

XXXIV.—*On the Constitution of Salts.*

[A Lecture delivered before the Chemical Society, May 7th, 1863.]

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VARIOUS views have been taken with regard to the classification of salts, but the chief theories are three in number.

The dualistic view supposes that salts are constituted of bases and acids which have an affinity for each other, owing to their opposite basylous and chlorous characters.

The salt-radicle theory views haloid and oxysalts as being constituted on the same type, the only difference being that, in one case, there are simple halogens, and, in the others, compound halogens, as chlorous constituents.

In consequence of the new system of notation followed by Gerhardt, a third system of classification was introduced and has received the support of many leading chemists. On this system, there are only a few typical bodies necessary for classification, and, under these types, all chemical elements and compounds may be grouped.

The four types are as follow :—

Hydrogen	H.H
Hydrochloric acid	H.Cl
Ammonia	NH ₃
Water	H ₂ O ₂ .

Besides these types or their multiples, the requirements of the science as it progressed, demanded "mixed types," formed by the coalescence of two distinct types. Undoubtedly the comprehensiveness of this system of types, and the clear account which it gives of the phenomena of decompositions and recompositions, justify the favour which it has received from chemists. But to my own mind it has not carried conviction, at least to the full extent which has been accorded to it by chemists generally; and as it is a useful exercise in our science to look at the constitution of compounds from various points of view, I have ventured to ask your attention this evening to the manner in which I am accustomed to regard the constitution of salts. As we proceed, it will

be seen that, in the construction of my building, I use very freely the materials left in the remains of the venerable dualistic edifice, and I am glad to borrow also the strong and sound cement which Gerhardt and his followers have mixed up for the use of all chemists. Whether this cement will adhere tenaciously to the old materials or not, I do not know, but the strength of the structure is likely to be tried this evening by young and vigorous hands which will speedily disintegrate it if incoherent.

During recent years much attention has been devoted to the atomicities of elementary bodies and their compounds. The sense, however, in which the term atomicity is held varies with different chemists. According to one class of chemists, if nitrogen unites with five atoms of oxygen, it has a pentatomic power in combination, and may replace five equivalents of hydrogen in a compound. In the other sense, nitrogen is pentatomic because it is capable of saturation with five atoms of oxygen or other radicle, but 14 parts of nitrogen still equal 1 part of hydrogen. It is in the latter sense only that I speak of the atomicities of the elements. I need not enlarge upon the tendencies of different elements to acquire a certain number of atoms to reach a stage of repose, or to appropriate an additional number to attain their state of saturation, because this subject has already been fully brought before the Society by Dr. Frankland.* Each element might in fact be said to have as many atomicities as it forms distinct compounds with an increasing number of atoms of any other body, but, in a more limited sense, the atomicities are represented by those stages of repose which it manifests in its way to its highest period of saturation. In the oxides of manganese, for example, we find a distinct period of repose in the peroxide Mn_2O_4 , an oxide which enjoys strict neutrality, but which becomes basylous by the removal of oxygen, and chlorous by increments of that element. It is, however, not constant that neutrality is the result of periods of atomic rest.

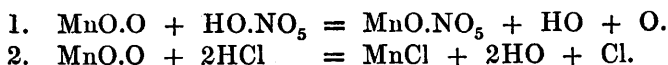
Thus we have characteristic teroxides, such as those of arsenic, antimony, and nitrogen, when their atoms at least, if not their molecules, enjoy active chemical characters. In all bodies of active chemical habits, there is a want of symmetrical formation, which demands the accession of new atoms to produce that symmetry which is essential for an independent existence. Such

* Frankland—*Organo-metallic Bodies*, Chem. Soc. Qu. J., xiii, p. 227; and Phil. Trans., 1852, p. 438.

bodies as the teroxides, with odd numbers of atoms of oxygen, double themselves into molecules, when this symmetry cannot be attained by union with additional atoms of other bodies. The chemical activity of a body depends upon two circumstances, (1) its want of the conditions of symmetry necessary for a period of repose or of saturation; (2) its greater or less amount of zincous or chlorous elements by which its basylous or chlorous characters are determined. In the oxides of manganese we find that the atoms of the protoxide and sesquioxide, both containing an uneven number of atoms of oxygen, are basylous, being still impressed with the zincous character of the metal; that, in the peroxide, with conditions for symmetry in an even number of atoms of oxygen, there is a strict neutrality; but that an accession of oxygen now impresses its chlorous character upon the oxide, manganic and permanganic acids being strongly chlorous. In bodies with conditions of symmetry, we generally find that the atom and molecule is the same, as in NO_2 and NO_4 ; while in the compounds which are unsymmetrical, we find the molecule double that of the atom, as in N_2O_2 protoxide of nitrogen; N_2O_6 nitrous acid; N_2O_{10} nitric acid. As the unsymmetrical body shows active properties, which may either be basylous or chlorous according to the relative amount and original character of its constituents, we may expect to find that, even with a fully gratified atomicity, the product may differ in character according to the nature of the combining atoms. We see this fact well illustrated in the organo-metallic bodies, as for example, in arsenious or arsenic acid, where the substitution of basylous methyl for chlorous oxygen gradually overpowers the acid character of the type, until, in the oxide of tetramethylarsonium, we have a base comparable in power with the caustic alkalies. (Frankland.)

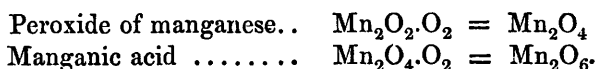
In entering upon the constitution of salts, it is necessary that we should understand in what sense I use the term *radicle*. As I understand a radicle, it is the portion of any compound which is moveable under a given set of decompositions and recompositions. Under this definition there may be primary and secondary radicles in the same compound. Thus, in alcohol, we have as a secondary radicle, ethyl C_4H_5 , but, by another set of decompositions, we may have ethylene C_4H_4 as the radicle, this body having united with hydrogen to form ethyl in its way to a completed atomicity as presented in hydride of ethyl $\text{C}_4\text{H}_4\text{H.H} = \text{C}_4\text{H}_6$. In like manner when we act on peroxide of manganese by an oxygen-acid, the

secondary moveable radicle is MnO , the protoxide, but when we act on it by hydrochloric acid the primary radicle is the metal itself—

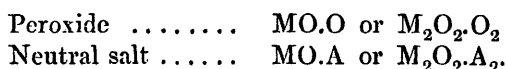


We admit this view in the case of certain oxides without difficulty. Thus the protoxide of uranium is an admitted radicle in the chloride of uranyl $\text{U}_2\text{O}_2.\text{Cl}$ or in the nitrate $\text{U}_2\text{O}_2.\text{O.NO}_5$. (Peligot.) We admit it also in like compounds with chromium, and see a probability of it in sesquisalts of iron and in aluminous silicates. (Odling's Chemistry, p. 134.)

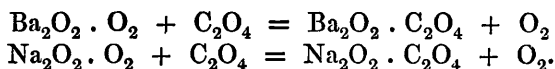
In examining the series of oxides presented to us by nature, it is therefore not probable that they are all built up from the primary radicle by successive increments of oxygen, but it is more likely that the lower oxides act as radicles to the higher oxides. By this is meant, that in such oxides as peroxide of manganese and manganic acid, the protoxide in the first case and the peroxide in the second, may be the radicles uniting with oxygen.



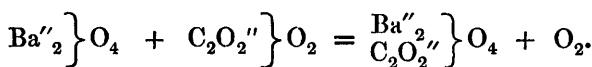
In such cases, we are to expect that the oxygen which unites with the lower oxide may be displaced by other radicles playing its part in the gratified atomicity of the primary radicle. Thus in peroxide of tin, $\text{Sn}_2\text{O}_2.\text{O}_2$ we find the last two atoms of oxygen substituted by ethyl, as in stannic oxydiethide $\text{Sn}_2\text{O}_2.(\text{C}_4\text{H}_5)_2$. But when we see these atoms of oxygen substituted by zincous atoms, it cannot be surprising that we should very frequently see them replaced by chlorous atoms chemically analogous to themselves. This is in fact the function of anhydrides, either when they unite directly with oxides to form salts, or by the exchange of water with which they may be already combined. The nature of this substitution may perhaps be better understood if we confine our attention for the present to that class of salts which are known as neutral salts. They are constituted, according to this view, on the type of the neutral peroxides by the replacement of an atom of oxygen by an atom of an anhydride.



It is to be observed that this view has the merit of closely adhering to the analogies of the case. In most neutral salts on this type the condition of neutrality is really achieved, that is, the basylous and the chlorous characters of the constituents have disappeared in the product. This is precisely the case in most peroxides, though not in all of them. On the water type, neutral salts are constructed on the type of oxides of highest basic character, as instanced by soda, oxide of lead, and the protoxides generally. In other words, salts distinguished for their neutrality are built upon a type marked only by active basicity. But in viewing a salt as consisting of MO.A, like MO.O, the peroxide from which it is derived, it is essential to show that an anhydride can displace oxygen, and also that oxygen may displace an anhydride. As an instance of the first reaction, I may quote the decomposition of peroxide of barium by carbonic acid, as described by Duprey, or that of binoxide of sodium as mentioned by Harcourt.

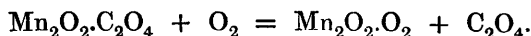


These equations represent simply the facts of the case without hypothesis; let us compare them in this respect with an equation on the water type—



In the latter equation two hypotheses are required, viz., that one atom of barium in the peroxide functions as two atoms of hydrogen, and secondly, that in the carbonate it functions only as one atom of hydrogen.

The converse of this decomposition, where oxygen displaces an anhydride, occurs, though not frequently. It is brought into action in the process for recovering the manganese from its chloride formed in the manufacture of chloride of lime. The first step in this process is, to form a carbonate of manganese; the second, to substitute oxygen for the anhydride by heating it in the air. (Forchammer, Tennent.)



We see like reactions when oxygen replaces carbonic acid in the preparation of minium from white lead, or when acetic acid is displaced by oxygen in the process of ageing mordants for the calico-printers.

It frequently happens that water functions as part of the oxygen in an oxide or of the anhydride in a salt. We see an instance of this in the action of water on tetroxide of potassium. (Harcourt, Chem. Soc. Qu. J., xiv., 267.)



It is true that no definite hydrate of this kind is obtained in a separate state in the case of potassium, although the hydrate of the corresponding binoxide of sodium is described, the reason being that on evaporation the water displaces another atom of oxygen from the binoxide of potassium. The converse takes place, although only partially, when hydrated potash in a state of fusion absorbs oxygen with the displacement of water. (Bloxam, Chem. Soc. Qu. J., xiv, 145.) The reciprocal functions of water, oxygen, and an anhydride may be advantageously compared in their relations to peroxide of barium.

1. $\text{Ba}_2\text{O}_2 \cdot \text{O}_2 + 2\text{HO} = \text{Ba}_2\text{O}_2 \cdot 2\text{HO} + \text{O}_2$
2. $\text{Ba}_2\text{O}_2 \cdot 2\text{HO} + 2\text{O} = \text{Ba}_2\text{O}_2 \cdot 2\text{O} + 2\text{HO}.$
3. $\text{Ba}_2\text{O}_2 \cdot \text{O}_2 + \text{C}_2\text{O}_4 = \text{Ba}_2\text{O}_2 \cdot \text{C}_2\text{O}_4 + \text{O}_2$
4. $\text{Ba}_2\text{O}_2 \cdot 2\text{HO} + \text{C}_2\text{O}_4 = \text{Ba}_2\text{O}_2 \cdot \text{C}_2\text{O}_4 + 2\text{HO}.$

The first and second equations represent Boussingault's plan for preparing oxygen on a large scale, by passing air over hydrate of baryta, and then expelling the oxygen by a jet of steam. In the first case, we observe water taking the place of oxygen; in the second place, oxygen taking the place of water. The third equation represents Duprey's process for making peroxide of hydrogen (Compt. rend., lv. 736), and shows an anhydride expelling and substituting oxygen,—while the fourth equation indicates the familiar action of carbonic anhydride on hydrate of baryta where the acid takes the place of water. As a general result of these equations, we see in the type, $\text{M}_2\text{O}_2 \cdot \text{R}_2$, that the position R_2 may be occupied indifferently, either by oxygen, a chlorous anhydride, or by water.* We might quote numerous instances in

* The burning of limestone, during which steam is necessary, is probably a displacement of the anhydride by water at a temperature incompatible with the

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which water and anhydrides mutually replace each other; but perhaps one example will suffice (Wurtz).

Glycol.....	$C_4H_4O_2$.	HO, HO
Monacetate of ethylene....	$C_4H_4O_2$.	HO, $(C_4H_3O_3)$
Binacetate of ethylene	$C_4H_4O_2$.	$2(C_4H_3O_3)$.

The acetins of glycerin will also occur as an instance of the case in point. According to the view now taken, peroxides, salts, and their hydrates are analogous :—

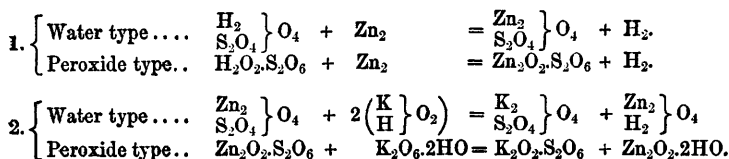
Peroxide.....	$M_2O_2.O_2$.
Neutral salts.....	$M_2O_2.A_2$.
Hydrates	$M_2O_2.(aq.)_2$.

It is quite true that anhydrides as such do not manifest any great desire to expel oxygen from a peroxide in order to unite with its radicle the protoxide. But neither does ethyl exercise a strongly basylous character when free. Both the alcohol-radicles and the anhydrides possess unsymmetrical atoms, and double by uniting with themselves into salt-molecules, and as such are comparatively indifferent. In the hydrated acids, however, we have the atom of these chlorous bodies ready to exercise their functions. Hydrated acids of the type to which we are now confining our attention, represent peroxide of hydrogen in which oxygen is replaced by an anhydride.

Peroxide of hydrogen	HO.O.
Hydrated acid	HO.A.
Metallic derivative.....	MO.A.

This is merely symbolising Gerhardt's definition of an acid—namely, “a salt whose basyl is hydrogen.” It may here be useful to take two simple cases of decomposition,—the solution of lime in sulphuric acid and the addition of potash to sulphate of zinc, for comparing the constitution of salts on the water type and on the peroxide type.

permanent existence of the hydrate. No doubt the escape of the carbonic anhydride is also facilitated by the presence of a gaseous atmosphere of steam into which it can diffuse.



Both views give simple accounts of the transaction, but their differences will be more apparent if we formulate the acid and its salt along with the type:—

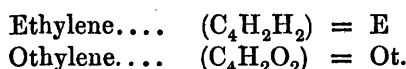
	Peroxide type.	Water type.
Type.....	$\text{H}_2 \left\{ \begin{array}{c} \text{O}_2 \\ \text{O}_2 \end{array} \right\}$	$\frac{\text{H}_2}{\text{H}_2} \left\{ \begin{array}{c} \text{O}_2 \\ \text{O}_2 \end{array} \right\} \text{O}_4$
Acid.....	$\text{H}_2 \left\{ \begin{array}{c} \text{O}_2 \\ \text{S}_2\text{O}_6 \end{array} \right\}$	$\frac{\text{H}_2}{\text{S}_2\text{O}_4} \left\{ \begin{array}{c} \text{O}_2 \\ \text{O}_2 \end{array} \right\} \text{O}_4$
Salt	$\text{Zn}_2 \left\{ \begin{array}{c} \text{O}_2 \\ \text{S}_2\text{O}_6 \end{array} \right\}$	$\frac{\text{Zn}_2}{\text{S}_2\text{O}_4} \left\{ \begin{array}{c} \text{O}_2 \\ \text{O}_2 \end{array} \right\} \text{O}_4$

In the first view the acid, “a salt with its basyl hydrogen,” is built upon its type according to strict analogy, a chlorous anhydride substituting its chlorous oxygen, while, in its metallic derivative, the basylous hydrogen is replaced by a basylous metal. On the water type, one portion of the basyl is replaced by a basylous metal, and another portion of the basyl by a chlorous radicle. The advocates of the latter view, however, could point with much propriety to the substitution of all the basylous by the chlorous radicle in the anhydrides as $\frac{\text{S}_2\text{O}_4}{\text{S}_2\text{O}_4} \left\{ \begin{array}{c} \text{O}_2 \\ \text{O}_2 \end{array} \right\} \text{O}_4$. On the peroxide type, anhydrides are simply related to the salts, as may be shown by taking nitric acid as an example—

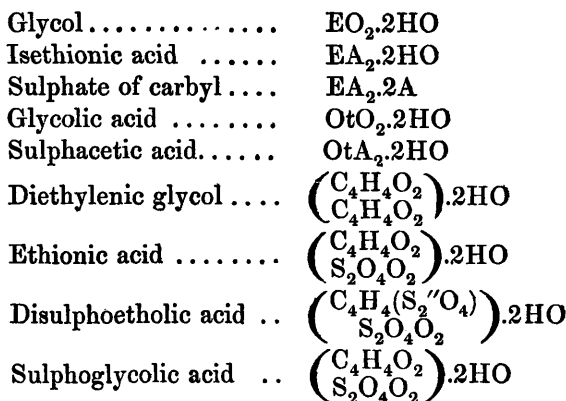
Peroxide type.....	HO.O
Molecule of protoxide	MO.MO
Nitric anhydride	(NO ₄)O.(NO ₄)O
Nitric acid	HO.(NO ₄)O
Nitrate	MO.(NO ₄)O

It may further be contended that in the water type, $\frac{\text{H}}{\text{H}} \left\{ \begin{array}{c} \text{O}_2 \\ \text{O}_2 \end{array} \right\}$, there is a complete replacement of the basyl radicles, while in the peroxide type, $\text{H} \left\{ \begin{array}{c} \text{O} \\ \text{O} \end{array} \right\}$ there is only a partial substitution of the oxygen. But this objection could only arise from a misconception of the type, as the whole argument implies that it

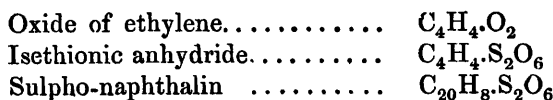
should be written MO.O , the protoxide acting as a radicle. In hydride of ethyl, $\text{C}_4\text{H}_5.\text{H}$, we expect to replace one part of the hydrogen as we do in chloride of ethyl $\text{C}_4\text{H}_5.\text{Cl}$, but the fifth atom of hydrogen in ethyl is persistent in many recompositions, although it may at last be removed as in chloride of ethylene, $\text{C}_4\text{H}_4.\text{Cl}_2$. Ethylene here may be viewed as the primary radicle, like the metal in the peroxide, while ethyl represents the secondary radicle, the protoxide. In point of fact we do occasionally find the primary radicle assuming anhydrides directly instead of oxygen, as in the following cases, where, for simplicity of expression, we write the hydrocarbon and oxidised olefines by symbols and sulphuric anhydride, S_2O_6 , by the symbol A_2 :—



The compounds are either on the type of glycol or of diethlenic-glycol :—



In all these cases we have either sulphuric or sulphurous anhydride functioning as oxygen in glycol, or acting as oxide of ethylene in the polyethylenic glycols. Perhaps this will be more obvious if we compare isethionic anhydride, although its separate existence is still doubtful, with oxide of ethylene and with sulphonaphthalin, the separate existence of which is established:—



But even if we had no such clear instances of anhydrides taking the place of the oxygen attached to the secondary radicle, we have so many examples of this complete atomic substitution in organo-metallic bodies that we could not hesitate in admitting the possibility of such replacements. It will suffice to quote the following cases in regard to the oxide of zinc:—

Oxide of zinc	Zn ₂	$\begin{Bmatrix} \text{O} \\ \text{O} \end{Bmatrix}$
Zinc-methyl	Zn ₂	$\begin{Bmatrix} \text{C}_2\text{H}_3 \\ \text{C}_2\text{H}_3 \end{Bmatrix}$
Dinitromethylate of zinc	Zn C ₂ H ₃	$\begin{Bmatrix} \text{NO}_2 \\ \text{NO}_2 \end{Bmatrix}$
Methyldithionate of zinc	Zn C ₂ H ₃	$\begin{Bmatrix} \text{SO}_2 \\ \text{SO}_2 \end{Bmatrix}$

Guthrie's compounds of amylene and ethylene with peroxide of nitrogen (C₁₀H₁₀.2NO₄ and C₄H₄.2NO₄) (Qu. J. Chem. Soc., xiii., 129) will naturally occur as illustrations. By admitting that anhydrides may function as oxygen in oxides, we are relieved from the difficulties attending the explanation of the constitution of salts which have an excess of an anhydride, as in the case of the chromates of potash, which now are seen to represent the oxides of potassium:—

Bin oxide of potassium....	K ₂ O ₂ .O ₂	..	Chromate of potash....	K ₂ O ₂ .Cr ₂ 'O ₆
Teroxide.....(?)	K ₂ O ₂ .O ₄	..	Bichromate of potash..	K ₂ O ₂ .2Cr ₂ 'O ₆
Tetroxide	K ₂ O ₂ .O ₆	..	Tetrachromate of potash..	K ₂ O ₂ .3Cr ₂ 'O ₆

Having now explained the general views upon which I contend that anhydrides function oxygen in the completion of a deficient atomicity of an oxide, it is necessary to examine whether these views are sufficient to explain the various classes of salts. Neglecting for the present the mixed oxides and suboxides, the following are the main classes of oxides which present themselves; in formulating them, the symbol R represents such elements as nitrogen, phosphorus and arsenic, and M such metals as manganese or iron.

	Atoms.		Molecules.
1. Protoxides	MO	or	M ₂ O ₂
	RO ₃	} or {	$\begin{Bmatrix} \text{R}_2\text{O}_6 \\ \text{or} \\ \text{M}_4\text{O}_6 \end{Bmatrix}$
2. Teroxides and sesquioxides	or M ₂ O ₃		

3. Peroxides	MO_2	or	$\begin{cases} \text{RO}_4 \\ \text{or} \\ \text{M}_2\text{O}_4 \end{cases}$
4. Nitric acid type.....	RO_5	or	R_2O_{10}
5. Manganic	MO_3	or	M_2O_6

In addition to these, and beyond the manganic acid type, we have the permanganic acid Mn_2O_7 , and a still higher oxide in the case of potassium, where, however, the basylous character of the element is not yet converted into a chlorous function by the eight atoms of oxygen in the tetroxide KO_4 or K_2O_8 .

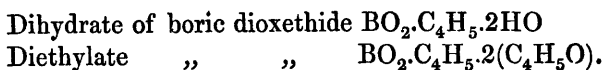
It will be seen, as I proceed, that although all these oxides must be borne in mind, in order to understand the struggle for a completed atomicity, yet that a limited number of them is quite sufficient to use as types for classification. We may at once neglect the detailed consideration of the *atomic** protoxide MO , because it ranges itself in Gerhardt's class of HH or HCl , which, large and comprehensive as it is, enforces our complete acquiescence. We pass then to the next oxide of the series, the teroxide in the cases of such elements as nitrogen and bismuth, and the sesquioxide of the metals generally.

Teroxide Type.

The teroxide type has been fully studied in the beautiful investigations of Hofmann, so far as regards one important class of its derivatives on the general atomic type of the class ammonia NH_3 . It will be unnecessary for me, especially as this has already formed the subject of one of your lectures, to dwell upon this important member of the class, and I therefore pass to the consideration of the other bodies which I propose to group under this atomic type, which, as in the previous cases described, has the atomic form RO_3 and the molecular form $\text{R}_2\text{O}_6 = \text{R}_2\text{O}_3 \cdot \text{O}_3$. The teroxide type receives its fittest illustrations in nitrous, phosphorous, arsenious, antimonious, bismuthous, and boracic anhydrides. The probable *atomic* constitution of these teroxides is $\text{RO}_2 \cdot \text{O}$. For this expression there is abundance of evidence even

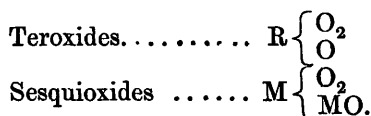
* I would here mention, once for all, that although I frequently formulate the *atom* of a body in order to show its active chemical character and inner constitution, that I accept as a general rule four-volume formulæ for molecules, the completed symmetry of which however would not explain the chemical activity of the body.

when, as in the case of arsenic, we have no clear proof of the separate existence of the radicle RO_2 . But we have cacodyl $\text{As}(\text{C}_2\text{H}_3)_2$, its oxide $\text{As} \left\{ \begin{smallmatrix} (\text{C}_2\text{H}_3)_2 \\ \text{O} \end{smallmatrix} \right.$, and corresponding sulphide and chloride; and we have this atomic structure receiving direct confirmation in arsenious dioxmethide $\text{AsO}_2 \cdot \text{C}_2\text{H}_3$, and its sulphur analogue $\text{AsS}_2 \cdot \text{C}_2\text{H}_3$. Again, looking at Frankland's researches (Chem. Soc.^a J. xv, 363) on the boron compounds, we find the radicle BO_2 forming a methide and ethide, the latter of which acts as an acid, and unites with water and ether as follows:—



To support the radicle in oxide of bismuth, we have Schroeder's discovery of the binoxide BiO_2 , and we find its analogue in dichlorethide $\text{BiCl}_2 \cdot \text{C}_4\text{H}_5$. In regard to antimony we are familiar with Peligot's chloride and iodide of antimonyl $\text{SbO}_2 \cdot \text{Cl}$ and $\text{SbO}_2 \cdot \text{I}$.

As respects phosphorus, every theory admits the existence of phosphoryl PO_2 . We are, therefore perfectly justified by our knowledge in writing the *atoms* of teroxides $\text{RO}_2 \cdot \text{O}$, although, for convenience of comparison, I prefer to write it arbitrarily as $\text{R} \left\{ \begin{smallmatrix} \text{O}_2 \\ \text{O} \end{smallmatrix} \right.$. The analogies of sesquioxides to the teroxides are so obvious that few would be inclined to separate them; and yet their formula M_2O_3 is distinct from that of the teroxide RO_3 . Some of the sesquioxides, like those of nickel and cobalt, act to acids exactly as if they were constituted of peroxides united to protoxides $\text{MO}_2 \cdot \text{MO}$, and sesquioxide of manganese comports itself thus in a less decided manner; but many other oxides of this class, such as those of uranium, chromium, iron, and aluminum, behave as if they contained protoxides as radicles $\text{M}_2\text{O}_2 \cdot \text{O}$. On the first view, the relation of teroxides to sesquioxides is obvious—an atom of a protoxide taking the place of an atom of oxygen:—



However, as our knowledge does not justify this general assump-

tion, and as it is probable that there are varieties in the constitution of the numerous members of this group, we prefer to write the atoms of these oxides in the arbitrary formula $M_2 \begin{Bmatrix} O_2 \\ O. \end{Bmatrix}$

It is a notable characteristic of basic sesquioxides, that they unite with one or with three atoms of acid, just as the acid teroxides affect one or three atoms of base. The biatomic type is rarer and not so well defined. To compare this properly, we select three salts from Bloxam's* paper on the arsenites, and compare them with known salts of peroxides of iron :—

Arsenite of zinc	$AsO_3.3ZnO$	Persulphate of iron.	$Fe_2O_3.3SO_2O$
„ magnesium	$AsO_3.2MgO$	Binacetate of iron†	$Fe_2O_3.2C_4H_3O_2.O$
„ ammonium	$AsO_3.NH_4O$	Mononitrate of ferric oxide‡	$Fe_2O_3.NO_4O.$

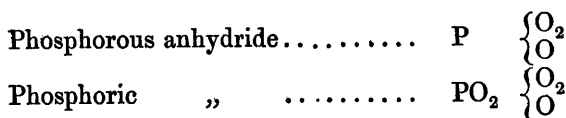
It is clear from such a comparison that these compounds are atomically similar, this variety being mainly due to the fact that, in one case, the atomicity is gratified by chloroids, in the other case by basyls. In fact, we not unfrequently find sesquioxides affecting either of these according to circumstances, as sesquioxide of uranium in uranate of soda $U_2O_3.NaO$, and as nitrate of uranium $U_2O_3.NO_4O$. Vanadic acid, in like manner, though usually taking up basyls, forms a well marked sulphate $VO_3.3SO_3$. Alumina, chiefly affecting chloroids, still shows us in *Spinelle-ruby* ($Al_2O_3.MgO$), and in *Gahnite* ($Al_2O_3.ZnO$), that it can unite with basyls. Then, again, for every compound of an acid with a sesquioxide we have a corresponding hydrate, in which water represents the chloroids. We may, therefore, safely assert that the mere difference as to whether an oxide gratifies its wanting atomicity by chloroids or by basyls, forms no ground for separating them into distinct types. But if we are led to this conclusion, with regard to teroxides and sesquioxides, from observing their common disposition to unite with one or with three atoms, either of basyls or chloroids, it becomes both natural and logical to examine whether all tribasic anhydrides should not be brought into the same type. When we review Frankland and Buckton's researches on organo-metallic bodies, we find abundant illustrations that the radicle phosphoryl (PO_2) and arsenyl (AsO_2) play a yet

* Chem. Soc. Jour., xv, 298.

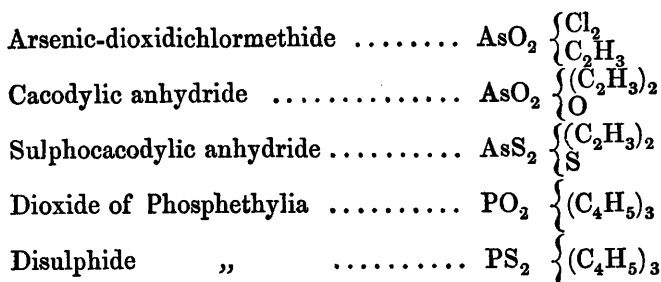
† Crum, Chem. Soc. Journ.

‡ See also Parkman, American Jour. of Science, xxxiv, p. 321, for monocarbonates of sesquioxides and teroxides.

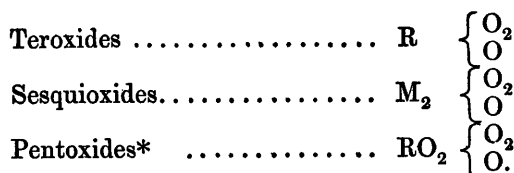
more intimate part in the pentacids by assuming in fact the function of the primary radicles P and As in the teroxides:—



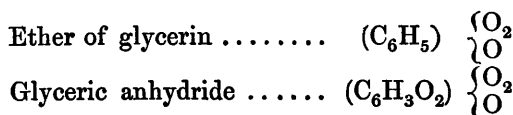
A very few remarks will indicate the grounds on which we demand this new function for phosphoryl in phosphoric acid. For this purpose, the following illustrations will suffice:—



In all these cases we find binoxides or bisulphides acting apparently as primary radicles. We have now only to compare the teroxides, sesquioxides, and tribasic acids to see that they have a similar constitution with varying primary radicles:—

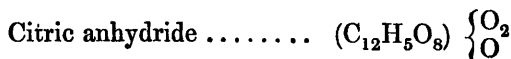


Before discussing the reasons of these mono- or triatomicities, it will be well to allude to the ether of glycerin and to glyceric anhydride, which are obviously constructed on the type of the sesquioxides:—

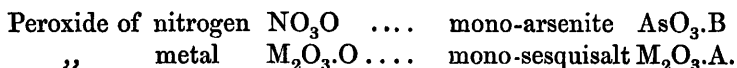


* Nitric acid, generally acting as a monobasic acid, is probably NO_4O instead of $(\text{NO}_2)_2\text{O}$. We see the change of radicle in this class of salts when nitric acid acts on arsenious acid $\text{AsO}_2\text{O} + \text{NO}_4\text{O} = \text{NO}_2\text{O} + \text{AsO}_4\text{O}$.

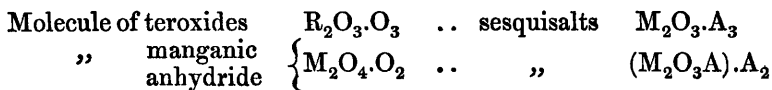
It would be a waste of time to support this analogy by the extensive series of chlorhydrins described by Berthelot and Luca.* In like manner as glyceric acid is built up by the oxidation of the olefines (Allylene) C_6H_4 , so citric acid, a well defined tribasic acid, may be supposed to have its primary radicle derived from hexylene $C_{12}H_{12}$, or the secondary radicle, hexyl $C_{12}H_{13}$.



In all the previous formulæ, we have divided the oxygen external to the radicle, with the view of explaining more readily their varying atomicities. The next oxide to the teroxide in the series of oxides is the peroxide type, a position of repose and neutrality, and which from this circumstance is typical of many salts. A teroxide only requires one atom to reach this stage, which is represented by NO_4 in the nitrogen class, and by Mn_2O_4 in the metallic oxides. A single atom of a basyl or of a chloroid will suffice for the peroxides, or the sesquioxides, to reach this period of repose. Let us, representing chloroids by A, and basyls by B, indicate this completion of an unsymmetrical atom.



But in a peroxide, although a stage of repose is attained, there is yet incomplete gratification of atomic affinities, and passing over for the moment the nitric acid type, the next stage is represented by manganic anhydride, $Mn_2O_6 = Mn_2O_4.O_2$, or $Mn_2O_3.O_3$. If we tabulate a few examples of this type, the triatomic power of the oxides under consideration will be very apparent. For simplicity we formulate sesquisalts and their analogues as corresponding to the double teroxide $R_2O_3.O_3$ —thus $R_2O_3.A_3$ —but it is obvious that they may be put intelligibly on the manganic acid type, $Mn_2O_4.O_2$ —thus $M_2O_3.A.A_2$. Example: $Fe_2O_3.NO_4.O, 2(C_4H_3O_2)O$ —one of the nitro-acetates of iron.



* Ann. Ch. Phys. [3] lii, 433.

Molecule of Sesquioxides	$M_4O_3.O_3$	..	Molecule of	} $(RO_2)_2O_3.O_3$
			Penta-anhydrides	
Glycerin.	$(C_6H_5)O_3.3HO$	..	Glycerides	$(C_6H_5)O_3.A_3$
Phosphoric acid ..	$(PO_2)O_3.3HO$	..	Phosphates	$(PO_2)O_3.B_3$
Ferricyanide }	$Fe_2Cy_3.3KC_y$	..	Double chlo-	} $Fe_2Cl_3.3KCl$
of potassium }			ride of iron and potassium	

From the remarks which have preceded, it is obvious that both the monobasic and tribasic character of teroxides and pent-oxides are necessary for the establishment of a period of stability in one case and of saturation in the other. But the assumption of a bibasic character is not so easy of explanation, either on this view or on the water-type, unless indeed we assume that such bodies as the pyrophosphates are compounds formed by the union of ortho-, with metaphosphates (Odling's Chemistry, p. 300). Of course the difficulty ceases altogether if we place them on the nitric acid or pentacid type : for then $NO_3.2O$ is analogous to $RO_3.2A$, or $RO_3.2B$. It ceases also if we believe, what may be possible when we recollect the results of their electrolysis, that there are different radicles in the three kinds of phosphates, similar to the changes which take place in propyl when its hydrogen is subtracted, thus :—

Metaphosphates	PO_4	$\left\{ \begin{array}{l} O \\ B \end{array} \right.$	like salts of Propylic ether	C_6H_7	$\left\{ \begin{array}{l} O \\ A \end{array} \right.$
Pyrophosphates	PO_3	$\left\{ \begin{array}{l} O_2 \\ B_2 \end{array} \right.$	like salts of Propylene ether	C_6H_6	$\left\{ \begin{array}{l} O_2 \\ A_2 \end{array} \right.$
Orthophosphates	PO_2	$\left\{ \begin{array}{l} O_3 \\ B_3 \end{array} \right.$	Glycerides	C_6H_5	$\left\{ \begin{array}{l} O_3 \\ A_3 \end{array} \right.$

I do not therefore profess to solve this difficulty, which is as great on the water-type, if we attempt to preserve simplicity ; for pyrophosphoric acid cannot be written as constructed on 4 atoms of water $\left\{ \begin{array}{l} PO_3'' \\ H_2 \end{array} \right\} O_4$ without breaking the unitary system, and must be made as 8 atoms of water, $\left\{ \begin{array}{l} P_2O_6''' \\ H_4 \end{array} \right\} O_8$.

Before leaving this part of the subject, I would remark, in conclusion, that we do not find perfect neutrality in the salts of the teroxide type, as we generally do on those of the peroxide : for when the basyls complete the wanting atomicities, an alkaline

character is generally impressed on the product, or the reverse, when chloroids are employed in the completion. But this result is what we would expect in the case of bodies built up on such a high condition of completed atomicity as manganic acid. I would also in this place refer to a circumstance which might naturally be brought as an objection to my views, viz., that in some cases the base is used as the body whose wanting atomicity is to be completed, while in other cases reference is made to the acid. But in all instances of combination, there is both action and reaction between the two classes of bodies. The very chemical activity of the basyl on the one hand, and of the chloroid on the other, shows that both of them have their atomicities incomplete, and that both require atomic saturation. It is therefore necessary to look at the atomic wants both of the basyls and of the chloroids entering into combination. It depends in fact upon the atomicities which are to be gratified whether the base determines the character of the compound, or whether the acid plays the predominant part in producing the result, or whether they neutralise each other.

Peroxide Type.

This type embraces a large class of compounds, which can only be brought under your notice by a few general examples. It is obvious that there may be three different forms under which salts on the peroxide type may occur.

1.	MO.O	in salts	MO.A. or MO.B
2.	M ₂ O ₂ .O ₂	„	M ₂ O ₂ .A ₂ or M ₂ O ₃ .B ₂
3.	M ₂ O ₃ .O	„	M ₂ O ₃ A. or M ₂ O ₃ .B

All three varieties are included under the two modifications of the type MO₂ or M₂O₄. The first of these may be illustrated by binoxide of sodium NaO₂, or peroxide of hydrogen HO₂; the second by the peroxide of tin Sn₂O₄. It will be convenient to consider each modification separately.

1. *Type—Peroxides of Uniatomic Metals MO.O.*

The molecules of protoxides and sulphides of the metals range themselves under this type. Thus, following the type of binoxide of sodium NaO.O, we have the molecule of soda NaO.NaO, its hydrate NaO.HO., and any neutral salt of soda, NaO.A. All

derivatives of these also are included, as NaS.NaS ; NaS.HS. ; NaS.A. As the basylous protoxides and their derivatives range themselves under this type, so also do the chlorous molecules of a like order, for example, hypochlorous anhydride ClO.ClO , the protochloride of sulphur ClS.ClS. , hypochlorous acid ClO.HO , and a hypochlorite ClO.NaO . The radicles which in the molecules of their protoxides come under this division of the class, may be compound as well as simple, as in basylous oxide of ammonium $\text{NH}_4\text{O.NH}_4\text{O}$ or chlorous nitric anhydride $\text{NO}_4\text{O.NO}_4\text{O}$, or in their better known hydrates $\text{NH}_4\text{O.HO.}$ and $\text{NO}_4\text{O.HO.}$ The anhydrides and acids of the nitric acid class, and the oxides and hydrates of the monamines, naturally include themselves in this class, as in the case of arsenic anhydride $\text{AsO}_4\text{O.AsO}_4\text{O}$, arsenic acid $\text{AsO}_4\text{O.HO}$, and hydrated oxide of tetrethylarsonium $\text{As(C}_4\text{H}_5)_4\text{O.HO}$.

The oxides, chlorides, sulphides, &c., of biatomic radicles find themselves arranged in this division. Just as tin gives us Sn_2O_2 , Sn_2S_2 , Sn_2Cl_2 , so we have corresponding compounds of ethylene EtO_2 , EtS_2 , EtCl_2 ; and on the chlorous side we have such compounds as carbonic anhydride $\text{C}_2\text{O}_2\text{O}_2$, sulphuric anhydride $\text{S}_2\text{O}_4\text{O}_2$, succinic anhydride and chloride $\text{C}_8\text{H}_4\text{O}_4\text{O}_2$, and $\text{C}_8\text{H}_4\text{O}_4\text{Cl}_2$. As the hydrates and salts of monotomic bases and acids are included in this division, it embraces the large class of alcohols and ethers, of which methylic alcohol is the starting point: thus we have ethyl ether $\text{C}_4\text{H}_5\text{O.C}_4\text{H}_5\text{O}$, like methyl-ethyl ether $\text{C}_4\text{H}_5\text{O.C}_2\text{H}_3\text{O}$, or like alcohol $\text{C}_4\text{H}_5\text{O.HO}$, or acetic ether $\text{C}_4\text{H}_5\text{O.C}_4\text{H}_3\text{O}_2\text{O}$. So with the oxidised derivatives we have acetic anhydride $(\text{C}_4\text{H}_3\text{O}_2)\text{O}(\text{C}_4\text{H}_3\text{O}_2)\text{O}$, acetic acid $(\text{C}_4\text{H}_3\text{O}_2)\text{O.HO}$, and acetate of sodium $(\text{C}_4\text{H}_3\text{O}_2)\text{O.NaO}$.

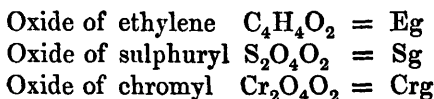
It may be objected to this view that we arrange under this division a large number of bodies with the typical peroxides of which we are not acquainted. But after the beautiful discovery by Brodie† of the peroxides of acetyl and succinyl, no one will be inclined to deny their possible existence, while the mere fact of so many of them, either as acids or as bases, showing incomplete saturation, renders to my mind their future discovery probable.

The second division of this class, viz., $\text{M}_2\text{O}_4 = \text{M}_2\text{O}_2\text{O}_2$ is more extensive than the first. In the first place we find the biatomic alcohols and bibasic acids generally. The following examples will show their relation to the type $\text{M}_2\text{O}_2\text{O}_2$:—

* Proc. Royal Soc., ix, 361.

Ethylene glycol...	$(C_2H_4)_2O_2 \cdot 2HO$	Glycollic acid	$(C_2H_3O_2)_2 \cdot O \cdot 2HO$
Ethylene of sodium	$(C_2H_4)_2O_2 \cdot 2NaO$	Glycollate of soda	$(C_2H_3O_2)_2O_2 \cdot 2NaO$
Acetate of ethylene	$(C_2H_4)_2O_2 \cdot 2\bar{A}$	Sulphacetic acid	$(C_2H_3O_2)(SO_3)_2 \cdot 2HO$
Monacetate "	$(C_2H_4)_2O_2 \left\{ \begin{smallmatrix} HO \\ \bar{A} \end{smallmatrix} \right\}$	Binoxalate of potash.	$(C_4O_4)_2O_2 \cdot \left\{ \begin{smallmatrix} KO \\ HO \end{smallmatrix} \right\}$
Ethylene-mercaptide of ethyl	$(C_2H_4)_2S_2 \left\{ \begin{smallmatrix} C_2H_5S \\ HS \end{smallmatrix} \right\}$	Tartrovinic acid	$(C_8H_4O_8)_2O_2 \cdot \left\{ \begin{smallmatrix} C_4H_5O \\ HO \end{smallmatrix} \right\}$
Aceto-butyric glycol	$(C_4H_4)_2O_2 \cdot \left\{ \begin{smallmatrix} (C_2H_3O_2)_2O \\ (C_2H_7O_2)_2O \end{smallmatrix} \right\}$	Tartrate of antimonyl and potassium	$(C_8H_4O_8)_2O_2 \cdot \left\{ \begin{smallmatrix} SbO_2 \cdot O \\ KO \end{smallmatrix} \right\}$

Wurtz has already pointed out in his lecture to the society (Chem. Soc. Journ., xv. 387), as Kekulé has also done (*Lehrbuch*, i. 1058), that the diethylenic alcohols find their analogues not only in oxides which coalesce and unite with water, but also more completely in the case of sulphuric acid and the Nordhausen acid. The following Table will put this in a still more comprehensive view, if we represent the respective glycol-ethers by symbols to save repetition:—



Glycol	Eg . 2HO	.....	Sulphuric acid	Sg . 2HO
" (diethylenic)	Eg ₂ . 2HO	.....	Nordhausen "	Sg ₂ . 2HO
K. "	Eg ₂ . 2KO	.....	Bichromate of potash ..	Crg ₂ . 2KO
Glycol (triethylenic)	Eg ₃ . 2HO	.....	Terchromate "	Crg ₃ . 2KO
Glycol-chlorhydrin	Eg . HCl	.....	Sulphuric chlorhydrin ..	Sg . HCl
Monoxethelamine	Eg . HNH ₂	.....	Sulphamic acid	Sg . HNH ₂
Dioxethelamine	Eg ₂ . HNH ₂	.....	Chlor-sulphate of sodium	Sg . NaCl
Dichlorhydrin	Eg ₂ . HCl	.....	Peligot's salt	Crg . KCl

The above examples must suffice to show that biatomic alcohols and their derivatives, and bibasic acids, may readily be included in this division. In it are also embraced peroxides, sulphides, and chlorides, as carbonic and silicic anhydrides, C_2O_4 and Si_2O_4 , bisulphide of carbon C_2S_4 , and tetrachloride of silicon Si_2Cl_4 , and similar compounds of tin, manganese, strontium, &c.

It may be less obvious how suboxides may be placed in this division; but as we have already shown that the atomicity of a body may be indifferently gratified, either by chlorous or by basylous atoms, in the general type $M_2O_2 \cdot R_2$, the terms R_2 may either be filled up by oxygen, as in a peroxide, or by a basyl. This we see in peroxide of tin $Sn_2O_2 \cdot O_2$, and stannic oxydiethide $Sn_2O_2(C_2H_5)_2$ where 2 atoms of ethyl take the place of 2 atoms of oxygen in

the peroxide. In like manner, suboxide of lead Pb_2O_2 . Pb_2 represents peroxide of lead in which 2 atoms of oxygen are replaced by 2 atoms of lead; and suboxide and subchloride of copper Cu_2O_2 . Cu_2 and Cu_2Cl_2 . Cu_2 have a like atomic constitution, in this respect exactly resembling the chloride of stannic diethide, $\text{Sn}_2\text{Cl}_2(\text{C}_4\text{H}_5)_2$, and the sulphide of stannic dimethide $\text{Sn}_2\text{S}_2(\text{C}_2\text{H}_3)_2$.

Lastly we come to the third division of this class, viz., when a sesquioxide completes its atomicity as a peroxide by assuming a single atom of a chloroid or of a basyl, the form of the type now being M_2O_3 .R. All the magnetic oxides and sulphides range themselves under this division, the term R being filled up by a protoxide, a protosulphide, water, or a single atom of an anhydride.

Typical oxide	M_2O_3 .R.
Magnetic oxide of iron	Fe_2O_3 .FeO
Hydrate of sesquioxide of iron ..	Fe_2O_3 .HO
Chrome iron ore	Cr_2O_3 .FeO
Red oxide of manganese	Mn_2O_3 .MnO
Hydrate of sesquioxide of manganese..	Mn_2O_3 .HO
Aluminate of soda	Al_2O_3 .NaO
„ zinc	Al_2O_3 .ZnO
Protocarbonate of alumina	Al_2O_3 .CO ₂
Acetate of uranium	U_2O_3 .C ₄ H ₃ O ₃
Silicate of iron	Fe_2O_3 .SiO ₂
Chlortriplumbethide	$\text{Pb}_2(\text{C}_4\text{H}_5)_3$.Cl
Oxisesquistannic trimethide	$\text{Sn}_2(\text{C}_2\text{H}_3)_3$.O

These examples, showing that the wanting atom may be filled up either by chlorous or by basylous bodies, will suffice to explain how it is that magnetic oxides and anomalous salts of sesquioxides naturally range themselves under this division.

Having incidentally said so much regarding the manganic acid and nitric acid types, we will pass them over for the present, as it is necessary to curtail the lecture within proper dimensions, and refer you, in conclusion, to the tetroxide type.

Tetroxide Type.

This type, expressed by the formula MO_4 or M_2O_8 , has a very limited range, and might possibly disappear altogether if we were

better acquainted with it. Nevertheless there are a few compounds which, at present, require this type for their explanation.

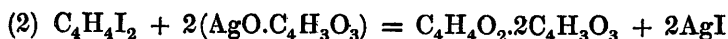
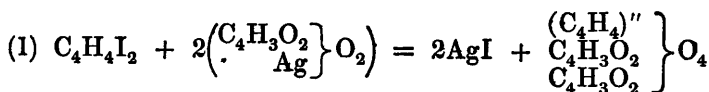
The first example which occurs is that of the tetroxide of potassium KO_4 or K_2O_8 , which we have also represented in the sulphides of potassium K_2S_8 , and of sodium Na_2S_8 . We find it also in the hydrates of the binoxides as $\text{Sn}_2\text{O}_4 \cdot 4\text{HO}$, stannate of soda $\text{S}_2\text{O}_4 \cdot 4\text{NaO}$, and in the salts $\text{M}_2\text{O}_4 \cdot 4\text{A}$. It also occurs rarely in certain salts in which anhydrides enter into combination with the base in multiple proportions, as in terchromate of potash $\text{K}_2\text{O}_2 \cdot 3\text{Cr}_2\text{O}_6$. This type, however, is indirectly necessary, as showing the highest state of atomic saturation with which we are acquainted in the metallic oxides, and to which many of them tend in completing their atomicities. Thus the complete saturation of M_2O_8 is shown in a permanganate $\text{M}_2\text{O}_7\text{B}$, in which the last atom of oxygen is filled up by a basylous body. The attainment of this highest atomic saturation for oxides is also observed in the salts of acids of the manganic acid type, as $\text{S}_2\text{O}_6 \cdot 2\text{B}$, or of the tribasic nitric acid type $\text{NO}_5 \cdot 3\text{B}$, in which the general point of atomic saturation RO_8 or M_2O_8 is obtained. But, although the tetroxide is the highest point of atomic saturation in the case of the metals, the compound radicles which play their part in the chlorous metallic compounds throw them into types of greater simplicity than this one.

In the preceding portion of the lecture I have endeavoured to show how chemical compounds may be classed under four types, viz., the type of hydrochloric acid, that of a peroxide, tetroxide, and tetroxide. In Gerhard's classification, the type of water is made to alter in magnitude from $\text{H}_2\text{O}_2 \dots \text{H}_4\text{O}_4$ to H_nO_n ; while in those upon which my classification is based, the only two divisions of a type (except in the case of polyethylenic alcohols, the oxides and the compounds which they represent) are two in number, as represented in the peroxide MO_2 or M_2O_4 . With this small limit to classification, there is no difficulty in arranging under the four types, all substances which I have tried to include under them. But it still remains for me to show by contrast whether the types of Gerhard or those which I advocate give the simplest expression in cases of difficulty. I select for this purpose the compounds of sulphuric anhydride with the olefines to bring the two systems into comparison. I take a few of these, as formulated by Kekulé, and place beside them the formulæ on the type of peroxides.

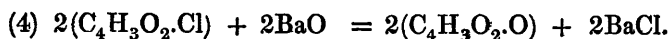
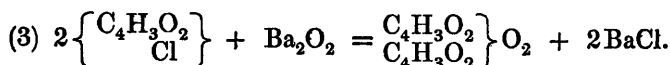
	Kekulé's formulæ.		Peroxide type formulæ.	
Sulphate of carbyle	$\left. \begin{array}{l} (C_4H_4)'' \\ (S_2O_4)'' \\ (S_2O_4)'' \end{array} \right\} \begin{array}{l} O_2 \\ O_2 \\ O_2 \end{array}$	like $\left\{ \begin{array}{l} H \\ H \\ H \\ H \\ H \end{array} \right\} O_2$	$C_4H_4, (S_2O_6)'' \cdot (S_2O_6)''$ like Glycol $C_4H_4, O_2, 2HO$	
Ethionic acid	$\left. \begin{array}{l} (C_4H_4)'' \\ (S_2O_4)'' \\ (S_2O_4)'' \\ H_2 \end{array} \right\} \begin{array}{l} O_2 \\ O_2 \\ O_2 \\ O_2 \end{array}$	like $\left\{ \begin{array}{l} H \\ H \\ H \\ H \\ H \end{array} \right\} O_2$	$C_4H_4O_2 \left. \vphantom{\begin{array}{l} C_4H_4O_2 \\ S_4O_4O_2 \end{array}} \right\} \cdot 2HO$ like Diethylenic glycol $\left. \begin{array}{l} C_4H_4O_2 \\ C_4H_4O_2 \end{array} \right\} \cdot 2HO$	
Isethionic acid	$\left. \begin{array}{l} (C_4H_4)'' \\ (S_2O_4)'' \\ H_2 \end{array} \right\} \begin{array}{l} O_2 \\ O_2 \\ O_2 \end{array}$	like $\left\{ \begin{array}{l} H \\ H \\ H \\ H \end{array} \right\} O_2$	$C_4H_4, S_2O_6 \cdot 2HO$ like Glycol $C_4H_4O_2 \cdot 2HO$	
Sulphacetic acid	$\left. \begin{array}{l} (C_4H_2O_2)'' \\ (S_2O_4)'' \\ H_2 \end{array} \right\} \begin{array}{l} O_2 \\ O_2 \\ O_2 \end{array}$	like $\left\{ \begin{array}{l} H \\ H \\ H \\ H \end{array} \right\} O_2$	$C_4H_4O_2, S_2O_6 \cdot 2HO$ like $\left\{ \begin{array}{l} \text{Glycollic acid} \\ C_4H_2O_2, O_2 \cdot 2HO \end{array} \right\}$	
Sulphuric acid	$\left. \begin{array}{l} H \\ (S_2O_4)'' \\ H \end{array} \right\} \begin{array}{l} O_2 \\ O_2 \\ O_2 \end{array}$	like $\left\{ \begin{array}{l} H \\ H \\ H \\ H \end{array} \right\} O_2$	$S_2O_4 \cdot O_2 \cdot 2HO$ like Glycol $C_4H_4, O_2, 2HO$	

It will be observed that the formulæ on the peroxide type, besides being much simpler in expression, keep to the type glycol (or the peroxide type) throughout, while the formulæ as given by Kekulé alter in value according to the difficulties of the explanation. I now bring into comparison some of the equations of decomposition which are thought particularly to support the water type, in order to show that they receive at least an equally simple expression on the oxide types. Let us take, for instance, the

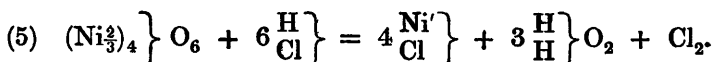
formation of acetate of ethylene as represented on the two types:—



If we now take Geil's* method of preparing acetic or benzoic anhydride, the equations on the two systems are the following:—



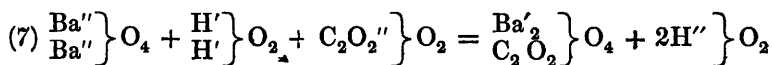
The simplicity of the peroxide type becomes however more apparent when the equations of decomposition involve a change in the atomicity. Thus, when sesquioxide of nickel is acted on by hydrochloric acid, the equation on the water type is the following:—



In this equation nickel on one side represents only $\frac{2}{3}$ of the atomicity which it affects on the other side. On the peroxide type the equation, without change of atomicities, is—



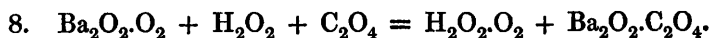
The difference will be still more apparent if we represent the formation of peroxide of hydrogen by Duprey's method of passing carbonic acid through peroxide of barium suspended in water:—



In this equation we have not only barium with a biatomic power on one side and a monoatomic power on the other, but we have hydrogen itself equal to one atom of itself on one side and equal to two atoms of itself on the other side of the same equation. On the peroxide type, the formation of peroxide of hydrogen is

* Geil, Comptes rendus, lvi, 360.

represented as follows, without any change in the atomicities of the radicles:—



I have in this lecture endeavoured to compress within reasonable limit the views which I entertain in regard to the constitution of salts. The main support of these views consists in the gratification of certain atomic affinities possessed by the combining radicles, the atomicity being capable of saturation either by basylous or chlorous radicles,—themselves generally bodies possessing the character of radicles by being in a state of unsatisfied atomic union. I fear that these views are too far apart from those which are yet doing such good service to chemistry to receive general acceptance; but I fancy that I do not do a disservice to our science when I invite you to look upon chemical compounds under various aspects.
