Report of the Committee for the Reform of Inorganic Chemical Nomenclature, 1940.

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The following " Rules for naming Inorganic Compounds " were drawn up by a committee of the International Union of Chemistry which consisted of Professors H. Bassett (Reading), A. Damiens (Paris), F. Fichter (Basle), W. P. Jorissen (Leyden), and H. Remy (Hamburg). They are based upon a report which had been drawn up by Professor Remy on behalf of the German Chemical Society and in collaboration with some of its members, of whom Professor A. Stock was the most active.

Two meetings of the Committee were held, the first in Berlin on January 28th and 29th, 1938, and the second in Rome on May 16th, 1938.

Dr. E. Pietsch, Editor of " Gmelin," attended the Berlin discussions by invitation of the Committee.

Professor Bassett is responsible for the English translation of the original German version of the Rules and for certain omissions and modifications rendered necessary by differences between the two languages.

Rules for Naming Inorganic Compounds.

INTRODUCTION.

The aim of these " Rules " is the unification of Inorganic Chemical Nomenclature and the removal of names which are out of date or incorrect.

An attempt has been made to produce a uniform, rational nomenclature for inorganic compounds, especially for scientific purposes. As it was nearly always possible to have recourse to the system of naming already in use, the problem was chiefly that of separating, in any particular systematic series, names which agreed with the general plan of the series from those which did not and replacing the latter by other suitable names.

Registration of inorganic compounds, *e.g.*, in the indexes of journals, lies outside our reference, although unification of inorganic nomenclature is evidently of importance for systematic reporting. These " Rules " were accordingly worked out with the help of colleagues who had special experience in this field.

The naming of individual elements has not been considered, since the Committee on Atomic Weights deals with this matter.

A. GENERAL.

Names and Formulæ.

A chemical compound can be designated in two ways, either :

(1) by means of the formula.
(2) by means of the name.

(1) Formulæ should be widely used in designating inorganic compounds, since they provide the simplest and clearest method of doing this. Their significance is, moreover, the same in all languages and for brevity and saving of space they are unequalled.

Formulæ are of particular use when dealing with complicated compounds. They have a special significance in the wording of descriptions of preparative procedure, since they prevent misunderstanding. Their use must naturally be avoided in cases where any uncertainty might be introduced.

Examples : Precipitation with H_2S—treat with gaseous HCl—aqueous or alcoholic HCl solution—passing the gas through KOH solution.

(2) When giving names to compounds there are two possibilities :

(*a*) systematic names,
(*b*) trivial names.

(*a*) In the case of systematic names it is not always necessary to indicate stoicheiometric proportions in the names unless there is some special reason for doing so, because a glance at the formula shows at once the quantitative and atomic composition.

In many cases sufficient abbreviation of the systematic name can be secured by omitting all numbers, indications of valency, etc., which are not needed in the given circumstances. For instance, indication of the valency or atomic proportions is generally not required with compounds of elements of essentially constant valency.

Examples : Aluminium sulphate instead of aluminium(III) sulphate.
Potassium chloroplatinate instead of potassium hexachloroplatinate(IV).
Potassium cyanoferrate(II) instead of potassium hexacyanoferrate(II).
Potassium cyanoferrate(III) instead of potassium hexacyanoferrate(III).

(*b*) In the case of trival names one must distinguish between :

(*aa*) pure trivial names,
(*bb*) incorrectly formed names.

(*aa*) Pure trivial names are those which are free from false scientific significance or other wrong indications. In most cases they originate from the people who use the compounds. Examples of such names are saltpetre—caustic soda—quicklime. The use of such pure trivial names is permissible.

(*bb*) Incorrectly formed names are those which were originally constructed to bring out certain ideas on the composition or constitution of the compounds in question, but are now opposed to our present views and knowledge. Such names are sulphate of magnesia—carbonate of lime—nitrate of potash—acetate of alumina. Their use is widespread, but scientifically they are incorrect.

Such names should not be used in any circumstances and they should be eliminated from technical and patent literature.

B. BINARY COMPOUNDS.

I. *Position of Constituents in Names and Formulæ.*

The electropositive constituent should always be put first in the formula and in the name whenever it is recognisable from the character of the compound—as in salts or salt-like compounds. The name of the electronegative constituent is given the termination—*ide*. In the case of non-polar compounds and of those in which it is not known which constituent is to be regarded as electropositive in the compound, that constituent should be placed first which has the more electropositive character *in the free condition.*

Examples : Sodium chloride, silver sulphide, lithium hydride—boron carbide, oxygen difluoride.

The above rule summarises the customary usage in English and German. Exactly the opposite applies in French and Italian, so that in these languages the order of constituents in formulæ will also be just the opposite to that which is correct in English and German. Such differences are due to the very nature of the several languages and cannot be eliminated. Names are also in use in some languages which are obtained by simple juxtaposition of the separate names of the constituents without any termination. This method of name construction is used in German more particularly for the easily volatile compounds of hydrogen. It should be rigidly restricted to non-polar compounds (though, even for them, the rule given first is to be preferred), and the constituent should be placed first which is the more *electronegative* in the free condition.

Examples : Chlorwasserstoff, Siliciumwasserstoff.—Schwefelkohlenstoff, Chlorstickstoff (but better : Kohlendisulfid, Stickstofftrichlorid).

But *not* : Chlornatrium, Bromkalium, Schwefelsilber.

But *only* : Natriumchlorid, etc.

II. *Indication of the Proportions of Constituents.*

There are two possible ways of indicating the proportions of the constituents in chemical compounds. It can be done :

(1) by indicating the valency,
(2) by giving the stoicheiometric composition, or the functional nature.

(1) Indication of the electrochemical valency in the names of compounds should be made only by Stock's method. This is done by means of Roman figures, placed in parentheses, and following, without hyphen, immediately after the names of the elements to which they refer.

Examples :

$CuCl$ = Copper(I) chloride
$CuCl_2$ = Copper(II) chloride
FeO = Iron(II) oxide
Fe_3O_4 = Iron(II,III) oxide.

The system of valency indication by terminations such as -ous, -ic (ferrous, ferric) which was previously in use has proved unsatisfactory and should now be avoided not only in scientific but also in technical writing.

If the valency needs to be shown in formulæ or when using symbols for the elements, then the Roman figures should be placed just above the appropriate symbol on the right-hand side.

Examples :

Cu^{I} salts,
Fe^{II} compounds.

(2) Indication of the stoicheiometric composition should be made by means of Greek numerical prefixes, which should precede, without hyphen, the constituent to which they refer. This method of showing the composition in names instead of by means of the valency is customary, more especially with non-polar compounds. It is also indicated in cases where the composition differs from that to be expected from the usual valency or in those in which the electrochemical valency is unknown. The prefix " mono " can generally be omitted, 8 should be indicated by " octa," 9 by " ennea." Greek prefixes above 12 are replaced by Arabic figures (without hyphen), as they are more easily understood. Arabic figures are also used for indicating fractions of molecules, although $\frac{1}{2}$ can also be expressed by " hemi." The functional system of naming compounds can be employed instead of the stoicheiometric. This is used more particularly in French.

Examples :

	Stoicheiometric System.	*Functional System.*
N_2O	= Dinitrogen (mon)oxide	
NO	= Nitrogen oxide	
N_2O_3	= Dinitrogen trioxide	nitrous anhydride
NO_2	= Nitrogen dioxide	
N_2O_4	= Dinitrogen tetroxide	
N_2O_5	= Dinitrogen pentoxide . . .	nitric anhydride
Ag_2F	= Disilver fluoride	
$Fe(CO)_4$	= Iron tetracarbonyl	
FeS_2	= Iron disulphide	

The formula is to be preferred to awkward names. Thus one should never say for $Na_{12}Hg_{13}$, 12 sodium 13 mercuride. In such cases always use the formula.

Out-of-date and superfluous terms such as Oxydul, Sulfür, Cyanür, Chlorür, etc., for compounds of lower valency stages, should vanish from the German language, both because they lack precision and because of the way in which many of these terms are used in French.*

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* In French, sulfure, cyanure, chlorure, etc., have the same significance as sulphide, cyanide, chloride, etc., in English.

III. *Designation of Intermetallic Compounds.*

Intermetallic compounds do not follow the usual laws of constant composition and must often be regarded rather as phases having a range of existence over which they are more or less homogeneous. There is lacking at present a clear understanding and grouping together of the laws which govern this class of compounds, so that any attempt at a rigid system of nomenclature for intermetallic compounds would be premature.

For this reason the use of names in this field should be avoided and formulæ alone should be used in all cases, and these should give the exact numbers of atoms, if possible. A simplified formula which represents the compound in a satisfactory manner can be used in those cases where either the exact number of atoms cannot be stated or where it is a question of an intermetallic compound which has a wide range of composition. To avoid any danger of confusion with a compound of definite composition, a bar should be placed over the formula to show that the composition is variable.

Example : AuZn occurs as β-phase in the system Au–Zn as an intermetallic compound with properties which differ from those of the components Au and Zn. It is homogeneous over the range of 41 to 58 atoms % Zn, so that all formulæ between $Au_{59}Zn_{41}$ and $Au_{42}Zn_{58}$ would be correct for which the shortened form AuZn or $\overline{AuZn}$ may be used.

Compounds such as $\overline{AuZn}$ which do not have a constant composition should be called " non-Daltonian " compounds to distinguish them from " Daltonian " compounds of constant composition.

A future systematic nomenclature of intermetallic compounds will have to consider also the field of mixed crystals and superstructures.*

IV. *Indicating the Mass, Atomic Number, and State of Ionisation on the Atomic Symbols.*

When dealing with nuclear reactions, the ordinary representation of an element by the plain symbol is not sufficient. The latter must be expanded so as to show the atomic mass and atomic number.

An index on the right and below the symbol is already used to show the stoicheiometric proportion, while another on the right above the symbol shows the state of ionisation. The corresponding positions on the left are available for the atomic number and mass.

We then have :

right lower index	the number of atoms
right upper index	the state of ionisation
left lower index	the atomic number
left upper index	the mass

Example :

$${}^{35}_{17}Cl_2^{+1}$$

This represents a singly ionised chlorine *molecule* Cl_2 each atom of which has the atomic number 17 and mass 35.

The following is an example of an equation for a nuclear reaction :

$${}^{26}_{12}Mg + {}^{4}_{2}He = {}^{29}_{13}Al + {}^{1}_{1}H$$

V. *Group Names.*

Compounds of the halogens are to be called *halogenides* (not haloides or halides), while the elements oxygen, sulphur, selenium, and tellurium may be called *chalkogens*, and their compounds *chalkogenides.*

The alkali metals should not be called " alkalis " nor the alkaline-earth metals " alkaline earths," since these names are old-fashioned terms for the oxides of these metals and should be avoided in scientific language. If compounds are concerned, the use of " alkali " or

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* The Committee wishes to draw the attention of workers in this field to the urgent need for some consistency in the notation used for distinguishing different modifications and intermediate phases.

" alkaline earth " as an abbreviation for " alkali metal " or " alkaline-earth metal " is general and permissible, *e.g.*, alkali chlorides.

In German " Kohlen- " is permissible as an abbreviation for " Kohlenstoff " in many carbon compounds.

C. TERNARY, QUATERNARY, ETC., COMPOUNDS.

The preceding rules which have been developed for binary compounds are valid, when suitably extended, also for compounds of more than two elements.

Radicals having special names are treated like the elementary constituents of a compound when constructing names.

Examples :

NH_4Cl = Ammonium chloride
KCN = Potassium cyanide
$Fe(SCN)_3$ = Iron(III) thiocyanate
$Pb(N_3)_2$ = Lead azide.

If several electropositive constituents are combined with one electronegative, then the rule holds that the more electropositive constituent is to be placed first, just as in the case of binary compounds.

In the same way, if a compound contains several electronegative constituents, these should be placed, both in the name and in the formula, in order of increasing electronegative character so far as this is possible.

Sulphur replacing oxygen in an acid radical should always be indicated by " thio " (see under D, p. 1410), so that compounds of the radical SCN should be called " thiocyanates," * not " sulphocyanates " and not sulpho- or thio-cyanides.

Names such as the following are permissible for mixed salts : Lead chlorofluoride, lead sulphochloride.

The terms alumino-, boro-, beryllo-, etc., silicates should only be applied to such silicates as contain Al, B, Be, etc., in place of some of the Si.

Examples :

Orthoclase, $K[AlSi_3O_8]$ is an aluminosilicate (potassium aluminotrisilicate).
Spodumen, $LiAl[Si_2O_6]$ is an aluminium silicate (lithium aluminium disilicate).
Muscovite, $KAl_2[AlSi_3O_{10}](OH)_2$ is an aluminium aluminosilicate.

D. OXY-ACIDS.

Well-established names for the majority of the important simple oxy-acids have been in use for a long time, and their alteration is neither desirable nor necessary. It is only necessary to consider a number of cases in which uncertainty or confusion has arisen in the course of time owing to the employment of some names which are incorrect.

In the following tables are shown the names which should be used for the more important acids of sulphur, nitrogen, phosphorus, and boron, as well as their salts.

Formula.	Acid.	Salt.
	Acids and Salts of Sulphur :	
H_2SO_2	Sulphoxylic acid	Sulphoxylate
$H_2S_2O_4$	Dithionous acid	Dithionite
H_2SO_3	Sulphurous acid	Sulphite
$H_2S_2O_2$	Thiosulphurous acid	Thiosulphite
$H_2S_2O_5$	Pyrosulphurous acid	Pyrosulphite
H_2SO_4	Sulphuric acid	Sulphate
$H_2S_2O_3$	Thiosulphuric acid	Thiosulphate
$H_2S_2O_7$	Pyrosulphuric acid	Pyrosulphate
H_2SO_5	Peroxy(mono)sulphuric acid	Peroxy(mono)sulphate
$H_2S_2O_6$	Dithionic acid	Dithionate
$H_2S_xO_6$ (x = 3, 4, etc.)	Polythionic acids	Polythionates
$H_2S_2O_8$	Peroxydisulphuric acid	Peroxydisulphate

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* " Rhodanide " is the usual German name.

Formula.	Acid.	Salt.
	Acids and Salts of Nitrogen:	
$H_2N_2O_2$	Hyponitrous acid	Hyponitrite
H_2NO_2	Nitroxylic acid	Nitroxylate
HNO_2	Nitrous acid	Nitrite
HNO_3	Nitric acid	Nitrate
HNO_4	Peroxynitric acid	Peroxynitrate
	Acids and Salts of Phosphorus:	
H_3PO_2	Hypophosphorous acid	Hypophosphite
H_3PO_3	Phosphorous acid	Phosphite
$H_4P_2O_5$	Pyrophosphorous acid	Pyrophosphite
$H_4P_2O_6$	Hypophosphoric acid	Hypophosphate
H_3PO_4	(Ortho)phosphoric acid	(Ortho)phosphate
$H_4P_2O_7$	Pyrophosphoric acid	Pyrophosphate
HPO_3	Metaphosphoric acid	Metaphosphate
H_3PO_5	Peroxy(mono)phosphoric acid	Peroxy(mono)phosphate
$H_4P_2O_8$	Peroxydiphosphoric acid	Peroxydiphosphate
	Acids and Salts of Boron:	
H_3BO_2	Borous acid	—
$H_4B_2O_4$	Hypoboric acid	Hypoborate
H_3BO_3	Orthoboric acid	Orthoborate
HBO_2	Metaboric acid	Metaborate
$H_2B_4O_7$	Tetraboric acid	Tetraborate

For other polyboric acids see under F. II.

Decisions made on six points arising out of the above tables must be explained.

(1) $H_2S_2O_4$ = Dithionous acid, and not *hydro*sulphur*ous* or *hypo*sulphur*ous* acid; salts = dithionites.
(2) $H_2S_2O_3$ = *Thio*sulphur*ic* acid, and not *hypo*sulphur*ous* acid; salts = thiosulphates.
(3) H_2SO_5 = *Peroxymono*sulphur*ic* acid, and not *per*sulphur*ic* acid.
(4) H_2NO_2 = *Nitroxylic* acid, and not *hydro*nitr*ous* acid; salts = nitroxylates.
(5) $H_2B_4O_7$ = *Tetra*bor*ic* acid, and not *pyro*bor*ic* acid; salts = tetraborates.
(6) H_2PO_3 = salts to be called hypophosphates.

Notes to (1) *and* (2): The name hydrosulphurous acid for the compound $H_2S_2O_4$ was proposed by its discoverer Schützenberger because of the erroneous assumption that the salts had the formula RHS_2O_4. This name has lost its justification since the later proof by Bernthsen and Bazlen that the salts of the acid are free from hydrogen and have the formula $R_2S_2O_4$, for the term " hydro " has no sense for compounds containing no hydrogen, for which it is an unsatisfactory abbreviation in any case.

The name " hyposulphurous " acid proposed by Bernthsen and others for the compound $H_2S_2O_4$ also appears to be unsatisfactory quite apart from the fact that its employment might give rise to confusion so long as the use of the name " hyposulphite " for " thiosulphate " has not been entirely abandoned.

It is customary to apply the name " hypo...ous " to that acid in which each atom of the acid-forming element is less oxidised by two valency stages than the corresponding atoms in the acid to which the name ending in " ous " is given (compare chlorous with hypochlorous acid; nitrous with hyponitrous acid).

Each atom of sulphur in the acid $H_2S_2O_4$ is, on the average, two valency stages less oxidised than each atom of sulphur in dithionic acid. It follows that $H_2S_2O_4$ should be called *dithionous* acid to fall into line with the general rules employed in naming the oxy-acids. This name does not imply any assumption as to the constitution of the compound; it was first proposed by Noyes and Steinour (*J. Amer. Chem. Soc.*, 1929, **51**, 1409). It is quite wrong to use the name hyposulphurous acid for $H_2S_2O_3$, though this is still frequently done. The acid $H_2S_2O_3$ is derived from sulphuric acid, H_2SO_4, by replacement of one oxygen atom by sulphur. It must accordingly be called *thiosulphuric* acid, since the presence of sulphur which has taken the place of oxygen is in general indicated by the prefix " thio " (see later).

The name " hyposulphurous acid " would be justified for the acid H_2SO_2, but the well-established name " sulphoxylic acid " should be retained for this compound. The names " hyposulphurous " acid and " hyposulphite " should therefore cease to be used at all.

Note to (3) : A distinction must be made between those acids or salts which are derived by substitution from hydrogen peroxide and in consequence contain peroxidic oxygen, —O—O—, and those which are derived from the highest oxidation stages of some elements and are free from peroxidic oxygen. The last named are correctly called *per*-salts (such as $NaClO_4$, $KMnO_4$).

The first group, such as $R_2S_2O_8$ and R_3PO_5, must be separated from the genuine per-salts and called peroxy-salts, the corresponding acids being peroxy-acids.

Examples :

H_2SO_5 = Peroxymonosulphuric acid
$H_4P_2O_8$ = Peroxydiphosphoric acid
NH_4BO_3 = Ammonium peroxyborate

In the same way the oxides derived from H_2O_2 should be called peroxides, and not superoxides or hyperoxides.

Note to (4) : The acid H_2NO_2 has been called hydronitrous acid, but it is more correctly called nitroxylic acid by analogy with sulphoxylic acid. The sodium salt Na_2NO_2 obtained by Zintl is, correspondingly, sodium nitroxylate.

Note to (5) : The prefixes " ortho," " meta," and " pyro " are used generally in the sense that the term " ortho " is applied to the most hydroxylated acid known either in the free state or as salts or esters.

Examples :

H_3BO_3 = Orthoboric acid
H_4CO_4 = Orthocarbonic acid
H_4SiO_4 = Orthosilicic acid
H_3PO_4 = Orthophosphoric acid
H_6TeO_6 = Orthotelluric acid
H_5IO_6 = Orthoperiodic acid

The pyro- and meta-acids are derived from the ortho-acids by removal of water in stages. Pyro-acids are those which have lost 1 mol. of H_2O from 2 mols. of ortho-acid (*Examples :* $H_2S_2O_7$, $H_2S_2O_5$, $H_4P_2O_7$, $H_4P_2O_5$). This rule does not apply, however, to the polyboric acid $H_2B_4O_7$ (= $2B_2O_3,H_2O$), which contains less water than metaboric acid HBO_2 (= B_2O_3,H_2O). To avoid breaking the rule, the acid $H_2B_4O_7$ should not be called pyroboric acid, but tetraboric acid, in agreement with the proposals for the naming of isopolyacids (see F. II).

Replacement of O *by* S.—Acids which are derived from oxy-acids by replacement of O atoms by S atoms are to be called thio-acids, their salts thio-salts.

Examples :

H_2CS_3 = Trithiocarbonic acid.
Na_3SbS_4 = Trisodium tetrathioantimonate (sodium thioantimonate for short).

The group $[H_3O]^+$.—When the hydrogen ion is considered to occur (in aqueous solution or in a compound) in the form $[H_3O]^+$, it is advisable to call it the ***hydronium*** ion (not ***hydroxonium*** ion).

E. SALTS.

I. *General.*

Salts should always be named so that the name of the metal or electropositive radical precedes that of the acid radical which carries the termination -ate, -ite, or -ide.

Examples :

Silver nitrate—Magnesium sulphate—Calcium carbonate
Sodium nitrite—Iron sulphide—Potassium cyanide.

Names such as nitrate of silver, sulphate of magnesium are permissible, but it is wrong to use in this way the name of the metal oxide in place of that of the metal, so that sulphate of magnesia, carbonate of lime, etc., are definitely wrong, and should not be employed (see A., p. 1405).

Names derived from the German names of the acids, such as Salpetersaures Silber, Schwefelsaures Magnesium, Kohlensaures Calcium, may be used in popular writing (German), but should be avoided in scientific language (in this case also the name of the metal oxide must not be used in place of that of the metal). The use in English of names such as " copper vitriol " or " blue vitriol " for $CuSO_4,5H_2O$ and " oil of vitriol " for sulphuric acid is analogous to the above German usage. Such names are still used to some extent in technical literature and in chemical works, though only relatively few compounds are affected. There is little to be said in favour of these archaic names and it would be better if they went out of use.

In the case of *mixed or double salts* the rules given under C should be applied.

Examples :

$KNaCO_3$ = Potassium sodium carbonate
$KCaPO_4$ = Potassium calcium phosphate
NH_4MgPO_4 = Ammonium magnesium phosphate

Salts of nitrogen compounds, if regarded as co-ordination compounds like ammonium chloride, NH_4Cl, are to be designated as -onium or -inium compounds.

Examples :

Tetramethylammonium chloride—Hydrazinium chloride—Pyridinium chloride.

If, however, the nitrogen compounds are regarded as addition compounds, then the rules derived for these will apply (see F., V).

II. *Acid Salts* (*Hydrogen Salts*).

The rational names for acid salts are formed by using " hydrogen " for the hydrogen atoms which they contain. The hydrogen is to be named last of the electropositive constituents.

Examples :

$KHSO_4$ = Potassium hydrogen sulphate
$NaHCO_3$ = Sodium hydrogen carbonate
Na_2HPO_4 = Disodium hydrogen phosphate
NaH_2PO_4 = Sodium dihydrogen phosphate

In complicated cases use formulæ.

Examples :

$4K_2SO_4,3H_2SO_4 = K_8H_6(SO_4)_7$ Rationally : Octapotassium hexahydrogen heptasulphate.
$5K_2SO_4,3H_2SO_4 = K_5H_3(SO_4)_4$ Rationally : Pentapotassium trihydrogen tetrasulphate.

If it is desired to emphasise the type of compound rather than its composition, the term *acid salts* (monacid, diacid, etc.) can be used as well as the expressions primary, secondary, tertiary, etc., salts. Designation in terms of the acid : base ratio by means of " bi " is not in agreement with the fundamental principles of rational nomenclature. It is therefore wrong to say bicarbonate, bisulphate, bisulphite.

III. *Basic Salts.*

Basic salts which can be shown to contain hydroxyl groups and can be considered and named as addition compounds of hydroxides to neutral salts are called *hydroxy-salts.*

Example :

$Cd(OH)Cl$ = Cadmium hydroxychloride.

When the hydroxyl group is bound in a complex, Werner's system of notation should be used, according to which the hydroxyl groups are designated *hydroxo-* or *ol-* groups. Basic salts in which there are oxygen atoms as well as acid radicals attached to the metal are called *oxy*-salts. If they contain radicals with special designations, names derived from these can be employed.

Examples :

$BiOCl$ = Bismuth oxychloride or bismuthyl chloride
$UO_2(NO_3)_2$ = Uranium(VI) dioxynitrate or uranyl nitrate

For oxygen atoms bound in a complex, the Werner notation applies and the oxygen atoms are to be called *oxo*-atoms.

F. HIGHER ORDER COMPOUNDS.

I. *Complex Compounds (Co-ordination Compounds). General.*

The nomenclature devised by A. Werner still regulates the naming of co-ordination compounds, and its value lies in the fact that it permits of uniform treatment of the whole range of compounds. An alteration is needed only as regards the indication of valency. In order to get a uniform method of indicating valency, both for simple and for co-ordination compounds, Stock's method, already applied to the former, has been extended to the latter.

In the case of complex kations the Roman figures expressing the valency are placed in parenthesis after the name of the element to which they relate (as with the simple compounds).

Examples :

$[Cr(OH_2)_6]Cl_3$ = Hexa-aquochromium(III) chloride
$[Cr_3Ac_6(OH)_2]X$ = Hexa-acetatodihydroxotrichromium(III) salt

In the case of complex anions of acids or salts the valency of the central atom is given in parenthesis after the name of the complex which ends in -ate. The Latin names of metals must often be used in this connection for reasons of euphony.

Examples :

$H_2[PtCl_6]$ = Hydrogen hexachloroplatinate(IV)
$H_4[Fe(CN)_6]$ = Hydrogen hexacyanoferrate(II)

$K_4[Fe(CN)_6]$ = Potassium hexacyanoferrate(II)
$K_3[Fe(CN)_6]$ = Potassium hexacyanoferrate(III)
$K_3[Co(NO_2)_6]$ = Potassium hexanitrocobaltiate(III)
$K[Au(OH)_4]$ = Potassium tetrahydroxoaurate(III)

It is not necessary to give the valency of the central atom in the case of neutral complexes (non-electrolytes). If it is desired specially to emphasise it, this can be done as in the case of the complex kations. Mention of the valency is not necessary when the number of the ionised atoms or groups is given in the name.

Examples :

$[Cr(OH_2)_6]Cl_3$ = Hexa-aquochromium trichloride
$K_4[Fe(CN)_6]$ = Tetrapotassium hexacyanoferrate
$K_3[Fe(CN)_6]$ = Tripotassium hexacyanoferrate

This method of naming is, however, only to be recommended in those cases where the electrochemical valency of the central atom is not known or not with certainty, as, for instance, with compounds containing NO in the complex.

Order of the attached atoms or groups. Atoms or groups co-ordinated in the complex are to be mentioned in the name in the order (i) *acidic groups* such as chloro (Cl), cyano (CN), cyanato (NCO), thiocyanato (NCS), sulphato (SO_4), nitro (NO_2), nitrito (ONO), oxalato (C_2O_4), and hydroxo (OH); (ii) *neutral groups :* aquo (H_2O), substituted amines [$C_2H_4(NH_2)_2$ = en], and last of all ammine (NH_3).

II. *Isopolyacids and their Salts.*

As isopolyacids in the widest sense are to be understood those acids which can be regarded as resulting from two or more molecules of one and the same acid by elimination of water. In this sense the pyro- and meta-acids which are formed from ortho-acids by removal of water are also to be included among the isopolyacids.

Even although the rule holds for the polyacids in an accentuated form, that formulæ should be used for characterising compounds in complicated cases, there is yet need for a rational nomenclature if only for designating the groups of compounds. There belong to the isopolyacids as especially important representatives the boric, silicic, molybdic, tungstic, and vanadic acids. Rules will be considered with reference to them therefore.

It is proposed that the empirical formulæ should always be resolved into the base anhydride : acid anhydride ratios. For this it is unnecessary to go into the still uncertain questions of the constitution of these compounds, and this avoids introducing any instability in the method of designation which might arise from changes in outlook.

This procedure gives a method of representation for this class of compounds which is clear and straightforward and very suitable for systematic treatment. Characterisation by means of the base : acid ratio has already thoroughly justified itself in the systematic description of the polyacids and their salts in Gmelin's " Handbuch der anorganischen Chemie." It has always made possible a classification which was free from contradictions.

The following equally satisfactory methods for constructing names are available :

(1) The composition, referred to the simplest empirical formula, is given by means of Greek numerical prefixes just as with other compounds (compare B. II., p. 1406).

(2) The simplest formula which expresses the analytical results for the compound in terms of base anhydride and acid anhydride is resolved into these. The ratio base anhydride : acid anhydride is shown in the name by means of Arabic figures in parentheses.

In both cases the basic component is to be named before the acid. Acid hydrogen atoms are to be indicated by " hydrogen " and should always be given (also in the names of the free acids).

These proposals have been carried out for a number of borates, silicates, molybdates, tungstates, and vanadates as shown in the following tables.

Empirical formula.	Name formation by Greek numerical prefixes.	Resolved formula.	Name formation by base : acid ratio.	Present customary name.
		Borates :		
Na_3BO_3	Trisodium (mono)borate	$3Na_2O,B_2O_3$	Sodium(3 : 1)-borate	Orthoborate
$Na_4B_2O_5$	Tetrasodium diborate	$2Na_2O,B_2O_3$	Sodium(2 : 1)-borate	Pyroborate
$NaBO_2$	Monosodium (mono)borate	Na_2O,B_2O_3	Sodium(1 : 1)-borate	Metaborate Monoborate
$Na_2B_4O_7$	Disodium tetraborate	$Na_2O,2B_2O_3$	Sodium(1 : 2)-borate	Tetraborate Pyroborate
NaB_3O_5	Sodium triborate	$Na_2O,3B_2O_3$	Sodium(1 : 3)-borate	Hexaborate Triborate
$Na_2B_8O_{13}$	Disodium octaborate	$Na_2O,4B_2O_3$	Sodium(1 : 4)-borate	Octaborate Tetraborate
NaB_5O_8	Sodium pentaborate	$Na_2O,5B_2O_3$	Sodium(1 : 5)-borate	Decaborate Pentaborate
$Na_2B_{12}O_{19}$	Disodium dodecaborate	$Na_2O,6B_2O_3$	Sodium(1 : 6)-borate	Dodecaborate Hexaborate
		Silicates :		
Na_4SiO_4	Tetrasodium (mono)silicate	$2Na_2O,SiO_2$	Sodium(2 : 1)-silicate	Orthosilicate
$Na_6Si_2O_7$	Hexasodium disilicate	$3Na_2O,2SiO_2$	Sodium(3 : 2)-silicate	Pyrosilicate
$Na_8Si_3O_{10}$	Octasodium trisilicate	$4Na_2O,3SiO_2$	Sodium(4 : 3)-silicate	Pyrosilicate
Na_2SiO_3	Disodium (mono)silicate	Na_2O,SiO_2	Sodium(1 : 1)-silicate	Metasilicate
$Na_6Si_4O_{11}$	Hexasodium tetrasilicate	$3Na_2O,4SiO_2$	Sodium(3 : 4)-silicate	Metasilicate
$Na_4Si_3O_8$	Tetrasodium trisilicate	$2Na_2O,3SiO_2$	Sodium(2 : 3)-silicate	Metasilicate
$Na_2Si_3O_7$	Disodium trisilicate	$Na_2O,3SiO_2$	Sodium(1 : 3)-silicate	Metasilicate
		Molybdates :		
Na_2MoO_4	Disodium monomolybdate	Na_2O,MoO_3	Sodium(1 : 1)-molybdate	Normal molybdate
$Na_2Mo_2O_7$	Disodium dimolybdate	$Na_2O,2MoO_3$	Sodium(1 : 2)-molybdate	Dimolybdate
$Na_{10}Mo_{12}O_{41}$	Decasodium dodecamolybdate	$5Na_2O,12MoO_3$	Sodium(5 : 12)-molybdate	Paramolybdate
$Na_2Mo_3O_{10}$	Disodium trimolybdate	$Na_2O,3MoO_3$	Sodium(1 : 3)-molybdate	Trimolybdate
$Na_2Mo_4O_{13}$	Disodium tetramolybdate	$Na_2O,4MoO_3$	Sodium(1 : 4)-molybdate	Tetramolybdate

and so on up to $Na_2O,16MoO_3$.

Empirical formula.	Name formation by Greek numerical prefixes.	Resolved formula.	Name formation by base : acid ratio.	Present customary name.
		Tungstates :		
Na_2WO_4	Disodium (mono)tungstate	Na_2O,WO_3	Sodium(1 : 1)-tungstate	Normal tungstate
$Na_4W_3O_{11}$	Tetrasodium tritungstate	$2Na_2O,3WO_3$	Sodium(2 : 3)-tungstate	Normal tungstate
$Na_2W_2O_7$	Disodium ditungstate	$Na_2O,2WO_3$	Sodium(1 : 2)-tungstate	Ditungstate
$Na_{10}W_{12}O_{41}$	Decasodium dodecatungstate	$5Na_2O,12WO_3$	Sodium(5 : 12)-tungstate	Paratungstate
$Na_2W_3O_{10}$	Disodium tritungstate	$Na_2O,3WO_3$	Sodium(1 : 3)-tungstate	Tritungstate
$Na_2W_4O_{13}$	Disodium tetratungstate	$Na_2O,4WO_3$	Sodium(1 : 4)-tungstate	Tetratungstate (with water (Metatungstate)
—	—	—		
—	—	—	—	
—	—	—	—	—
—	—	—	—	—
—	—	—	—	—
—	—	—	—	—
$Na_2W_8O_{25}$	Disodium octatungstate	$Na_2O,8WO_3$	Sodium(1 : 8)-tungstate	Octatungstate
		Vanadates :		
Na_3VO_4	Trisodium (mono)vanadate	$3Na_2O,V_2O_5$	Sodium(3 : 1)-vanadate	Normal Orthovanadate
$Na_4V_2O_7$	Tetrasodium divanadate	$2Na_2O,V_2O_5$	Sodium(2 : 1)-vanadate	Pyrovanadate
$NaVO_3$	Sodium (mono)vanadate	Na_2O,V_2O_5	Sodium(1 : 1)-vanadate	Metavanadate
$Na_2V_4O_{11}$	Disodium tetravanadate	$Na_2O,2V_2O_5$	Sodium(1 : 2)-vanadate	Tetravanadate
NaV_3O_8	Sodium trivanadate	$Na_2O,3V_2O_5$	Sodium(1 : 3)-vanadate	Hexavanadate

In more complicated cases the formula itself is best employed. Even though a correct systematic name is possible in such cases, it is generally unwieldy, as, for instance :

$Ba_2(VO_2)H_2(V_5O_{16})$ = Dibarium vanadyl dihydrogen pentavanadate.

In a similar way, for example, the compounds of the tungstic acids with organic bases are grouped together as " tungstates of organic bases." Subordinated to this group are the sub-groups " methylammonium tungstates," " propylammonium tungstates," and so on, of which the individual compounds then follow with their formulæ only, since an attempt to form names for each compound would lead to an unsatisfactory and insufficient symbolisation of their composition.

III. *Heteropolyacids and their Salts.*

The formulæ of the heteropolyacids and their salts are resolved into their constituent base and acid anhydrides, as in the case of the isopolyacids, and for this purpose the simplest formula which expresses the analytical composition is employed.

This resolution is made,

for the *acid* into : Non-metallic acid—oxide of the acid-forming metal—water;
for the *salt* into : Salt of the non-metallic acid (resolved perhaps into base anhydride-acid anhydride ratio) *—oxide of the acid-forming metal—water.

The numbers of atoms of the two acid-forming elements derived from this *simplest* formula are shown in the name by means of Arabic figures or Greek numerical prefixes. Here again only the group name is given, which should be supplemented by the formula if necessary in individual cases.

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* If by so doing simpler numerical relations can be obtained.

Examples :

$R_3PO_4,12MoO_3$ = Dodecamolybdophosphate or $3R_2O,P_2O_5,24MoO_3$ = 24-Molybdo-2-phosphate
$R_3PO_4,12WO_3$ = Dodecatungstophosphate or $3R_2O,P_2O_5,24WO_3$ = 24-Tungsto-2-phosphate
$2R_5PO_5,17WO_3$ = 17-Tungstodiphosphate or $5R_2O,P_2O_5,17WO_3$ = 17-Tungsto-2-phosphate
$R_5BO_4,12WO_3$ = Dodecatungstoborate or $5R_2O,B_2O_3,24WO_3$ = 24-Tungsto-2-borate
$R_8SiO_6,12WO_3$ = Dodecatungstosilicate or $4R_2O,SiO_2,12WO_3$ = 12-Tungsto silicate

IV. *Double Salts.*

The name of the double salt is formed by putting together the names of the simple salts from which it is formed. The order of the kationic constituents should be that of decreasing electropositive character. Constituents common to both salts should only be mentioned once.

Examples :

$KCl,MgCl_2$ = Potassium magnesium chloride
$Na_2SO_4,CaSO_4$ = Sodium calcium sulphate
$3CaO,Al_2O_3,CaCl_2,10H_2O$ = Calcium chloroaluminate
$KCl,MgSO_4$ = Potassium chloride, magnesium sulphate.

In the third example only the group name is given, under which all the single members are collected.

V. *Hydrates, Ammoniates, and other Addition Compounds.*

The collective names: Hydrate, peroxyhydrate (not perhydrate), and ammoniate should be applied to compounds which contain molecules of H_2O, H_2O_2, or NH_3.

Either Greek numerical prefixes or Arabic figures can be used to show the number of such molecules present.

Examples :

$CaCl_2,6H_2O$ = Calcium chloride hexahydrate or calcium chloride 6-hydrate
$CaCl_2,4H_2O$ = Calcium chloride tetrahydrate or calcium chloride 4-hydrate
$CaCl_2,2H_2O$ = Calcium chloride dihydrate or calcium chloride 2-hydrate
$CaCl_2,H_2O$ = Calcium chloride monohydrate or calcium chloride 1-hydrate

Collective name : Calcium chloride hydrates.

$NaOOH,H_2O_2$ = Sodium hydrogen peroxide peroxyhydrate
$AlCl_3,xNH_3$ = Aluminium chloride ammoniate

If it needs to be shown that the molecule in question forms part of a complex, then the compounds are to be named as aquo, peroxyhydrato, and ammine compounds (compare F. I., p. 1412).

Examples :

$[Cr(NH_3)_6]Cl_3$ = Hexamminechromium(III) chloride
$[Cr(OH_2)_6]Cl_3$ = Hexaquochromium(III) chloride
$[Cr(OH_2)_4Cl_2]Cl,2H_2O$ = Dichlorotetraquochromium(III) chloride dihydrate

Other addition compounds. Addition compounds containing added PCl_3, NOCl, H_2S, $C_2H_5{\cdot}OH$, etc., are better shown by the formula than by a special name. For systematic consideration of this field it is advisable to make use of a group name.

Examples :

$AlCl_3,4C_2H_5{\cdot}OH$ = Compound of aluminium chloride with alcohol
$AlCl_3,NOCl$ = Compound of aluminium chloride with nitrosyl chloride
$AlCl_3,H_2S$ = Compound of aluminium chloride with hydrogen sulphide

Group names :

" Compounds of aluminium chloride " with " organic compounds," with " sulphur compounds," etc.