriat of mercury and sulphat of ammonia-and-mercury, or nitrat of ammonia-and-mercury, according to the acid. The addition of muriatic acid renders it soluble in water *. In this last state it has been long known by the names of *sal alembroth* and *salt of wisdom.* It was formed by dissolving oxy-muriat of mercury in a solution of sal ammoniac in water, or by subliming the two salts together.

Sp. 6. Phosphat of Mercury.

Phosphoric acid does not act on mercury; but it combines with its oxide, and forms phosphat of mercury. This salt is formed most conveniently by mixing together the solutions of nitrat of mercury and phosphat of soda. The salt immediately precipitates in the state of a white powder. This salt has been lately introduced into medicine, and seems to answer equally well with the other mercurial preparations. It phosphoresces when rubbed in the dark; and when distilled, it yields phosphorus, like the other metallic phosphats. Its specific gravity is 4.9835 †.

Sp. 9. Fluat of Mercury.

Fluoric acid has no action on mercury; but it combines with its oxide, and forms a white insoluble fluat of mercury ‡. The same salt is precipitated when the alkaline fluats are mixed with the nitrat of mercury.

Sp. 8. Borat of Mercury.

Boracic acid has no action on mercury; but borat of

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* *Ann. de Chim.* xiv. 47.

† Hassenfratz, Ibid. xxviii. 12.

‡ Scheele, i. 32.

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soda, poured into a solution of that metal in nitric acid, occasions a precipitate of borat of mercury in the state of a yellow powder, first described by Monnet. Its specific gravity is 2.266 [*].

Sp. 9. *Carbonat of Mercury.*

Carbonic acid does not attack mercury, but it may be combined with its oxide by pouring an alkaline carbonat into nitrat of mercury. The precipitate in that case is a white powder, composed, according to Bergman, of . . . . 90.9 mercury
9.1 oxygen and acid

100.0 [†]

Sp. 10. *Arseniat of Mercury.*

When arsenic acid and mercury are heated in a retort, white oxide of arsenic, mercury, and yellow oxide of mercury, are driven over, and there remains a yellow-coloured insoluble mass, consisting of arseniat of mercury. The same salt is precipitated in the form of a yellow powder when arsenic acid is poured into the liquid nitrat or sulphat of mercury [‡].

Sp. 11. *and* 12. *Tungstat and Molybdat of Mercury.*

These salts have the form of insoluble powders; but their properties have not been examined [§].

Sp. 13. *Chromat of Mercury.*

This salt may be formed by mixing together the so-

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[*] Hassenfratz, *Ann. de Chim.* xxviii. 12.

[†] Bergman, ii. 391.

[‡] Scheele, i. 170.

[§] Ibid. ii. 90. & i. 246.

lutions of an alkaline chromat and a mercurial nitrat. It is an insoluble powder of a fine purple colour *.

Sp. 14. *Acetite of Mercury.*

ACETOUS ACID has no action on mercury; but it dissolves its oxides readily at the boiling temperature. As the solution cools, thin brilliant plates of acetite of mercury are deposited, resembling boracic acid. It may be prepared also by mixing together nitrat of mercury and acetite of potass. It has an acrid taste, is scarcely soluble in water, blackens when exposed to the light, and is decomposed by the action of heat.

Sp. 15. *Oxalat of Mercury.*

OXALIC ACID does not act on mercury; but it dissolves its oxide, and forms with it an oxalat in the state of a white powder, scarcely soluble in water. When exposed to the light, it very soon becomes black. The same salt is precipitated when oxalic acid is poured into the sulphat or nitrat of mercury †. Klaproth first discovered that this salt has the property of detonating when heated ‡; the same observation was afterwards made by Von Packen §. Howard's fulminating powder consists chiefly of this salt.

Sp. 16. *Tartrite of Mercury.*

TARTAROUS ACID does not attack mercury; but it dissolves its oxide, and forms with it an insoluble white salt, which soon becomes yellow when exposed to the

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* Vauquelin.

† Bergman, i. 266.

‡ Westrum's *Kl. Ph. Chim. Abh.* i. 228.

§ *De Sale Acido Tartari*, 1779.

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light. This salt precipitates also when tartarous acid is poured into nitrat of mercury.

Sp. 17. *Triple Tartrite of Mercury.*

THIS salt, first described by Monnet, may be formed by boiling in water six parts of tartar and one part of oxide of mercury. The liquid, when evaporated, yields small crystals of tartrite of potass-and-mercury. Thenart has ascertained, that the same triple salt may be formed by mixing together the solutions of tartar and mercurial nitrat. This salt is decomposed by the alkalies, the alkaline carbonats, the hydro-sulphurets, the sulphats, and the muriats [*].

Sp. 18. *Citrat of Mercury.*

THIS salt has been examined by Vauquelin. Citric acid does not attack mercury; but when poured upon its red oxide, an effervescence takes place, and the oxide becomes white and unites into one mass. The citrat thus formed has a mercurial taste, but is scarcely soluble in water. Nitric acid decomposes it. When distilled, there comes over acetous and carbonic acids, and the mercury is reduced [†].

Sp. 19. *and* 20. *Mucite and Malat of Mercury.*

WHEN mucous acid or malic acid is dropt into nitrat of mercury, a white precipitate appears [‡].

Sp. 21. *Benzoat of Mercury.*

BENZOIC ACID dissolves the oxide of mercury, and

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[*] *Ann. de Chim.* xxxviii. 36.

[†] Fourcroy, vii. 209.

[‡] Scheele, ii. 80. and Crell's *Annals*, ii. 11. Engl. Trans.

forms with it a white powder, not altered by exposure to the air. It is insoluble in water, and very sparingly soluble in alcohol. A moderate heat sublimes this salt, and a strong heat decomposes it. It is decomposed by lime, by sulphuric and muriatic acids, and by sulphur*.

Sp. 22. *Succinat of Mercury.*

When succinic acid is digested with the oxide of mercury, it forms with it a shapeless mass, from which the oxide is precipitated by alkalies and hydro-sulphurets †.

Sp. 23. *Prussiat of Mercury.*

This salt, which was first formed by Scheele, is composed of the prussic acid combined with the red oxide of mercury. It may be formed by boiling the red oxide of mercury with prussian blue. It crystallizes in tetrahedral prisms, terminated by quadrangular pyramids, the sides of which correspond with the angles of the prism. Its specific gravity is 2.7612 ‡.

This salt is capable of combining with sulphuric and muriatic acids, and forming triple salts, which have not yet been examined §.

Sp. 24. *Sebat of Mercury.*

When sebacic acid is repeatedly distilled from mercury, silver-coloured plates are formed soluble in sebacic acid, and not decomposed by common salt. This

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* Trommsdorf, *Ann. de Chim.* xi. 316.

† Wenzel's *Verwand.* p. 337.

‡ Hassenfratz, *Ann. de Chim.* xxviii. 15.

§ Berthollet, *Ann. de Chim.* i. 33.

acid readily dissolves the oxide of mercury; and after distillation of the liquor, a white sublimate may be obtained, which is very difficultly soluble in water. When sebacic acid is dropt into a solution of oxy-muriat of mercury, it occasions a white precipitate, which is considered as characteristic of this acid *.

Genus V. Salts of Copper.

These salts, in consequence of the facility with which copper absorbs oxygen, are in general more easily formed, and, of course, may be more readily examined than the preceding genera. Hence, no doubt, the reason that some of them have been so long known and so generally employed. The alchymists and the earlier chemists distinguished them by the name of *salts of Venus*, because Venus was the term by which they denoted copper. They are the class of metallic salts with the composition of which we are at present best acquainted, in consequence of the accurate analysis to which they have been subjected by the celebrated Proust †, and the important additions lately made to that analysis by Mr Chenevix ‡.

The cupreous salts may be distinguished by the following properties:

Characters.

1. They are almost all soluble in water, or at least become so by the addition of an acid. This solution has either a blue or a green colour, or it acquires that colour after being for some time exposed to the air.

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* Crell, *Phil. Trans.* 1780.

† *Ann. de Chim.* xxxii. 26.

‡ *Phil. Trans.* 1801. p. 193.

2. When ammonia is poured into this solution, it assumes a deep blue colour.

3. Triple prussiat of potass occasions a greenish-yellow precipitate when poured into a cupreous solution.

4. Hydro-sulphuret of potass occasions a black precipitate.

5. Gallic acid occasions a brown precipitate.

6. A plate of iron, when plunged into a liquid salt of copper, precipitates the copper in the metallic state.

Almost all the acids, as far as is known, combine only with copper oxidated to a maximum; so that, strictly speaking, all the salts of copper are oxygenated. To this general rule, however, there is one exception; the muriatic acid combines with both oxides of this metal, so that there is both a muriat and an oxy-muriat of copper.

Sp. 1. Sulphat of Copper.

Formation.

Sulphuric acid does not attack copper while cold; but at a boiling heat part of the acid is decomposed, the copper is oxidated, and combines with the remainder of the acid. But recourse is seldom had to this process, as the sulphat of copper is found native abundantly, dissolved in mineral waters connected with copper mines. From these waters it is often obtained by evaporation; or it is formed by burning native sulphuret of copper, or by moistening that substance and exposing it to the air. By either of these methods the sulphur is acidified, and the sulphat of copper formed. This salt appears to have been known to the ancients. In commerce it is distinguished by the name of *blue vitriol*, and sometimes by that of *blue copperas*.

Properties.

This salt has a deep blue colour. The primitive form of its crystals, according to Hauy, is an oblique parallelopiped, whose sides are inclined to each other at angles of 124° 1′ and 55° 59′; and whose base makes, with one of the sides, an angle of 109° 21′, and with the opposite side an angle of 70° 39′. It sometimes passes into the octahedron and decahedron, and the edges at the bases are often truncated.

It has a strong styptic metallic taste, and indeed is employed as a caustic. Its specific gravity is 2.1943*. It is soluble in four parts of water at the temperature of 60°, and in two parts of boiling water. When exposed to the air, it undergoes a very slight efflorescence, and its surface is covered with a greenish white powder. When heated, it loses its water, and is converted into a bluish white powder: if the heat be increased, the acid is driven off, and the brown oxide of copper remains behind.

Composition.

This salt, according to the analysis of Mr Proust, is composed of . . . . . 33 acid
32 oxide
35 water

100†

But part of this water is intimately combined with the

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* Hassenfratz, *Ann. de Chim.* xxviii. 12.

† *Ann. de Chim.* xxxii. 33.—According to Kirwan, it is composed of
31 acid
40 oxide
29 water

100

This agrees almost exactly with the experiments of Proust, if we suppose Mr Kirwan's oxide was in the state of a hydrat.

oxide in the state of hydrat of copper, as Mr Chenevix has observed. We may therefore consider the salt as composed of . . . . . 33 acid
42 hydrat of copper
25 water

100

This salt is decomposed by the alkalies and earths, the alkaline carbonats, borats, and phosphats, and by those metallic salts whose base forms with sulphuric acid a salt nearly insoluble, as the salts of lead.

This salt is used as a dye-stuff, and in the preparation of various pigments.

2. *Sub-sulphat of copper.* When a small quantity of pure potass is poured into a solution of sulphat of copper, a green-coloured powder appears, which swims in the solution. It may be separated by filtration; and when sufficiently edulcorated, is insoluble in water. This powder was first examined by Mr Proust: he has ascertained it to be a sub-sulphat of copper, and to be composed of . . . 18 acid
68 oxide
14 water

100[*]

The experiments of Proust render it probable that sulphuric acid does not combine with the orange oxide of copper: for when that acid is poured upon orange oxide, one part of the metal attracts oxygen from the other. The consequence is, the formation of blue sul-

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[*] *Ann. de Chim.* xxxii. 34.

phat of copper, and the precipitation of a red powder, which is copper reduced [*].

Sp. 2. *Sulphite of Copper.*

Sulphurous acid does not attack copper; but it dissolves its oxide with facility, and forms with it a sulphite of copper. This salt has been hitherto examined by Fourcroy and Vauquelin only. It may be formed by mixing together the solutions of sulphite of soda and sulphat of copper. An orange-coloured precipitate immediately falls, and afterwards small whitish-green crystals are deposited; the colour of which becomes deeper by exposure to the air. The first of these, in the form of an orange-coloured powder, is a *sub-sulphite;* the second, in the form of crystals, is a *sulphite* of copper.

When these salts are heated, they melt, and acquire a leaden-grey colour. The sub-sulphite is insoluble in water; but that liquid dissolves the sulphite, though sparingly. Nitric acid converts them into sulphat of copper; sulphuric acid separates the acid from the sulphite, and part of the oxide is reduced to the metallic state [†].

Sp. 3. *Nitrat of Copper.*

Nitric acid attacks copper with considerable violence; nitrous gas is emitted in great purity, while the metal is oxidated and dissolved. The solution is of a fine blue colour; and when slowly evaporated yields regular crystals of nitrat of copper.

These crystals are long parallelopipeds. Their spe-

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[*] *Jour. de Phys.* li. 182.

[†] Fourcroy, vi. 272.

cific gravity is 2.174 *. They have a fine blue colour. Their taste is acrid and metallic: and they are exceedingly caustic, corroding the skin with great energy. They are very soluble in water; and when exposed to the air, gradually attract moisture, and deliquesce. At a heat not exceeding 100° they undergo the watery fusion; and if the heat be increased, they lose their water and part of their acid. On burning coals they detonate feebly. These crystals detonate also when mixed with phosphorus and struck with a hammer, as Brugnatelli first observed. When a quantity of them, moistened with water, is wrapt up in a sheet of tinfoil, they act with amazing energy upon that metal, nitrous gas is emitted, a strong heat is produced, the tinfoil is burst open in every direction, and very often it takes fire. This curious experiment was first made by Dr Higgins †.

Action on combustibles.

Hydrat of copper.

When nitrat of copper is thrown into a diluted solution of potass, a bulky precipitate of a beautiful blue colour is obtained, provided the potass predominate. This precipitate has been called by Mr Proust *hydrat of copper*, because it is composed of the oxide of copper and water. To obtain this substance in a state of purity, it must be diluted with a large portion of boiling water, then filtered, and well washed. When dry, it does not assume the form of a powder, but of a solid mass, of the consistence of prussian blue. When heated upon paper, it gradually loses its water, and becomes green, and at last black. When kept dry, its colour remains unchanged; but when preserved under water,

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* Hassenfratz, *Ann. de Chim.* xxviii. 12.

† *Phil. Trans.* lxiii. 137.

it is gradually decomposed, and converted into black oxide. Black oxide accelerates this change. It is soluble in the fixed alkalies, and abundantly in ammonia*. It is this hydrat, mixed with a small portion of lime, which forms the beautiful blue paint sometimes employed for making painted paper. Mr Chenevix has shewn, that it is in the state of a hydrat that the oxide of copper exists in almost all the cupreous salts†.

Sub-nitrat.

When potass is poured into a solution of nitrat of copper, a blue precipitate appears, which soon becomes green by agitation, provided the quantity of potass be insufficient to decompose the whole of the nitrat. Mr Proust has proved, that this green precipitate is a *sub-nitrat* of copper. It may be obtained also by distilling nitrat of copper in a retort. At a particular period of this process the salt becomes thick, and encrusts the retort in the state of a green lamellar concretion. It is then converted into sub-nitrat. This salt is completely insoluble in water. Sulphuric acid separates its acid; and the same separation may be effected also by distillation. According to Proust, it is composed of

16	acid
67	oxide
17	water
100‡	

Nitric acid does not combine with orange oxide of copper; but when concentrated, it oxidates the metal to a maximum, and then dissolves it: when diluted, one part of the metal attracts oxygen from the other.

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* Proust *Ann. de Chim.* xxxii. 40.

† *Phil. Trans.* 1801, p. 204.

‡ *Ann. de Chim.* xxxii. 26.

The consequence is, the formation of blue nitrat, and the precipitation of a red powder, which is copper reduced *.

Sp. 4. Muriated Copper.

Muriatic acid has no action on copper while cold; but, by the assistance of heat, it oxidates and dissolves that metal, while at the same time hydrogen gas is evolved, and part of the acid volatilized. By this process the copper is oxidated to a maximum. But muriatic acid is also capable of combining with the orange oxide of copper, and of forming another salt, first discovered by Mr Proust, and afterwards more precisely examined by Mr Chenevix. Let us distinguish these salts, by calling the first *oxy-muriat* of copper, because the metal contained in it is oxidated to a maximum, and giving the name of *muriat* to the salt discovered by Mr Proust.

1. *Oxy-muriat of copper.* This salt may be obtained either by dissolving copper in muriatic acid by the assistance of heat, or by throwing the oxide of copper into that acid cold. The solution, which is of a fine green colour, yields, when sufficiently concentrated, and allowed to cool slowly, crystals of oxy-muriat of copper, in the form of rectangular parallelopipeds, of a fine grass-green colour.

Properties.

This salt is exceedingly acrid and caustic. Its specific gravity is 1.6775 †. It is very soluble in water; and when exposed to the air, very soon attracts moisture, and is converted into a liquid of the consistence of oil. At a moderate heat it melts, and assumes a solid

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* *Jour. de Phys.* li. 182.

† Hassenfratz, *Ann. de Chim.* xxviii. 12.

form when cold. According to Proust, it is composed of . . . . 24 acid
40 brown oxide
36 water.

100*

Sub-oxy-muriat.

This salt may be distilled to dryness without alteration; but if the heat be increased, oxy-muriatic acid passes over, the copper loses part of its oxygen, and there remains behind muriat of copper. When potass is poured into the solution of oxy-muriat of copper, a green powder is precipitated, which is a sub-oxy-muriat, containing 72 parts in the hundred of brown oxide of copper. When copper is dissolved in nitro-muriatic acid, a similar green powder separates, composed, according to Proust, of 12.5 acid
79.0 oxide
8.5 water

100.0†

Muriat of copper is not decomposed by sulphuric or nitric acid; but the alkalies and alkaline earths precipitate the oxide in the state of a sub-salt, if the muriat of copper predominate; and in the state of a hydrat if the alkalies predominate‡.

2. *Muriat of copper.* This salt, which contains copper combined with a minimum of oxygen, was discovered by Mr Proust while engaged in his experiments on tin. He observed, that when the salts of copper were mixed with the muriat of tin, that last salt deprived the copper of part of its oxygen, and formed a salt

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* *Ann. de Chim.* xxxii. 47.

† Ibid.

‡ Ibid.

of a white colour, not acted on by sulphuric acid, but soluble in muriatic acid. This solution yielded him a colourless salt, which on examination proved to be a muriat of copper *.

Formation.

Mr Chenevix has discovered a very simple process for obtaining this salt. He mixed together, in a mortar, 57.5 parts of the black oxide of copper, and 50 parts of copper in the state of a fine powder, obtained by precipitating that metal from its solution in muriatic acid by means of a plate of iron. The mixture was put along with muriatic acid into a well-stopped phial. A violent disengagement of caloric took place, the liquor became of a red-orange colour, and the whole was dissolved except 7.5 of metallic copper. The solution consisted entirely of muriat of copper †.

It may be obtained also, as Proust has shewn, by distilling oxy-muriat of copper. After the greatest part of the water has passed over, the acid attracts oxygen from the metal, and passes over partly in the state of oxymuriatic acid; a grey mass remains in the retort, which is muriat of copper. The salt may be obtained also by keeping a plate of copper plunged in a bottle filled with muriatic acid. Crystals of muriat gradually form upon the plate; and when the colourless acid is diluted with water, muriat of copper precipitates in the state of a white powder ‡.

Properties.

This salt crystallizes in tetrahedrons. When its concentrated solution is diluted with water, the salt precipitates in the state of a white powder, being no doubt deprived of the excess of acid which held it in solution.

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* *Ann. de Chim.* xxviii. 218.

† *Phil. Trans.* 1801, p. 237.

‡ *Jour. de Phys.* li. 181.

When repeatedly washed with water, its acid is carried off, and the orange oxide of copper only remains *. From the experiments of Proust, compared with those of Chenevix, this salt seems to be composed of about

24.75	acid
70.25	orange oxide
5.00	water
100.00	

When this salt is exposed to the air, it very speedily attracts oxygen, and is converted into oxy-muriat of copper. The sulphat of iron, when dropt into a solution containing it, precipitates the copper in the metallic state, while it passes itself to the state of oxy-sulphat †.

It dissolves in ammonia, and forms a colourless solution, which gradually attracts oxygen when exposed to the air, and at the same time acquires a fine blue colour ‡.

Sp. 5. *Phosphat of Copper.*

Phosphoric acid does not attack copper immediately; but when allowed to remain long upon that metal, oxidation at length takes place, and the phosphat of copper is formed. This salt may be obtained with great facility, by pouring phosphat of soda into a solution of nitrat of copper. A bluish-green powder immediately precipitates, which is phosphat of copper. This salt is insoluble in water. Its specific gravity, ac-

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* Chenevix, *Phil. Trans.* 1801, p. 230.

† Proust, *Ann. de Chim.* xxviii. 220.

‡ Id. *Jour. de Phys.* li. 182.

cording to Hassenfratz, is 1.4158[*]. When exposed to a red heat, it loses its water, and acquires a brown colour. When violently heated, phosphorated copper comes over. According to the analysis of Mr Chenevix, it is composed of

brown oxide 49.5	hydrat of copper	61.5
water 12		
acid		35.0
water		3.5
		100.0[†]

Sp. 6. *Fluat of Copper.*

Fluoric acid dissolves a small portion of copper when assisted by heat; and it dissolves its oxide with facility. The solution is gelatinous, and yields, when evaporated, blue crystals of fluat of copper, in the form of cubes or oblongs[‡].

Sp. 7. *Borat of Copper.*

When borax is poured into a solution of sulphat of copper, borat of copper is precipitated in the form of a pale light-green jelly, which when dried is with great difficulty soluble in water. It easily melts into a dark red vitreous substance[§]. According to Palm, by long trituration of filings of copper and boracic acid in water, and then digesting the mixture, it dissolves, and crystals may be obtained from it.

Sp. 8. *Carbonat of Copper.*

Carbonic acid does not attack copper; but it com-

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[*] *Ann. de Chim.* xxviii. 12.

[†] *Phil. Trans.* 1801. p 296.

[‡] Scheele, i. 33.

[§] Bergman.

bines readily with its oxide or with the hydrat of copper, when that compound is mixed with water, and a current of carbonic acid made to pass through it. Or the carbonat may be formed by precipitating a solution of nitrat of copper with a fixed alkaline carbonat*. To give the carbonat all its lustre, the solution should be mixed with boiling water, and the precipitate should be washed with great care, and exposed to the light of the sun. It has then a fine apple-green colour, and it is found often native in its greatest beauty. The native carbonat is known among mineralogists by the name of *malachite*. It is insoluble in water, and is entirely decomposed and reduced to the state of black oxide by the action of heat. According to the analysis of Proust, it is composed of . . . . 25.0 acid

69.5 brown oxide

5.5 water

100.0

A hundred parts of copper, dissolved in sulphuric or nitric acid, and precipitated by the carbonat of potass or soda, give 180 parts of carbonat of copper, which, being deprived of its acid and water by distillation, leaves 125 parts of oxide of copper†.

Sp. 9. *Arseniated Copper.*

WHEN arsenic acid is digested on copper, the metal is oxidated and dissolved, and a bluish-white powder is

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* Mr Chenevix has shown that the alkaline carbonats have the property of dissolving a portion of the oxide of copper, and of forming with it a triple salt.

† Proust, *Ann. de Chim.* xxxii. 28.

formed, which consists of the arseniat of copper. This salt may be formed also by pouring arsenic acid into acetite of copper, or by precipitating nitrat of copper by means of an alkaline arseniat *.

Found native.

Arseniat of copper has been lately found native in considerable quantities in the mine of Huel Gorland in the parish of Gwennap in Cornwall; and a very interesting description and analysis of it have been published by the Count de Bournon and Mr Chenevix in the Philosophical Transactions for 1801. From the experiments and observations of these celebrated philosophers, it appears that there are no less than five varieties of arseniated copper, differing from each other in the proportion of oxide, acid, and water, which they contain. In general they are insoluble in water, if we except one variety, which seems to be a super-arseniat, and which hitherto has not been found native. Their colour varies from a deep blue to green, and even to brown, yellow, and black. This variation seems to depend upon the proportion of water which they contain, the blue and the green containing most, and the brown least water.

Five varieties of it.

Variety 1. Obtuse octahedral arseniat. This variety is crystallized in obtuse octahedrons, composed of two four sided pyramids applied base to base, the faces of which are isosceles triangles; and two of them which are opposite are more inclined than the others. These meet at the apex at an angle of 130°, and at the base at an angle of 50°. The pyramids often terminate in ridges. These crystals are commonly a deep sky-blue, and sometimes a fine grass-green. Their specific gravity

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* Scheele, i. 175.

is 2.881 *. They are composed, according to the analysis of Chenevix, of

14.3	acid
50.0	brown oxide
35.7	water
100.0	

Variety 2. Hexahedral arseniat. This variety is commonly found in very fine six-sided laminæ, and is divisible into thin scales like mica. It is of a deep emerald green colour; and its specific gravity is 2.548 †. It is composed of . . .

21	acid
58	oxide
21	water
100	

This variety precipitates in the form of very small blue crystals when arseniat of ammonia is poured into nitrat of copper ‡.

Variety 3. Acute octahedral arseniat. This variety is composed of two four-sided pyramids applied base to base; two of the faces, which are more inclined, meet at the apex at an angle of 84°, and at the base at one of 96°. The other two form at the apex and base angles of 68° and 112°. The apex of the pyramids is often a ridge. Very frequently it assumes the form of a rhomboidal prism, terminated by dihedral summits, and in many cases the angles of 96° are truncated. Its usual colour is brown or dark bottle-green. Its specific gravity is 4.280 §. It is composed of

29	acid
50	oxide
21	water
100	

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* Bournon.

† Id.

‡ Chenevix.

§ Bournon.

But sometimes it is destitute of water altogether *.

Variety 4. Trihedral arseniat. The primitive form of this variety is a trihedral prism, whose basis are equilateral triangles; but it occurs crystallized in a great variety of figures, which have been described with great accuracy by the Count de Bournon. They are usually of a fine bluish-green colour, and of the same specific gravity as the last species. When opaque, they are sometimes nearly black. They are composed, according to the analysis of Chenevix, of 30 acid
54 oxide
16 water

100

Variety 5. Super-arseniat. This salt has not been found native; but it has been formed by Mr Chenevix by the following process: Arseniat of ammonia was poured into the nitrat of copper, and occasioned a precipitate, which was the second variety described above. The solution which retained its blue colour was partially evaporated, and then alcohol was poured into it. Another precipitation took place, and increased considerably on allowing the solution to stand This precipitate consisted of rhomboidal crystals of a blue colour. They were composed of . . . . 40.1 acid
35.5 oxide
24.4 water

100.0

Perhaps a more precise idea may be formed of the composition of these varieties from the following TABLE

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* Chenevix.

† *Phil. Trans.* 1801. p. 207.

which exhibits the proportion of oxide and water combined in each with 1.00 of acid.

Composition.

	Acid.	Oxide.	Water.
Variety 1.	1.00	3.70	2.56
2.	1.00	2.76	1.00
3.	1.00	1.72	0.70
4.	1.00	1.80	0.53
5.	1.00	0.88	0.60

Arsenite of copper.

The white oxide of arsenic is capable also of combining with copper. It forms with the oxide of that metal an *arsenite*, usually distinguished by the name of *Scheele's green*, because Mr Scheele first examined it, and proposed it as a paint. It may be formed by dissolving 2 parts of sulphat of copper in 44 parts of water, and likewise 2 parts of potass of commerce and nearly 1 part of the white oxide of arsenic pulverised in 44 parts of water, by the assistance of heat. The hot solution of copper is gradually added while hot to the arsenite of potass, and the whole is often stirred during the mixture. The mixture, on standing, gradually deposites the arsenite of copper in the form of a fine green powder. It is to be washed well with water and then dried*.

Sp. 10. *and* 11. *Tungstat and Chromat of Copper.*

Tungstic acid and its compounds occasion a white precipitate when poured into the salts of copper; and when chromic acid is dropt into nitrat of copper, a red precipitate falls†.

Sp. 12. *Acetite of Copper.*

Acetous acid attacks copper slowly, converts it

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* Scheele, i. 261.

† Scheele and Vauquelin.

into an oxide, and dissolves it. From this solution acetite of copper is obtained by evaporation. This salt was known to the ancients, and various ways of preparing it are described by Pliny *. It is usually obtained by exposing plates of copper to the action of vinegar till they be converted to a bluish-green powder called *verdigris*, and then dissolving this powder in acetous acid, and crystallizing it.

Properties.

Acetite of copper crystallizes in four-sided truncated pyramids. It has a beautiful bluish-green colour. Its specific gravity is 1.779†. Its taste is disagreeably metallic, and, like all the compounds into which copper enters, it is poisonous. It is very soluble in water; alcohol likewise dissolves it. When exposed to the air, it effloresces. By distillation it gives out acetic acid. Proust has made it exceedingly probable that this acid exists ready formed in the salt, and that therefore this is not an *acetite*, but an *acetat*, provided there be any difference between the acetous and acetic acids. When sulphurated hydrogen gas is made to pass through a solution of this salt in water, the copper is de-oxidated, and precipitates in the state of a blue sulphuret, and there remains behind an acid which possesses the properties of the acetic‡.

Composition.

According to Proust, the acetite of copper is composed of . . . . 61 acid and water

39 oxide

100

When the verdigris of commerce is put into water,

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* Lib. xxxiv. c. 11.

† Hassenfratz, *Ann. de Chim.* xxviii. 12.

‡ *Ann. de Chim.* xxxii. 36.

Book II. Division II. Verdegris.

0.56 parts of it are dissolved, and there remain 0.44 parts in the state of a fine green powder, which remains long suspended in the solution. Mr Proust has ascertained that this powder is a *sub-acetite* of copper. It is decomposed by sulphuric acid, by potass, and by distillation. According to the analysis of Proust, it is composed of . . . . 37 acid and water

63 oxide

100

Thus it appears, from the experiments of this philosopher, that the verdigris of commerce is composed of two different acetites of copper; the one soluble in water, the other insoluble. It is much used as a paint; and crystallized acetite of copper is a frequent ingredient in dyeing compounds. Verdigris is formed in great quantities at Montpelier. A particular account of the processes followed in that place has been lately published by Mr Chaptal †.

Sp. 13. *Oxalat of Copper.*

Oxalic acid is capable of attacking copper, and it combines with great facility with its oxide. The oxalat formed is in the state of a bluish-green powder, scarcely soluble in water unless with excess of acid. According to Bergman, to whom we are indebted for all that is yet known of this salt, 21 parts of copper require 29 parts of acid to dissolve them. Oxalic acid precipitates this salt from liquid sulphat, nitrat, muriat, and acetite of copper *.

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* *Ann. de Chim.* xxv. 305.

† Bergman, i. 267.

Sp. 14. *Tartrite of Copper.*

Tartarous acid has but little action on copper, but it dissolves its oxide; and when poured into the sulphat or muriat of copper, it precipitates a tartrite of that metal in the form of blue crystals*. According to Leonhardi this salt forms the better kind of the pigment called *Brunswick green.*

Sp. 15. *Triple Tartrite of Copper.*

This salt may be obtained by boiling together oxide of copper and tartar in water. The solution yields by evaporation blue crystals which have a sweetish taste, and contain a great proportion of metal†.

Sp. 16. *Benzoat of Copper.*

Benzoic acid combines readily with the oxide of copper. The salt formed is in small crystals of a deep green colour, sparingly soluble in water, and insoluble in alcohol. When heated, the acid evaporates and leaves the oxide. The alkalies and the carbonats of lime and barytes decompose it‡.

Sp. 17. *Succinat of Copper.*

Succinic acid dissolves copper when assisted by a long digestion. The solution is green, and yielded Wenzel small green crystals, the properties of which have not been examined.

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* Bergman, iii. 456.

† Thenart, *Ann. de Chim.* xxxviii. 36.

‡ Trommsdorf, Ibid. xi. 315.

Sp. 18. *Sebat of Copper.*

SEBACIC ACID dissolves copper when assisted by heat, and forms a saline mass, which yields crystals, but is very deliquescent *.

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* Crell, *Phil. Trans.* 1780.

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Fig. 9.

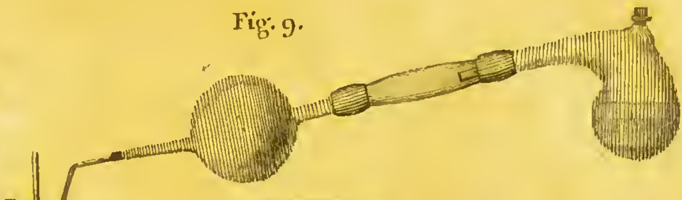

Fig. 10.

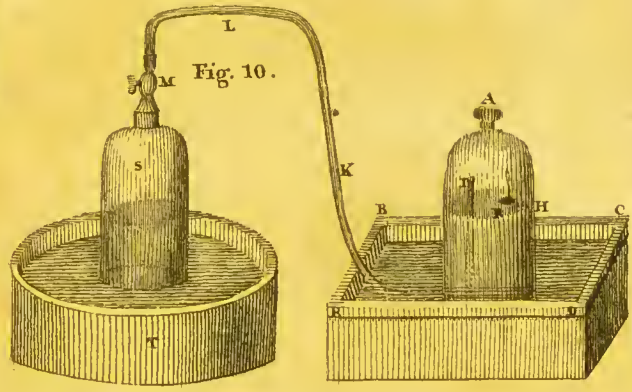

Fig. 11.

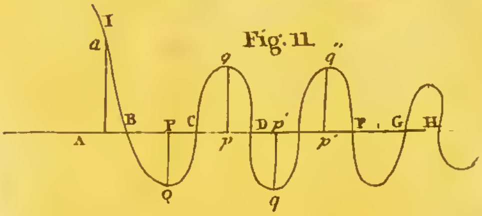

Fig. 12.

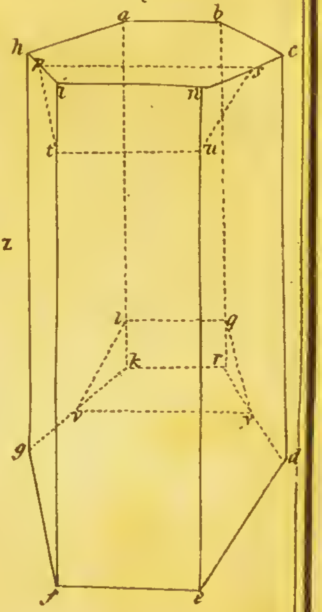

Fig. 13.

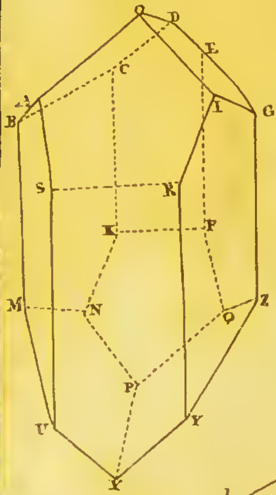

Fig. 14.

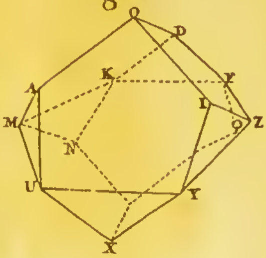

Fig. 15.