THE NEED FOR REFORM IN INORGANIC CHEMICAL NOMENCLATURE[1]

JANET D. SCOTT[2]

Chemical Abstracts, The Ohio State University, Columbus, Ohio

Received June 8, 1942

Lack of conformity of usage with formulated systems of inorganic nomenclature is discussed. Difficulties are encountered in indicating the proportions of constituents of compounds (either by valence or by stoichiometric composition), in varying usage of prefixes and suffixes, and in differences in the order of designating constituents. Nomenclature problems are pointed out relating to (*1*) elements, (*2*) groups such as alkaline earths and halides, (*3*) radicals or ions, and (*4*) certain classes of compounds. The classes considered are: intermetallic compounds, oxygen acids, salts (including acid and basic salts, double or multiple salts as con-

---

[1] This paper was presented as part of a Symposium on Inorganic Chemical Nomenclature, April 9, 1941, under the auspices of the Division of Physical and Inorganic Chemistry, at the 101st Meeting of the American Chemical Society, which was held in St. Louis, Missouri. The Symposium was introduced by Dr. E. J. Crane, Chairman of the Committee on Nomenclature, Spelling, and Pronunciation of the American Chemical Society, who said in part:

"This Symposium on Inorganic Chemical Nomenclature is timely. During the past year chemists have received the 'Rules for Naming Inorganic Compounds,' issued as a Report of the Committee for the Reform of Inorganic Chemical Nomenclature of the International Union of Chemistry (70). History will hardly record the year 1940 as one of general progress in international coöperation, but nevertheless this 1940 Report, a culmination of work done and in part reported during the past two decades, is a giant stride towards improved and internationally standardized nomenclature in the field of inorganic chemistry. Nothing so important along this line has happened since the work done by Berzelius beginning in 1811 in extending the system of nomenclature which was introduced in 1787 by Guyton de Morveau and Lavoisier and which has stood the test of time in remarkable manner.

"Evidence of the recognition of the importance of the recent 'Rules for Naming Inorganic Compounds' is to be found in the fact that this rather extensive Report has been published in a number of languages and has appeared in such publications of national chemical societies as *Journal of the Chemical Society*, *Berichte der deutschen chemischen Gesellschaft*, and the *Journal of the American Chemical Society*. The Report as published in the *Journal of the American Chemical Society* has been edited to provide an American version, this work having been done with the understanding that it was not the intention of the International Committee to influence spellings and other features of the written form peculiar to individual countries. . . .

"The above-mentioned international rules are fairly comprehensive, but there are problems remaining and there will, of course, always be new ones as inorganic chemistry develops. Inorganic chemists are dealing increasingly with complex compounds and this has naturally complicated the nomenclature problem. . . . This Symposium is intended to serve as a sign of interest in these inorganic nomenclature problems, as an opportunity for giving information and expressing views and as a source of stimulation of further interest and progress. . . .

"The Nomenclature, Spelling and Pronunciation Committee of the American Chemical Society both welcomes and encourages nomenclature activity by Divisions and Sections of the Society."

[2] Present address: Basic Magnesium, Incorporated, Las Vegas, Nevada.

trasted with complexes and molecular addition compounds, and salts with mixed halogen anions), molecular addition compounds (as hydrates and ammoniates), coördination compounds, and isopoly and heteropoly acids and their salts. Examples of miscellaneous compounds are also presented.

"Reform" is perhaps too strong a word, though even here, as in all questions of nomenclature, there is opportunity for disagreement. Delépine (21), in his report of the Commission for the Reform of the Nomenclature of Inorganic Chemistry in 1928, stated that "It has become legitimate to undertake, if not a reform, at least the suppression of all the vicious usages that have been introduced into the nomenclature." Not only should "vicious usages" be suppressed, but usages that in themselves can hardly be term "vicious," but that do conflict with a rational system of nomenclature, should be discouraged so far as possible. Can we agree that the ideal to be striven for is that the name for a given compound should definitely indicate the analytical composition and so far as possible the chemical structure? Yet some usages of long standing, though not ideal, have enough prestige on their side to counterbalance minor objections to them. It is such weighing of relative values that must be given careful consideration in any attempts at reform or change of a more or less drastic nature in the direction of systematization.

The oldest and most widely used names, and the names most difficult to change, are the common or trivial names. Such names always depend on memory, of course, and in some cases of complex compounds, with names based on the discoverer or on the color of the compound, for example, it is no mean feat to know off-hand the composition of a certain compound, such as Roussin's red salt, or to know which of the ammino cobalt chlorides is praseocobaltic chloride. Where common names refer to simpler specific compounds, involving no ambiguities or inconsistencies, there may be no objection to their use. Thus, if *lime* denotes only calcium oxide, well and good. However, a distinction must be made between common names used correctly and those that are used loosely or incorrectly or that are incorrect in themselves. Thus, the use of *lime* for calcium carbonate or any other compound of calcium is ambiguous and leads only to confusion. The term *alums* (14, 18) is applied to anhydrous double sulfates or to other hydrates than the 12 (or 24) H_2O, and also to aluminum sulfate itself. *Soda* and *potash* have been used for so many compounds that there can be no certainty with regard to them. *Saltpeter* may refer to any one of three nitrates.

Names like *phosphate of lime*, *bicarbonate of soda*, *alumina chloride*, and *potash prussiate*, formerly considered correct, are now ruled incorrect, though they are still all too common. *Carbonic acid* is still used for carbon dioxide, *sulfurous acid* for sulfur dioxide, and *phosphoric acid* for phosphorus pentoxide.

Mineral names are often used loosely for the synthetic compounds, even though these compounds may not have the crystal structure and other physical properties characteristic of the naturally occurring minerals. Synthetic sodium fluoaluminate, for example, is commonly called *cryolite*. *Borax* is not limited to the decahydrate of sodium tetraborate.

The increasing number of trade and trade-marked names only adds to the confusion and to scattering in indexes. Different names may be introduced for the same substance, especially when it is intended for different purposes. Thus *Carbona* is carbon tetrachloride, but so is *Pyrene.*

However, the problems connected with common, mineral, and trade names are less intricate than those connected with strictly chemical or systematic names. It is the latter type that have occupied most of the attention of international committees for the reform of chemical nomenclature. New conceptions of structure, introduced particularly through physical-chemical, x-ray, and electron-diffraction studies, and new theories, especially the coördination theory, have indicated changes that should be made in long-established names. In the system approved for coördination compounds, the central atom is named last; this makes a few well-established names, notably *ferrocyanide* and *ferricyanide,* out of step. As early as 1923 the Nomenclature Committee of the British Chemical Society and that of the American Chemical Society agreed that *chloroplatinate* should be preferred to *platinichloride* and that, similarly, *chloroaurate* should be adopted. This rule should not be limited to these two classes of compounds, however. A well-known inorganic chemistry textbook, for example, has *chloroplatinic acid, chloroplatinate,* and *chloroplatinous acid,* but switches to *platinochloride* for K_2PtCl_4 and *platinocyanide* for $BaPt(CN)_4 \cdot 4H_2O$. *Fluosilicate* has replaced *silicofluoride* to a large extent, and *fluoborate* has replaced *borofluoride,* but *cobaltocyanide* and *cobalticyanide* (like *ferrocyanide* and *ferricyanide*) and *cobaltonitrite* and *cobaltinitrite* are still more common than the terms now considered correct. Heteropoly acids (and their salts) should also be named as coördination compounds: *molybdophosphoric acid* and *tungstophosphoric acid* should be used instead of *phosphomolybdic acid* and *phosphotungstic acid.* With some of the more complex heteropoly acids containing at least three significant elements the structure, or even the composition, often is not known and no suitable name can be selected.

Inconsistencies probably show up more readily in indexes than anywhere else. The great variety of compounds, from many sources over a period of years, in compilations like the *Decennial Indexes* of *Chemical Abstracts* is likely to lead to a great variety and inconsistency in names; consequently there is great need of guarding against scatterings. The possibilities of a variety of names for even a relatively simple compound may be surprisingly great. The word order in English names for salts, with the cations always first, is in some respects unfortunate, because the cations (particularly if simple) are likely to be of less interest than the anions, which exhibit greater variety in composition and wider discrepancies in names. Hence it has been found necessary in the *Chemical Abstracts* office to keep a file of names for anions in order to harmonize the names for cesium salts, for example, with those for sodium salts.

While it is agreed in English that the electropositive part of the name should come first, there is not complete agreement as to which is the more electropositive of two non-metallic elements. In only four of the reports of international committees (12, 13, 21, 48) has an electrochemical series for the non-metallic elements been given. These series do not agree in the positions of nitrogen and sulfur and of oxygen and fluorine. With still other pairs of elements, as carbon and silicon, usage is not yet uniform. The last two international reports (53, 70) do not include any electrochemical series.

Some attempts at systematization of chemical names, notably Werner's logical system for coördination compounds, have not met with general favor because of difficulties in carrying them out. Only the Germans seem to be able to distinguish clearly in speaking among the four vowels selected by Werner to denote valence. Clumsy names like those used by Mellor can hardly make any great appeal even to the most technically trained.

Once the various nomenclature problems have been settled for a given compound and a suitable systematic name has been selected, there still remains the question of the written form (*cf.* Crane (29)). Often there is a choice in regard to the use of one or two or more separate words and the use of hyphens. *Sodium fluoaluminate* might be written as two or three words or the *fluo-* might be hyphenated. Increasing complexity in compounds naturally increases the possibilities of variation in the written form as well as in the name. American and British spellings of chemical words differ, notably in the use of *f* or *ph* and *aluminum* or *aluminium*. It is hoped that the publications of the American Chemical Society are the best standard for American practice.

Another problem closely related to that of nomenclature is the method of writing formulas. The order of symbols in formulas naturally follows the order of the words in the name. Thus in English the electropositive element or radical comes first, as $NaCl$, while in French the electronegative portion comes first, as $ClNa$. Furthermore, the order of symbols might well indicate the structure as far as possible; e.g., for cyanates and thiocyanates, $—OCN$ and $—SCN$ are preferable to $—CNO$ and $—CNS$. Instead of subscripts to denote the number of atoms or groups present, the French often use superscripts. In some cases there is little uniformity in the matter of molecular weights represented by formulas. Formulas for alums are written with 12 or 24 H_2O, and for the simple molecules (as $KAl(SO_4)_2 \cdot 12H_2O$) or for addition compounds (as $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$). This question, like others, can be settled only by studies of structure. While formulas should logically conform to the names chosen and structures assumed, they do not always do so. Isopoly and heteropoly acids and salts may have (*1*) formulas representing only the analytical composition, (*2*) formulas resolved into the base anhydride and acid anhydride (70), or (*3*) formulas representing the structure at least in part. Trisodium dodecamolybdophosphate may accordingly be written as $Na_3PMo_{12}O_{40}$, $3Na_2O \cdot P_2O_5 \cdot 24MoO_3$, or $Na_3PO_4 \cdot 12MoO_3$. The use of brackets in coördination compounds has never been standardized, especially from the point of view of what to include within the brackets. Uncertainty is particularly marked with regard to molecules of water, as in ammino chromium complexes. The answers to many of these questions must be based again on the structure of the compounds. In all the cited types of inconsistencies in formulas, absolute standardization may not be advisable, since certain types of formulas may be selected in certain instances to bring out definite points under discussion. However, where no such purpose is being served, greater standardization in formulas than now exists would seem desirable.

A final general matter related to nomenclature is that of variations and carelessness in pronunciation. If either ȧ-mē′ nō or ăm′ ĭ-nō is used for both NH_2 and combined NH_3 without discrimination, how is one to know which is meant? A report of the Nomenclature, Spelling and Pronunciation Committee of the American Chemical Society on "The Pronunciation of Chemical Words" was published in the *News Edition* in 1934 (39).

Of great primary importance in naming inorganic compounds is the indication of the proportions of constituents, by means of either the valence or the stoichiometric composition. Difference in valence has been most commonly indicated by the use of the suffixes *-ous* and *-ic* for cations and acids, and *-ite* and *-ate* for anions. When only two valences are involved, as with copper, this system is reasonably satisfactory, though it is necessary to remember the valences of the given element. With the iron compounds, the greatest confusion occurs in the anion names (see table 1). The prefixes *hypo-* and *per-* have been used in combination with the suffixes *-ite* and *-ate* to represent four or even five valency stages in the case of anions. Terms like *ferrosoferric, ferrosic,* and *ferriferrous* have been introduced for cations with more than two valences, or prefixes like *sub-* and *proto-* have been used, especially with names of oxides. With elements having as many different valences as manganese and rhenium, however, these makeshift systems break down (see tables 2 and 3). The names of

TABLE 1

Nomenclature of iron compounds

OXIDES	HYDRATED OXIDES		SALTS	
	Formula	Name	Formula	Name
FeO	$FeO \cdot H_2O$ $Fe(OH)_2$	Ferrous hydroxide	M_2FeO_2	Hypoferrite Ferroate
Fe_3O_4				
Fe_2O_3	$Fe_2O_3 \cdot xH_2O$	Hydrated ferric oxide	$MFeO_2$ $M_2O \cdot Fe_2O_3$	Ferrite Metaferrite Ferrate Ferriate
	$HFeO_2$ $FeO(OH)$	Ferrous acid		
	$Fe(OH)_3$	Ferric hydroxide		
(FeO_2)	(H_2FeO_3)		M_2FeO_3	Perferrite Ferrate
(FeO_3)	(H_2FeO_4)	Ferric acid	M_2FeO_4	Ferrate Perferrate Ferronate
(FeO_4)	(H_2FeO_5)		M_2FeO_5	Perferrate

the manganites are in a confused state. The rhenium compounds that have caused the most trouble are those analogous in formula to the chloroplatinates and accordingly commonly called *chlororhenates.* Rhenium and platinum are not, however, chemically related, and the oxygen acid corresponding to M_2ReCl_6 is rhenous acid, H_2ReO_3.

Werner's system, based on the use of *a*, *o*, *i*, *e*, *an*, *on*, *in*, *en* for valences of one to eight, respectively, could be satisfactorily worked out only in German and never was generally adopted.

TABLE 2

Nomenclature of manganese compounds

OXIDES	SALTS		COMPLEXES	
	Formula	Name	Formula	Name
(Mn_2O)			$M_5Mn(CN)_6$	Double salt
MnO			$MMnCl_3$	Trichloromanganite
			M_2MnCl_4	Tetrachloromanganite Double salt
			M_4MnCl_6	Double salt
Mn_3O_4				
Mn_2O_3	$MMnO_2$	Hypomanganite Manganite	$MMnF_4$	
			M_2MnCl_5	Chlorohypomanganite Double salt
			$M_3Mn(CN)_6$	Double salt
MnO_2	M_2MnO_3 $M_2Mn_2O_5$ $M_2Mn_3O_7$ $M_2Mn_4O_9$ $M_2Mn_5O_{11}$ etc.	Manganite Permanganite	M_2MnCl_6	Chloromanganite Manganichloride
MnO_3	M_2MnO_4	Manganate		
Mn_2O_7	$MMnO_4$	Permanganate		

A third system, the Stock system (1, 2, 3, 4, 5, 48, 53, 70), is based on the use of Roman numerals in parentheses following the cation or anion name. The ending *-ate* is then used wherever *-ite* or *-ate* was used before. Fe_3O_4 is accordingly called *iron(II, III) oxide* and K_2ReCl_6 is called *potassium chlororhenate(IV)*. This system is adopted in the 1940 Rules (70) but it has not yet been put into general use. The Roman numeral can be used with symbols as well as names by placing it above and to the right, as Cu^{I} salts.

Stoichiometric composition is almost invariably indicated by Greek prefixes through twelve, though there have been proposals to use Arabic numerals either before or after the words making up the name (antimony-2 sulfide-3 or 2-antimony 3-sulfide) (13, 21). Even in the use of the Greek prefixes, however, there have been inconsistencies. *Di-* and *bi-* have both been used for two, and *octa-* and *octo-* for eight. The Latin prefixes *nona-* and *undeca-* have frequently replaced the Greek *ennea-* and *hendeca-*, respectively. *Hemi-* is used by some for half, but Mellor's *trita-*, *pentita-*, etc., for one-third, one-fifth, etc., respectively, are not in general use. *Sesqui-* is common for three-halves, especially for oxides, but P_4S_3 has been called *phosphorus sesquisulfide.* If no numerical prefix is used before a prefix denoting substitution, *mono-* may be understood, as in *thiosulfate*, or complete substitution may be indicated, as in *thiocarbonate* (used sometimes for *trithiocarbonate*) and *chloroplatinate* (for *hexachloroplatinate*). Further, a numerical prefix sometimes indicates the total number of atoms of a given element or radicals in a compound and at other times the number of equivalents or the number of atoms relative to the number of atoms of another element. *Tricalcium phosphate* is $Ca_3(PO_4)_2$, but *dicalcium phosphate* is $CaHPO_4$.

TABLE 3

Nomenclature of rhenium compounds

OXIDES	SALTS		COMPLEXES	
	Formula	Name	Formula	Name
Re_2O				
ReO				
Re_3O_4				
Re_2O_3	$MReO_2$	Hyporhenite	$MReCl_4$	Double salt
			M_2ReCl_5	Chlororhenite
			M_3ReCl_6	Hexachlororheniate Double salt
ReO_2	M_2ReO_3	Rhenite	M_2ReCl_6	Chlororhenite Chlororhenate (Hexa)chlororheneate Rhenochloride Rhenichloride Double salt
(Re_2O_5)	M_3ReO_4	Orthohyporhenate		
	$MReO_3$	(Meta)hyporhenate		
	$M_4Re_2O_7$	Pyrorhenate Pyrohyporhenate		
ReO_3	M_2ReO_4	Rhenate		
Re_2O_7	$MReO_4$	(Meta)perrhenate		
	M_3ReO_5	Mesoperrhenate		

Sulfur monochloride is S_2Cl_2. The number of atoms of the second element (as the sulfur) may be indicated or not. SO_3 and As_2O_3 are both called simply *trioxide.* With such simple familiar compounds as these, the inconsistencies are of minor importance, but similar instances among complex compounds like the iso- and hetero-poly acids may lead to confusion. Though less definite than the numerical prefixes, the prefixes *ortho-*, *pyro-*, *meta-*, etc., also serve to indicate the proportions of constituents. Their use will be considered later in connection with oxygen acids. Numerical prefixes may also indicate degree of polymerization, as in *sodium hexametaphosphate* $(NaPO_3)_6$.

Prefixes indicating the presence of specific radicals are used in three different ways in inorganic names. In the first place, they denote substitution, usually for oxygen or hydroxyl instead of for hydrogen as in organic names. Chloroplatinic acid, H_2PtCl_6, can be regarded as platinic acid, H_2PtO_3, in which six chlorine atoms have replaced the three oxygen atoms, or as the so-called hydroxy- (or hexahydroxy)platinic acid, $H_2Pt(OH)_6$, in which six chlorine atoms have replaced the six hydroxyl groups. The intermediate, partially substituted acids are also known and named as *chlorohydroxy*(or *chlorohydroxo*)*platinic acids*, e.g., $H_2Pt(OH)_5Cl$, *chloropentahydroxyplatinic acid.* The ambiguous use in these cases of *chloro-* without a numerical prefix, to indicate either complete substitution (H_2PtCl_6) or substitution of only one group ($H_2Pt(OH)_5Cl$) leads to the redundant use of the prefix *hydroxy-* or *hydroxo-*. The presence or number of hydroxyl groups or oxygen atoms is not ordinarily indicated in the names of oxygen acids (*hydroxyplatinic acid* is an exception). HPO_3 is not called *hydroxydioxyphosphoric acid*, though the prefix *meta-* is used to indicate that this is the least hydroxylated of the common acids of phosphorus. The monofluoro derivative, H_2PO_3F, however, has been called both *fluodihydroxyphosphoric acid* and *monofluorophosphoric acid.* For the difluoro derivative, HPO_2F_2, even though *difluo-* or *difluoro-phosphoric acid* is unambiguous, *difluodioxyphosphoric acid* has seemed better to some writers. Sometimes the prefix *meta-* is used with these phosphoric acid derivatives, but more often it is not. $CsPF_6$, for instance, has been called *cesium fluometaphosphate, cesium hexafluometaphosphate,* and *cesium hexafluophosphate.* A curious example of what might be termed backward substitution occurs with a difluoro derivative of boric acid. If fluoboric acid, HBF_4, is considered a completely substituted metaboric acid, then the difluoro derivative, $H_3BO_2F_2$, would be a partially substituted orthoboric acid and could be named *difluoboric acid.* The common name, however, seems to be *dihydroxyfluoboric acid*, based on the replacement by hydroxyl of two fluorine atoms in fluoboric acid, HBF_4. Also of interest at this point is the variation in the use of *hydro-* with names of complex acids. Thus *fluosilicic acid* and *hydrofluosilicic acid* are synonymous, as well as *ferricyanic acid* and *hydroferricyanic acid.*

Prefixes are also used in inorganic chemistry to indicate replacement of hydrogen (as in *dihydroxyammonia*, $NH(OH)_2$) and of other atoms and groups. In certain cases, discussed later, of compounds of boron, germanium, and silicon the prefixes *boro-*, *germano-*, and *silico-* denote replacement of carbon by these elements. The prefixes *alumino-*, *boro-*, *beryllo-*, etc., are supposed to be used for complex silicates only when these elements replace silicon (70).

Besides denoting substitution, prefixes are used in the second place to denote simply the presence of an atom or radical, not necessarily attached to the constituent denoted by the word to which the prefix is attached. Names like *phosphorus dichlorotrifluoride* for PCl_2F_3 are allowable according to the 1940 Rules (70), though the chlorine and fluorine atoms are all bound to phosphorus and the compound is as much a chloride as a fluoride. Here the prefix seems to mean "chloride and."

The third use of prefixes is to denote addition in a complex. $CsICl_2$, in which the chlorine atoms are attached to the iodine and not to the cesium, is called *cesium dichloroiodide*, but might also be given the name *cesium dichloro*(or *chloro*)*hypoiodite*, a name denoting substitution.

There is also disagreement as to what prefixes should be used to denote the presence of a given group. Correct decisions must often depend upon determinations of structure. *Nitro-* and *nitrito-*, designating the groups NO_2^- and ONO^-, respectively, have both been used in naming complexes like $K_3Co(NO_2)_6$ (commonly called *potassium cobaltinitrite*). *Per-* is used for acids and salts derived from hydrogen peroxide and also for those derived from the highest oxidation stages of some elements. *Persulfuric acid*, because it contains the —O—O— linkage, is an example of the former type, for which the rules of the international committee recommend the use of the prefix *peroxy-*, and *perchloric acid* is an example of the latter type. *Thio-* and *sulfo-* have both been used to denote replacement of oxygen by sulfur, but *sulfo-* in organic chemistry refers to the $—SO_3H$ radical.

More minor differences in prefixes also exist. *Hydroxy-* and *hydroxo-* are both used for —OH, *hydroxo-* usually in complexes. A similar situation exists for *oxy-* and *oxo-*. *Halo-* and *halogeno-* have been used interchangeably; so have *fluo-*, *fluor-* and *fluoro-*. The connecting vowels *o* and *a* are sometimes kept and sometimes dropped. *Chloroaurate* and *chloraurate* are both found, and so are both *metaantimonite* and *metantimonite*.

Suffixes, like prefixes, are used sometimes to denote substitution and sometimes to denote combination of atoms or groups. In *aminetrisulfonic acid*, $N(SO_3H)_3$ (also called *nitrilo*(*tri*)*sulfonic acid*), the *-sulfonic* denotes substitution of $—SO_3H$ for hydrogen in ammonia (since *amine* is regarded as equivalent to *ammonia*). Names of the type of *aminetrisulfonic* are approved in organic chemistry (e.g., *benzenesulfonic acid* instead of *phenylsulfonic acid*), but are rare in inorganic chemistry. On the other hand, the name *chlorosulfonic acid* for $ClSO_3H$ simply indicates that chlorine and $—SO_3H$ have combined. (*Chlorosulfuric acid*, analogous to *chlorophosphoric*, *chloroplatinic*, etc., has also been used for $ClSO_3H$.)

Minor differences in suffixes seem to consist chiefly of the use or omission of *i* before *-ous* and *-ate*. *Antimonious* and *antimonous*, *antimoniate* and *antimonate* all occur. *Selenious* and *tellurous* are the common terms in each case, but are inconsistent with each other. In names of coördination compounds containing trivalent central atoms the *i* of the Werner system is common, as in *cobaltiate*. The *i* is sometimes used even in a name having Roman numerals to indicate valence according to the Stock system. The English and German versions of the 1940 Rules have *potassium hexanitrocobaltiate(III)*, but this *i* was taken out in the American version because it seemed superfluous.

The order of naming constituents may also vary. Reference was made earlier to binary compounds of non-metallic elements. The hydrides are an outstanding example of variation. *Hydrogen sulfide* is, of course, common for H_2S (or still sometimes the older *sulfuret(t)ed hydrogen*), while *boron hydrides* (or sometimes *hydroborons*) is used for the compounds of boron and hydrogen. P_2H_4 has been called both *phosphorus dihydride* and *hydrogen phosphide*. A general question of alphabetical order *vs.* an order based on some chemical property, as electropositivity, comes up with names for double salts, coördination compounds as ammino compounds, heteropoly acids, and complex mixed halides. Again, the ammonobasic compound $HgNH_2Cl$, infusible white precipitate, can be called *mercury amidochloride* (analogous to *mercury hydroxychloride*), *amidomercury chloride*, or *mercury amide chloride*. In dealing with the complex mercury ions, on the other hand, it seems more natural to say *amido-* and *hydroxymercuric* or *-mercury*.

A more detailed examination of inorganic chemical nomenclature naturally begins with the names and symbols for the individual elements. Inconsistencies in this domain have been dealt with by the International Committee on Atomic Weights rather than the Committee on Inorganic Chemical Nomenclature, but it might be well to note a few of the cases here. Outstanding are *beryllium* and *glucinum*, and *columbium* and *niobium*. Among variations in symbols are *Ac* and *Act* for *actinium*, *Az* (still used to some extent in French) and *N*, *Tu* and *W*, *J* (in German) and *I*, *Ar* and *A*, *X* and *Xe*, *Em* and *Rn*, *Tu* and *Tm*, and *Cy* (in German) and *CN* for the cyano radical. This variation in symbols prevents formula indexes from ideally overcoming language as well as nomenclature indexing difficulties. Numerals used with atomic symbols to indicate mass, atomic number, and state of ionization have not always had the same positions around the symbol.

In recent years the discovery of isotopes has introduced another problem into the naming of both elements and compounds (42, 45). The hydrogen isotopes are, of course, the outstanding example. The confusion of names that arose almost at once for "heavy hydrogen," its nucleus, and its compounds (32, 33, 40, 41, 43, 44) was in large part dispelled by prompt action of the American Chemical Society Committee (47) in favor of *deuterium*, *deuteron*, and modified Boughton names (e.g., *ammonia-d* for NH_2D), respectively.

Names of groups of elements or compounds vary to some extent. The alkali metals are loosely called *alkalies*, and the alkaline-earth metals *alkaline earths*. In names of compounds, however, there is no objection to phrases like *alkali chlorides* or *alkaline-earth sulfates*. There have been suggestions to prefer *hydrogenides* to *hydrides* and *halogenides* to *haloids* or *halides* (the 1940 Rules recommend *halogenides*). Peroxides have been called *superoxides* and *hyper-*

oxides, and higher oxides like lead dioxide and manganese dioxide, which do not contain the —O—O— linkage, have been wrongly termed *peroxides*. Acid-forming oxides are appropriately called *anhydrides* (*sulfuric anhydride* for sulfur trioxide) or, as noted earlier, not so appropriately given the names of the corresponding acids. Hydrated oxides may be named as such or as *hydroxides* or *acids*. With amphoteric elements like aluminum and iron, all three types of names have been applied to the same compounds. Metal hydroxides are still incorrectly called *hydrates* at times, as *barium hydrate* instead of *barium hydroxide* for $Ba(OH)_2$. Certain oxides, like Fe_3O_4 and Pb_3O_4, can be regarded as salts and so named (*ferrous ferrite*, $Fe(FeO_2)_2$, and *plumbous plumbate*, Pb_2PbO_4). Salts of nitrogen compounds, as hydrazine, have been variously named. Acid sulfides are known as both *hydrosulfides* and *sulfhydrates*. Thiocyanates are still called *sulfocyanates* and *sulfo-* or *thio-cyanides*. *Sulfoxide*, which has a definite use in organic chemistry for compounds containing the $\rangle SO$ group, has been applied to the oxysulfide $P_4S_4O_6$. Acetylides like Cu_2C_2 and HgC_2 are frequently designated by the more general term *carbide*, and azides like $Pb(N_3)_2$ by *nitride*. *Hyponitrite* and *nitrosyl* both refer to compounds like $Ag_2(NO)_2$ containing the —NO group.

In connection with group names it is of interest to note the illogical use of *monoacid*, *diacid*, etc., in reference to bases, and of *monobasic*, *dibasic*, etc., in reference to acids. *Monohydric*, *dihydric*, etc., have been used for bases, acids, alcohols, and phenols. Some writers are now using *monoacid*, *diacid*, etc., to replace *monobasic acid*, *dibasic acid*, etc., and *monobase*, *dibase*, etc., to replace *monoacid base*, *diacid base*, etc.

Names for inorganic radicals and ions vary unnecessarily, and in some cases there is confusion between organic and inorganic usage (see table 4). *Amido-* and *amino-* are supposed to be distinguished in organic chemistry, but do not seem to be in inorganic chemistry; a similar situation exists with *imido-* and *imino-*. There has been much disagreement over the naming of $[H_3O]^+$, for which the 1940 Rules favor *hydronium*. Even the question of *when* to use a radical name at all has not been settled for inorganic compounds, particularly the basic salts. Thus $POCl_3$ is called *phosphorus oxychloride* slightly more frequently than it is *phosphoryl chloride*. Yet for the corresponding sulfur compound, *thiophosphoryl chloride* seems the most satisfactory name. Some elements with several valences, notably molybdenum and vanadium, form radicals with varying valence, which have usually not been distinguished by specific names.

Certain classes of compounds, as indicated in the various committee reports, have given rise to special difficulties in nomenclature. Intermetallic compounds, because of the variability and indefiniteness of their composition, are particularly troublesome. Suggestions have been made to name them in alphabetic order or in any order, with Arabic numerals to indicate the stoichiometric composition, if known. The 1940 Rules recommend the avoidance of names and the use of only formulas, as definite as possible. For compounds of indefinite or varying composition (non-Daltonian compounds) a bar placed above the formula is

TABLE 4

Nomenclature of inorganic radicals

RADICAL	NAME
NH_2—	Amido- Amino-
NH_4—	Ammonium
SbO—	Antimonyl Antimony oxy-
AsO—	Arsenyl
BiO—	Bismuthyl Bismuth oxy-
BO—	Boryl
Br—	Bromo-
CO=	Carbonyl Carbon oxy-
Cl—	Chloro-
ClO—	Chloryl
CbO≡	Columbyl Columbium oxy-
CrO_2=	Chromyl Chromium dioxy-
NCO—	Cyanato-
NC—	Cyano-
F—	Fluoro- Fluo-
GeO=	Germanyl Germanium oxy-
N_2H_4—	Hydrazinium
N_2H_5—	Hydrazonium Hydrazinium
N_2H_6—	Hydrazonium Hydrazinium
H_3O—	Hydronium Hydroxonium Oxonium
HO—	Hydroxy- Hydroxyl Hydroxo-
NH=	Imido- Imino-
OCN—	Isocyanato-
CN—	Isocyano-
SCN—	Isothiocyanato- Isothiocyano- Isosulfocyano-
I—	Iodo-
IO—	Iodoso-
IO_2—	Iodoxy-
MoO— MoO≡ MoO≣	Molybdenyl Molybdenum oxy-
MoO_2=	Molybdenyl Molybdenum dioxy-
MoO(OH)—	Molybdyl
NO_3—	Nitrato-
N≡	Nitrilo-
ONO—	Nitrito- Oxynitroso-
$N(OH)_3$=	Nitronium
NO—	Nitrosyl Nitroso- Nitrogen oxy- Oximido-
NO=	Nitrosyl
NO—	Nitrosyl Nitroso-
N(OH)=	Nitrosyl Isonitroso- Hydroxynitrilo- Nitrilohydroxy- Oximido-

TABLE 4—*Continued*

RADICAL	NAME
NO_2—	Nitryl Nitroxyl Nitro-
O=	Oxy- Oxo-
MnO_3—	Permanganyl
NP=	Phosphonitrile Phosphonitrilic
PH_4—	Phosphonium
PO—	Phosphoryl
PO≡	Phosphoryl Phosphorus oxy-
PO_2—	Metaphosphoryl
P_2O_3≡	Pyrophosphoryl Diphosphorus trioxy-
Se=	Seleno-
NCSe—	Selenocyanato- Selenocyano-
SeH—	Selenyl
SeO=	Selenyl Selenium oxy-
SeO_2=	Selenyl Selenonyl Selenium oxy-
SiH_3—	Silicyl Silyl
SiO=	Silicyl Siliconyl Silicocarbonyl
Si_2O_5=	Disilicyl
SiH_2=	Silicylene
NaO	Sodyl
SnH_3—	Stannyl
SnO=	Stannyl Tin oxy-
H_2NO_2S—	Sulfamyl
SO_4=	Sulfato-
SH—	Sulfhydryl Hydrosulfuryl
SH_3—	Sulfonium
SO_2=	Sulfuryl Sulfur oxy-
S_2O_5=	Pyrosulfuryl
Te=	Telluro-
TeO=	Telluryl Tellurium oxy-
S=	Thio- Sulfo- Thiol- (replacing O in OH) Thiono- } (replacing O in CO) Thione-
SC=	Thiocarbonyl
SC≡	Thiocarbonyl
NCS—	Thiocyanato- Thiocyano- Sulfocyano-
NOS—	Thionitro-
NS—	Thionitroso- Thiazyl
SO=	Thionyl Sulfurous oxy-
SP≡	Thiophosphoryl Phosphorus thio- Phosphorus sulfo-

TABLE 4—*Concluded*

RADICAL	NAME
$P_2S_3\equiv$	Thiopyrophosphoryl
$ThO=$	Thoryl Thorium oxy-
$TiO=$	Titanyl Titanium oxy-
$WO\equiv$	Tungstyl Tungsten oxy-
$UO_2=$	Uranyl
$VO-$	Vanadyl Vanadylous Vanadium oxy-
$VO=$	Vanadyl Vanadium oxy-
$VO\equiv$	Vanadyl Vanadylic Vanadium oxy-
V_2O_2- $V_2O_2\equiv$	Divanadyl Vanadium dioxy-
$ZrO=$	Zirconyl Zirconium oxy-

intended to prevent confusion with compounds of definite composition (Daltonian compounds).

Oxygen acids are often called *oxy acids*, a term which is also used for *hydroxy acids* in organic chemistry. Again, the extent of hydration has not been consistently indicated by the use of the prefixes *ortho-*, *pyro-*, *para-*, *meso-*, and *meta-*. The *ortho acid* should be the form of highest possible hydration, but is often the highest hydrated known form or the highest hydrated of the common forms (e.g., H_3PO_4 instead of H_5PO_5). The *pyro acid* should be intermediate between the ortho and meta acids, but *pyroboric acid* ($H_2B_4O_7$) contains less water than metaboric acid (HBO_2) and is therefore better called *tetraboric acid.* The acid $H_6B_4O_9$ can be properly called *pyroboric acid*, but this only adds to the confusion. Reference has already been made to difficulties in the use of the suffixes *-ic* and *-ous* and the prefixes *hypo-*, *per-*, *peroxy-*, *thio-*, and *sulfo-*.

The oxygen acids taken up in the committee reports are the sulfur, nitrogen, phosphorus, and boron acids. The most notorious case is that of $H_2S_2O_4$ (table 5), originally named *hydrosulfurous* because its salts were mistakenly thought to contain hydrogen. Later, it was called *hyposulfurous acid*, a name which has also been applied to $H_2S_2O_3$ (better called *thiosulfuric acid*). A still later name, *dithionous acid*, is adopted in the 1940 Rules, but it is objected to by some on the basis that the compound does not have a symmetrical structure, as does dithionic acid. Others maintain that it does have a symmetrical structure. Agreement on a suitable name for $H_2S_2O_4$ may have to await agreement on the structure.

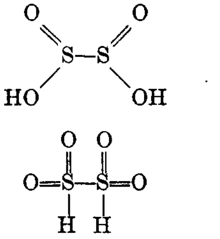
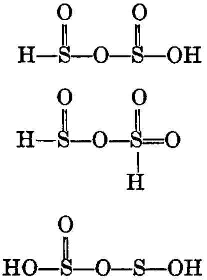
Among the other oxygen acids and salts that have received more than one name are *pyrosulfurous*, $H_2S_2O_5$ (the salts are often called *metabisulfites* or sometimes *metasulfites*), *pyrosulfuric* or *disulfuric*, $H_2S_2O_7$ (there are other cases of inconsistent uses of *pyro-* and *di-*), and *nitroxylic* or *hydronitrous acid*, H_2NO_2.

Salt names regularly end in *-ate*, *-ite*, or *-ide*. As mentioned earlier, incorrect names based on the oxide instead of the metal (phosphate of *lime* instead of *calcium*) have not yet dropped out of use.

In naming acid salts, the variety of terms used leads to needless confusion. *Acid*, *hydrogen*, *hydro-*, *bi-*, and *bin-* may all mean that only one hydrogen atom in a diacid such as sulfuric acid has been replaced. With salts of triacids, e.g., the calcium phosphates, the variety of names is amazing and appalling. The use of the prefix *bi-* is particularly objectionable, because *bi-* is still used sometimes to indicate the presence of two atoms or radicals, as in *bichloride of mercury*.

TABLE 5

$H_2S_2O_4$ *and its sodium salt*

(SOH)HO hydrosulfurous acid (Schützenberger (1869, 1873))	S(NaO,HO)	(acid) hydrosulfite
	$S(NaO)_2$	neutral hydrosulfite
$H_2S_2O_4$ (Bernthsen (1881–1910), Bazlen, Nabl, Moissan, and others)	$Na_2S_2O_4$	
hyposulfurous acid (Roscoe (1877), Wagner (1877), and others)		hyposulfite
dithionous acid (A. A. Noyes and Steinour (1929); 1940 Rules)		dithionite
Symmetrical structures	*Unsymmetrical structures*	
		

Basic salts can be named as such or as addition compounds of a salt with a hydroxide or oxide. Salts containing hydroxyl are named by prefixing *hydroxy-* (sometimes *hydroxo-*) to the anion name, and salts containing oxygen are named by prefixing *oxy-* (less often *oxo-*) (e.g., *bismuth oxychloride*) or by adding *-yl* to the cation name to form a radical name (e.g., *bismuthyl chloride*). The prefix *sub-* is attached to the names of some basic bismuth salts (e.g., *bismuth subnitrate*).

Double or multiple salts may be regarded as such, as complexes, or as molecular addition compounds. There is no sharp line that can be drawn at present. Shall it be *sodium aluminum fluoride*, $3NaF \cdot AlF_3$, *sodium fluoaluminate*, Na_3AlF_6, or *compound of aluminum fluoride with sodium fluoride?* Again, shall it be *sodium silver thiosulfate* or *sodium argentothiosulfate* (better, *thiosulfatoargentate*)?

The general tendency now seems to be to favor complexes, but there is as yet nothing approaching uniformity.

If it has been decided to name a compound as a double salt, there still remain a number of choices. The order of naming the cations or anions may be alphabetical; it may be based on the relative weight, valence, or interest of the elements or groups involved (the heavier, trivalent, and more significant element, as aluminum, chromium, or iron, is usually named first in alums); or it may follow the order of decreasing electropositivity (for cations) or increasing electronegativity (for anions), as recommended in the 1940 Rules. Names like *lead chlorofluoride,* as well as *lead chloride fluoride,* are permissible.

The similarity in names for the two types of mixed halogen anions, those in which the halogen atoms are attached to each other and those in which they are not, was discussed in connection with the use of prefixes in names like *cesium dichloroiodide* and *phosphorus dichlorotrifluoride.*

Molecular addition compounds, as hydrates and ammoniates, are not always readily distinguished from complexes. This failure leads to inconsistencies in naming and formulating these compounds. Compounds containing water in complexes are more properly considered *aquo complexes* than *hydrates,* and those with ammonia in complexes are *ammines* rather than *ammoniates,* though the term *ammines* has served to cover both types. Greek prefixes or Arabic numerals indicate the number of molecules of water or ammonia in the addition compounds. Compounds with hydrogen peroxide have been called *hydroperoxides, peroxyhydrates,* and *perhydrates.* Other types of addition compounds are designated as *compounds with aluminum chloride, nitrous oxide,* etc., or are represented simply by formulas.

Coördination compounds, especially the more complex ones, naturally offer opportunities for greater variation in systematic names than simpler compounds. Only a few general observations will be made here regarding compounds of this type. In the first place, the designations for the constituents of the compounds vary. The valence of the central atom has been indicated in anions by the insertion of only *o*- or *i*- or by the Werner system, or in either cations or anions by Roman numerals (Stock system). Of the neutral coördinating groups, ammonia has had applied to it or proposed for it the terms *ammine, ammino-, ammonio-, ammoniac, amman, ammono-,* and (in French) *-ammonique* at the end of complex cation names. Water is usually *aquo-,* but at the end of complex cation names it may be designated in French by *-aque* or *-hydrique. Pyridino-, pyridine,* and *-pyridique* (French) have all been used. Names for negative or acidic groups usually end in *o*- (*chloro-, nitro-, sulfato-*), but at the end of complex anion names salt endings (*chloride, nitrite, sulfate*) are sometimes used.

In the second place, the order in which the constituents are named varies. The same order of naming acid groups, neutral groups, and central atoms may be used for all types of complexes (as recommended in the 1940 Rules), or the order may vary depending on whether the compounds contain complex cations or complex anions or are non-electrolytes (as recommended in the Delépine reports of 1926 and 1928 (12, 21)).

In the third place, the components of the names of complexes may have special endings for complex cations and anions, or they may have none. Ordinarily, except in French, no endings are used for complex cations. Thus $[Cr(H_2O)_6]Cl_3$ is *hexaaquochromium(III) chloride*. For complex anions, however, the endings *-ite* and *-ate* are added to the central atom (*cobaltate*, *platinate*), or salt endings are used (*chloride*, *nitrite*). For complex acids, the endings *-ic* and *-hydric* are found and also, in German, no endings, whereas the 1940 Rules in English give, e.g., hydrogen hexachloroplatinate.

A further complication not even mentioned in the committee reports is introduced by stereoisomerism.

The isopoly and heteropoly acids and their salts present some of the same problems as the oxygen acids, chiefly with reference to the uses of the prefixes *ortho-* and *pyro-* and the numerical prefixes. The numerical prefix may indicate either the number of atoms of the significant elements or the number of molecules of anhydrides in the resolved formulas. For example, $Na_2B_4O_7$, incorrectly called *sodium pyroborate*, can be called *disodium tetraborate* (from the empirical formula) or *sodium diborate* (from the resolved formula, $Na_2O \cdot 2B_2O_3$). Another method of naming based on the resolved formulas makes use of Arabic numerals in parentheses to indicate the ratio of base anhydride to acid anhydride. By this system sodium tetraborate becomes *sodium (1:2) borate*.

These same problems are increased with heteropoly acids and salts by the presence of two or more significant elements. The question of order of naming constituents (*phosphomolybdate vs. molybdophosphate*) is added to the problem of indicating proportions of constituents. Because of their complexity and the lack of knowledge regarding their structure, heteropoly acids and their salts have proved about the toughest class of compounds to name systematically. Indeed, the international committees have never gone into this matter very thoroughly, though the latest reports give some discussion and examples.

Although a discussion of terms in connection with the newer concepts of acids, bases, and salts (50, 68) might be in place here, the decision of the German Nomenclature Commission (48) seems wise, namely, to limit its work to the problems of *nomenclature* and not to deal with definitions of terms, or to discuss "such questions as: how to define a base, or: in what way to differentiate between 'association' and 'polymerization'".

There still remain many miscellaneous groups of compounds and specific compounds that present interesting problems in nomenclature. A few of these seem worth brief consideration here. Compounds analogous to carbon compounds, with boron, germanium, silicon, etc., in place of part or all of the carbon, have been variously named, sometimes on the basis of this analogy (see table 6). The italicized names are used in *Chemical Abstracts* for the hydrides of germanium and silicon and for the derivatives of the boron and silicon hydrides. *Chemical Abstracts* practice is not meant to be the final word in nomenclature, but in indexing it is necessary to make a choice. The more rules that are generally agreed upon and are of reasonable ease of application, the simpler becomes the indexer's task. With metallic elements like germanium, lead, and tin, in accordance with a rule of the Commission on the Reform of the Nomenclature of

TABLE 6

Nomenclature of compounds analogous to carbon compounds

CARBON COMPOUNDS		BORON COMPOUNDS		GERMANIUM COMPOUNDS		SILICON COMPOUNDS	
Formula	Name	Formula	Name	Formula	Name	Formula	Name
CH_4	Methane	(BH_3 (BH_4	*Borine*) *Borane* Monoborane)	GeH_4	*Germane* Monogermane Germanomethane	SiH_4	*Silicane* Silane Silicomethane
C_2H_6	Ethane	B_2H_6	*Diborane* Boroethane	Ge_2H_6	*Digermane* Germanoethane	Si_2H_6	*Disilicoethane* Silicoethane Disilicane Disilane
C_3H_8	Propane	(B_3H_8	Triborane)	Ge_3H_8	*Trigermane* Germanopropane	Si_3H_8	*Trisilicopropane* Silicopropane Trisilicane Trisilane
C_4H_{10}	Butane	B_4H_{10}	*Dihydrotetraborane* Tetraborane Borobutane			Si_4H_{10}	*Tetrasilicobutane* Silicobutane Tetrasilicane Tetrasilane
$CHCl_3$	Chloroform			$GeHCl_3$	*Trichlorogermane* Germanium chloroform	$SiHCl_3$	*Trichlorosilicane* Trichlorosilane Trichlorosilicomethane Silicochloroform
CH_3OH	Methanol					SiH_3OH	*Silicol* Silicanol

C_2H_5OH	Ethyl alcohol	B_2H_5OH	Diboranol			$(SiH_3)_2O$	*Silicyl oxide* Disiloxane
$(CH_3)_2O$	Methyl ether						
HCHO	Formaldehyde					$(HSiHO)_x$	*Silicoformaldehyde* Prosiloxane
HCOOH	Formic acid			HGeOOH	*Germanoformic acid*	HSiOOH	*Silicoformic acid* Monosilanic acid
CH_3COOH	Acetic acid	$CH_3B(OH)_2$	*Methaneboronic acid* Methylboric acid Dihydroxymethylborine	CH_3GeOOH	*Methanegermanonic acid* Germanoacetic acid	CH_3SiOOH	*Methanesiliconic acid* Methylsiliconic acid Methylsilicic acid Silicoacetic acid
C_2H_5COOH	Propionic acid	$C_2H_5B(OH)_2$	*Ethaneboronic acid* Ethylboric acid	C_2H_5GeOOH	*Ethanegermanonic acid* Germanopropionic acid	C_2H_5SiOOH	*Ethanesiliconic acid* Ethylsilicic acid Silicopropionic acid Silicipropionic acid
C_6H_5COOH	Benzoic acid	$C_6H_5B(OH)_2$	*Benzeneboronic acid* Phenylboric acid Dihydroxyphenylborine Phenylboron dihydroxide	C_6H_5GeOOH	*Benzenegermanonic acid* Phenylgermanonic acid Germanibenzoic acid	C_6H_5SiOOH	*Benzenesiliconic acid* Silicobenzoic acid

TABLE 6—(*Concluded*)

CARBON COMPOUNDS		BORON COMPOUNDS		GERMANIUM COMPOUNDS		SILICON COMPOUNDS	
Formula	Name	Formula	Name	Formula	Name	Formula	Name
$Ca(CN)_2$.......	Calcium cyanide					$Ca(SiN)_2$......	*Calcium silicocyanide*
$CaCN_2$.........	Calcium cyanamide					$CaSiN_2$........	*Calcium silicocyanamide*

Organic Chemistry (31), names for organic derivatives are now based on the name of the element (e.g., *tetraethyllead*) instead of names of hydrides (*germane, plumbane, stannane*). Such compounds and also the compounds shown in the tables containing both carbon and boron, germanium, or silicon lie outside the province of this discussion.

The carbonyl and nitrosyl compounds, though belonging to the coördination compounds, are of special interest because the metal atom has an apparent valence of zero (see tables 7 and 8). Few names have even been proposed for these compounds.

Many other nitrogen compounds, because of their great variety, give rise to varied problems in naming. A general problem is how much to favor *ammono* names based on the analogy with the aquo system. The nitrogen compounds of phosphorus and sulfur will be discussed in a later paper.[3] Derivatives of hydrazine and hydroxylamine have been named in many ways. The acid HN_3 has been called *hydrazoic acid, hydronitric acid,* and *azoimide*, among other names, while its salts have usually been named as *azides* or *hydrazoates.*

TABLE 7

Nomenclature of iron carbonyl compounds

FORMULA	NAME	FORMULA	NAME
$Fe(CO)_3$	Tricarbonyl	$Fe(CO)_4H_2$	Iron carbonyl hydride Hydrogen iron carbonyl
$Fe(CO)_3(NH_3)_2$			
		$Fe(CO)_4Hg$	Mercury iron tetracarbonyl
$Fe(CO)_4$	Tetracarbonyl	$Fe(CO)_4Hg \cdot HgX_2$	
$[Fe(CO)_4]_3$	Dodecacarbonyl	$Fe(CO)_5 \cdot HgCl_2$	
$Fe_2(CO)_9$	Enneacarbonyl Nonacarbonyl	$[Fe(CO)_3X_2]_3$ $Fe(CO)_4X_2$ $Fe(CO)_5X_2$ $Fe_2(CO)_7X_4$	Carbonyl halide
$Fe(CO)_5$	Pentacarbonyl		
$Fe(CO)_5NH_3$		$M_3[Fe(CN)_5CO]$	

Examples of inconsistent, incorrect, ambiguous, or careless names could be multiplied indefinitely. Mellor's remark[4] about the hydrosulfurous–hyposulfurous acid situation perhaps could apply to the field of nomenclature in general: "The arguments in favor of hydrosulphurous or hyposulphurous as a name for the acid have different weights with persons of different temperaments." Atherton Seidell (24), from the eighty-four replies to an inquiry on the reform of nomenclature sent to chemists of various countries, concluded

---

[3] See L. F. Audrieth, R. Steinman, and A. D. F. Toy, "Nomenclature of the Nitrogen Compounds of Phosphorus and of Sulfur," Chem. Rev. **32**, 99 (1943).

[4] J. W. Mellor, *A Comprehensive Treatise on Inorganic and Theoretical Chemistry,* Volume X, p. 166. Longmans, Green and Company, London (1930).

that "efforts to improve the nomenclature of chemistry must be confined to new names and to the harmonizing of variations in usage which do not conflict with fundamental language differences." While there can probably never be complete agreement in matters as controversial as those of chemical nomenclature, much can be accomplished in that direction. Alternative names may be allowable in certain cases, sometimes to answer very definite purposes. Resort can of course always be had to formulas when they are known. Still the goal remains a workable standardized system of nomenclature.

TABLE 8

Nomenclature of iron nitrosyl compounds

FORMULA	NAME	FORMULA	NAME
$Fe(CO)_2(NO)_2$	Carbonyl nitrosyl Nitrosyl carbonyl Nitrosocarbonyl	FeX_2NO	
		$[NO][FeX_4]$	
		$Fe(NO)_2I$	
$Fe(NO)_4$	Tetranitrosyl	$M_2[Fe(CN)_5NO]$	Nitroprusside Nitrosocyanide
		$M_3[Fe(CN)_5NO]$	
		$M_2[(ON)_4Fe_2S_2]$	Roussin's red salt
		$M[(ON)_7Fe_4S_3]$	Roussin's black salt
		$[ONFeSO_4]$	
		$[4NOFe_2(SO_4)_3]$	
		$(ON)_2FeS_3$	
		$M_3[Fe(NO)_2(S_2O_3)_2]$	
		$M[Fe(NO)_2S_2O_3]$	Thiosulfatonitrosyl Nitrosyl thiosulfate

REFERENCES

(1) Stock, Alfred: Nomenclature in inorganic chemistry. Z. angew. Chem. **32**, I, 373–4 (1919); Chem. Abstracts **14**, 1941^7.

(2) Ohmann, O.: The value of the Stock nomenclature for chemistry teaching, with remarks on the symbols for the elements. Z. angew. Chem. **33**, I, 326–7 (1920); Chem. Abstracts **15**, 1095^2.

(3) Rosenheim, Arthur: Some questions of nomenclature in inorganic chemistry. Z. angew. Chem. **33**, Aufsatzteil, 78–9 (1920); Chem. Abstracts **15**, 2799^6.

(4) Stock, Alfred: Some questions of nomenclature in inorganic chemistry. Z. angew. Chem. **33**, Aufsatzteil, 79–80 (1920); Chem. Abstracts **15**, 2799^6.

(5) Ohmann, O.: Suggestions for chemical nomenclature. Z. physik. chem. Unterricht **33**, 41–6 (1920); Chem. Abstracts **14**, 3549^7.

(6) Salamon, M. S.: The plea for standardization. Analyst **49**, 169–75 (1924); Chem. Abstracts **18**, 1958^7.

(7) Delépine, M., *et al.*: La réforme de la nomenclature de chimie minérale. Rapport présenté au nom de la Fédération nationale des associations de chimie de France et du Comité national de nomenclature de chimie minérale. Separate. 5 pp.

(8) Meyer, R. J., and Rosenheim, A.: Proposals of the German Nomenclature Committee for Inorganic Chemistry. Z. angew. Chem. **38**, 713–15 (1925); Chem.

Abstracts **20,** 1038^6; Chem. Weekblad **23,** 93–6 (1926) (in German); Naturwissenschaften **14,** 269 (1926).

(9) Delépine, M.: Réunion des 6 et 7 Octobre 1925 [de la Commission de réforme de la nomenclature de chimie minérale]. Chem. Weekblad **23,** 96–8 (1926) (in French).

(10) Greenaway, John: Chem. Weekblad **23,** 98–9 (1926) (in English).

(11) Patterson, A. M.: Meetings of the international nomenclature committees, Paris, October, 1925. Ind. Eng. Chem. **18,** 320–1 (1926); Chem. Abstracts **20,** 1153^8.

(12) Delépine, Marcel: [Report of the Committee for the] Reform of the Nomenclature of Inorganic Chemistry. Chem. Weekblad **23,** 86–93 (1926) (in English); Bull. soc. chim. **43,** 289–300 (1928); Chem. Abstracts **22,** 2117^8; Chimie & industrie **20,** 603–9 (1928); Chem. Abstracts **23,** 350^2.

(13) Crane, E. J.: Report of the Commitee on Nomenclature in Inorganic Chemistry, Washington Meeting, September, 1926. Chem. Weekblad **23,** 486–7 (1926) (in English).

(14) Patterson, A. M.: The history of the word "alum." Ind. Eng. Chem. **18,** 634–5 (1926); Chem. Abstracts **20,** 2434^3.

(15) Jorissen, W. P.: 8ste Conferentie van de Union internationale de la Chimie pure et appliquée. Comité de travail de réforme de la nomenclature de chimie inorganique. Chem. Weekblad **24,** 542 (1927) (in French).

(16) Smith, J. D. M.: Valency terminology. Chemistry & Industry **46,** 188–90 (1927); Chem. Abstracts **21,** 1209^3.

(17) Sabatini, Angel: A suggestion as to the nomenclature and method of writing inorganic compounds. Rev. centro estud. farm. bioquim. **16,** 449–52 (1927); Chem. Abstracts **23,** 3867^5.

(18) Richardson, W. D.: The current significance of the word alum. Chicago: The Commonwealth Press. 93 pp. $1.00.

(19) Anon.: The nomenclature of inorganic compounds [review of report of International Union of Pure and Applied Chemistry]. Ann. chim. applicata **18,** 557–65 (1928); Chem. Abstracts **23,** 1833^1; Gazz. chim. ital. **58,** 883–91 (1928); Chem. Abstracts **23,** 3177^9.

(20) Dobbin, Leonard: Ortho, meta, para. I. History of the introduction of the prefixes into chemical nomenclature. Chemist and Druggist **109,** 643 (1928); Chem. Abstracts **23,** 4854^4.

(21) Jorissen, W. P.: Commission de réforme de la nomenclature de chimie minérale. Rapport de M. Marcel Delépine. Rec. trav. chim. **48,** 652–63 (1929).

(22) Sementsov, A.: Rational nomenclature of chemical compounds. Ukraïn. Khem. Zhur. **3,** No. 1, Sci. Pt. 39–45 (1928); Chem. Abstracts **23,** 5069^9.

(23) Ostrogovich, A.: Observations and new proposals regarding the rules of the official nomenclature for inorganic compounds. Bul. soc. stiinte Cluj **5,** 108–52 (1929); Chem. Abstracts **24,** 1589^8.

(24) Seidell, Atherton: Limitations upon the unification of chemical nomenclature. J. Chem. Education **6,** 720–9 (1929); Chem. Abstracts **23,** 3608^1.

(25) Sementsov, A.: Reform of chemical nomenclature in the U. S. S. R. J. Russ. Phys.-Chem. Soc. **61,** No. 3, Annexe 53–5 (1929); Chem. Abstracts **24,** 274^5.

(26) Fritzman, E. Kh.: The chemical nomenclature of inorganic compounds. J. Russ. Phys.-Chem. Soc. **61,** Appendix, 1–44 (1929); Chem. Abstracts **24,** 306^1.

(27) Bork, A. Kh.: Nomenclature of inorganic compounds. J. Russ. Phys.-Chem. Soc. **61,** Appendix, 45–52 (1929); Chem. Abstracts **24,** 306^2.

(28) Meyer, R. J.: The nomenclature of inorganic chemistry. Z. angew. Chem. **42,** 1059–62 (1929); Chem. Abstracts **24,** 560^4.

(29) Crane, E. J.: The standardization of chemical nomenclature. J. Chem. Education **8,** 1335–40 (1931); Chem. Abstracts **25,** 4158^3.

(30) Marcengo, Anna M.: Nozioni elementari di nomenclatura chimica inorganica. Milan: Libreria editrice politecnica. L. 6.

(31) Patterson, Austin M.: Definitive report of the Commission on the Reform of the Nomenclature of Organic Chemistry. J. Am. Chem. Soc. **55**, 3905–25 (1933).

(32) Urey, Harold C., Murphy, G. M., and Brickwedde, F. G.: A name and symbol for H^2. J. Chem. Phys. **1**, 512–13 (1933); Chem. Abstracts **27**, 4476^4.

(33) Rutherford, Lord: Heavy hydrogen. Nature **132**, 955–6 (1933).

(34) Perovskiĭ, P.: Chemical nomenclature of inorganic elements and compounds. Uspekhi Khim. **2**, 249–56 (1933); Chem. Abstracts **27**, 5224^8.

(35) Shilov, E. A.: The reform of Russian chemical nomenclature. Uspekhi Khim. **2**, 760–3 (1933); Chem. Abstracts **28**, 2228^6.

(36) Bork, A. Kh.: Some explanations of the "Plan of the resolution of the VIth Mendelyeev Congress on the problem of the reform of the Russian nomenclature of inorganic compounds." Uspekhi Khim. **2**, 763–8 (1933); Chem. Abstracts **28**, 4279^4.

(37) Spalding, Lyman: A new nomenclature of chemistry proposed by Messrs. de Morveau, Lavoisier, Berthollet, and Fourcroy. Baltimore: American Pharmaceutical Association. $1.00.

(38) Stock, Alfred: Valence notation in inorganic chemistry. Angew. Chem. **47**, 568 (1934); Chem. Abstracts **28**, 6379^7.

(39) Crane, E. J.: The pronunciation of chemical words. A report of the Nomenclature, Spelling, and Pronunciation Committee of the American Chemical Society. Ind. Eng. Chem., News Ed. **12**, 202–5 (1934); Chem. Abstracts **28**, 3947^8. Reprints can be obtained from E. J. Crane, The Ohio State University, Columbus, Ohio, at 5¢ each.

(40) Urey, Harold C., Brickwedde, F. G., and Murphy, G. M.: Designation of heavy hydrogen. Nature **133**, 173 (1934).

(41) Harkins, Wm. D.: Nomenclature for the isotopes of hydrogen (proto- and deutohydrogen) and their compounds. Science **79**, 138–40 (1934).

(42) Ficklen, J. B.: Isotopic nomenclature. Science **79**, 140 (1934).

(43) Boughton, Willis A.: Naming hydrogen isotopes. Science **79**, 159–60 (1934).

(44) Mulliken, Robert S.: Symbols and names for the hydrogen isotopes. Science **79**, 228–9 (1934).

(45) Anon.: Terminology of isotopes. Science **79**, 505 (1934).

(46) Crane, E. J.: Nomenclature of the hydrogen isotopes and their compounds. Science **80**, 86–9 (1934); Chem. Abstracts **28**, 5754^2.

(47) Crane, E. J.: Report of Committee on Nomenclature, Spelling, and Pronunciation. Nomenclature of the hydrogen isotopes and their compounds. Ind. Eng. Chem., News Ed. **13**, 200–1 (1935); Chem. Abstracts **29**, 4661^7.

(48) Meyer, R. J.: Report on the nomenclature of inorganic compounds. Chem. Weekblad **33**, 722–9 (1936) (in English); Helv. Chim. Acta **20**, 159–75 (1937); Chem. Abstracts **31**, 2054^7.

(49) Delépine, M., Fichter, Fr., and Rémy, Heinrich: Remarks of the Commission on the Reform of the Nomenclature of Inorganic Chemistry. Chem. Weekblad **33**, 729–30 (1936) (in French); Chem. Abstracts **31**, 2055^1.

(50) Sherk, Kenneth W.: Comments on the new nomenclature for acids, bases and salts. J. Chem. Education **13**, 358–61 (1936); Chem. Abstracts **30**, 6247^8.

(51) Smith, Clarence: Modern chemical nomenclature. J. Chem. Soc. **1936**, 1067–78; Chem. Abstracts **30**, 6247^9.

(52) Rapin, G.: Evolution of chemical nomenclature. La nature **1936**, 225–9; Chem. Abstracts **30**, 4367^1.

(53) Anon.: Rules [drawn up by H. Rémy in collaboration with the Deutsche chemische Gesellschaft] for naming inorganic compounds. Committee for the Reform of Inorganic Chemical Nomenclature. International Union of Chemistry. Separate (in German, English, French, and Italian). 64 pp.

(54) Škramovský, St.: Terminology of compounded salts. Chem. Listy **31**, 478–80 (1937); Chem. Abstracts **32**, 4396^6.

(55) Zelinskiĭ, N. D., *et al.*: Proposed reform of the nomenclature of inorganic compounds. J. Applied Chem. (U. S. S. R.) **10,** 1149–54 (1937); Chem. Abstracts **32,** 1595^4.

(56) Anon.: A project for the reform of the nomenclature of inorganic compounds. J. Gen. Chem. (U. S. S. R.) **7,** 1707-12 (1937); Chem. Abstracts **31,** 8411^3.

(57) Guimarães, Paulo Fonseca: Inorganic chemical nomenclature. Rev. brasil. chim. (São Paulo) **4,** 264–8 (1937); Chem. Abstracts **32,** 69^9.

(58) Sementsov, B.: Rationalization of international chemical nomenclature. Uspekhi Khim. **6,** 924–6 (1937); Chem. Abstracts **32,** 404^2.

(59) Luchinskiĭ, G. P.: The systematic classification and nomenclature of anhydrous halogen compounds. Uspekhi Khim. **6,** 1251-4 (1937); Chem. Abstracts **33,** 9176^1.

(60) Karpova, L. Ya.: Reform of the nomenclature of inorganic compounds. Uspekhi Khim. **6,** 1732-3 (1937); Chem. Abstracts **34,** 4351^9.

(61) Bork, A. Kh.: The chemical nomenclature of inorganic compounds. Uspekhi Khim. **7,** 605–14 (1937); Chem. Abstracts **31,** 7779^4.

(62) Zelinskiĭ, N. D., *et al.*: Project for the reform of the nomenclature of inorganic compounds. Uspekhi Khim. **7,** 615–21 (1937); Chem. Abstracts **31,** 7779^5.

(63) Jorissen, W. P., Bassett, H., Damiens, A., Fichter, F., and Rémy, H.: Committee for the Reform of Inorganic Chemical Nomenclature. Minutes of the meetings held in Berlin by invitation of the Deutsche chemische Gesellschaft, January 28th and 29th, 1938. International Union of Chemistry. Separate (in German, English, French, and Italian). 12 pp.

(64) Hammer, A. J.: Inorganic chemical nomenclature. Collected reprints of a series of articles in *The Iowa Science Teacher.* Cedar Falls, Iowa: Woolverton Printing Co., 1938. $0.50. 36 pp.

(65) Ormont, B.: Some further corrections to the modern theory and nomenclature of complex compounds. Acta Physicochim. U. R. S. S. **9,** 885–904 (1938) (in German); J. Phys. Chem. (U. S. S. R.) **12,** 23–33 (1938); Chem. Abstracts **33,** 7688^8.

(66) Richter, A. F.: The nomenclature of coördination compounds. Chem. Listy **32,** 115–17 (1938); Chem. Abstracts **32,** 5269^3.

(67) Škramovský, St.: The nomenclature of coördination compounds. Chem. Listy **32,** 117 (1938); Chem. Abstracts **32,** 5269^3.

(68) Alyea, Hubert N., *et al.*: A simplified nomenclature for the proton-transfer concept of acids. J. Chem. Education **16,** 535–8 (1939); Chem. Abstracts **34,** 917^1.

(69) Butkevich, A.: Attempt to solve some problems of nomenclature. Uspekhi Khim. **8,** 593–603 (1939); Chem. Abstracts **34,** 1216^4.

(70) Jorissen, W. P., Bassett, H., Damiens, A., Fichter, F., and Rémy, H.: Rules for naming inorganic compounds. Report of the Committee for the Reform of Inorganic Chemical Nomenclature, 1940. Analyst **65,** 509–11 (1940); Ber. **73A,** 53–70 (1940); Chem. Abstracts **34,** 5363^2; J. Chem. Soc. **1940,** 1404–15; J. Am. Chem. Soc. **63,** 889–97 (1941). Reprints of the last article can be obtained from E. J. Crane, The Ohio State University, Columbus, Ohio, at 10¢ each.