

International Union of Pure and Applied Chemistry

# Nomenclature of Inorganic Chemistry

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### IR-9.3.2.2 *Choosing between closely related geometries*

For real molecules or ions, the stereochemical descriptor should be based on the nearest idealized geometry. However, some idealized geometries are closely related [*e.g.* square planar (*SP*-4), four-coordinate square pyramidal (*SPY*-4), see-saw (*SS*-4), and tetrahedral (*T*-4); T-shaped (*TS*-3), trigonal planar (*TP*-3), and trigonal pyramidal (*TPY*-3)] and care may therefore be required in making the choice.

The following approach is useful in determining the polyhedral symbol for four-coordinate structures. The key is to consider the locations of the central atom and the coordinating atoms in relation to each other. If all five atoms are in (or are close to being in) the same plane, then the molecule should be treated as square planar. If the four coordinating atoms are in a plane, but the central atom is significantly displaced from the plane, then the square pyramidal geometry is appropriate. If the four coordinating atoms do not lie in (or close to) a plane, then a polyhedron can be defined by joining all four coordinating atoms together with lines. If the central atom lies inside this polyhedron the molecule should be regarded as tetrahedral, otherwise, it should be regarded as having a see-saw structure.

T-shaped and trigonal planar molecules both have a central atom that lies in (or close to) the plane defined by the coordinating atoms. They differ in that the angles between the three coordinating atoms are approximately the same in the trigonal planar structure, while one angle is much larger than the other two in a T-shaped molecule. The central atom lies significantly out of the plane in a trigonal pyramidal structure.

## IR-9.3.3 **Describing configuration – distinguishing between diastereoisomers**

### IR-9.3.3.1 *General*

The placement of ligands around the central atom must be described in order to identify a particular diastereoisomer. There are a number of common terms (*e.g.* *cis*, *trans*, *mer* and *fac*) used to describe the relative locations of ligands in simple systems. However, they can be used only when a particular geometry is present (*e.g.* octahedral or square planar), and when there are only two kinds of donor atom present (*e.g.*  $\text{Ma}_2\text{b}_2$  in a square planar complex, where M is a central atom and 'a' and 'b' are types of donor atom).

Several methods have been used to distinguish between diastereoisomers in more complex systems. Thus, stereoisomers resulting from the coordination of linear tetradentate ligands have often been identified as *trans*, *cis*- $\alpha$ , or *cis*- $\beta$ ,<sup>10</sup> and those resulting from coordination of macrocyclic tetradentate ligands have their own system.<sup>11</sup> The scope of most of these nomenclatures is generally quite limited, but a proposal with wider application in the description of complexes of polydentate ligands has been made more recently.<sup>12</sup>

Clearly a general method is required in order to distinguish between diastereoisomers of compounds in which either other geometries or more than two kinds of donor atoms are present. The *configuration index* has been developed for this purpose. The next section outlines the method by which a configuration index is obtained for a compound, and the

following sections give details for particular geometries. Commonly used terms are included for each geometry discussed.

#### IR-9.3.3.2 *Configuration index*

Once the coordination geometry has been specified by the polyhedral symbol, it becomes necessary to identify which ligands (or donor atoms) occupy particular coordination positions. This is achieved through the use of the configuration index which is a series of digits identifying the positions of the ligating atoms on the vertices of the coordination polyhedron. The configuration index has the property that it distinguishes between diastereoisomers. It appears within the parentheses enclosing the polyhedral symbol (see Section IR-9.3.2.1), following that symbol and separated from it by a hyphen.

Each donor atom must be assigned a priority number based on the rules developed by Cahn, Ingold and Prelog (the CIP rules).<sup>13</sup> These priority numbers are then used to form the configuration index for the compound. The application of the CIP rules to coordination compounds is discussed in detail in Section IR-9.3.5 but, in general, donor atoms that have a higher atomic number have higher priority than those that have a lower atomic number.

The presence of polydentate ligands may require the use of primes on some of the numbers in the configuration index. The primes are used to indicate either that donor atoms are not part of the same polydentate ligand as those that have unprimed priority numbers, or that the donor atoms belong to different parts of a polydentate ligand that are related by symmetry. A primed priority number means that that donor atom has lower priority than the same kind of donor atom without a prime on the priority number. More detail on the 'priming convention' can be found in Section IR-9.3.5.3.

#### IR-9.3.3.3 *Square planar coordination systems (SP-4)*

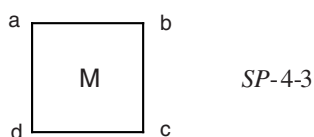
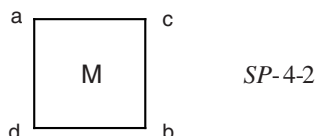
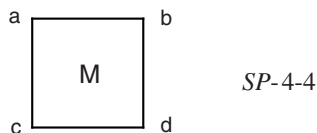
The terms *cis* and *trans* are used commonly as prefixes to distinguish between stereoisomers in square planar systems of the form  $[Ma_2b_2]$ , where M is the central atom, and 'a' and 'b' are different types of donor atom. Similar donor atoms occupy coordination sites adjacent to one another in the *cis* isomer, and opposite to one another in the *trans* isomer. The *cis-trans* terminology is not adequate to distinguish between the three isomers of a square planar coordination entity  $[Mabcd]$ , but could be used, in principle, for an  $[Ma_2bc]$  system (where the terms *cis* and *trans* would refer to the relative locations of the similar donor atoms). This latter use is not recommended.

The configuration index for a square planar system is placed after the polyhedral symbol (SP-4). It is the single digit which is the priority number for the ligating atom *trans* to the ligating atom of priority number 1, *i.e.* the priority number of the ligating atom *trans* to the most preferred ligating atom.

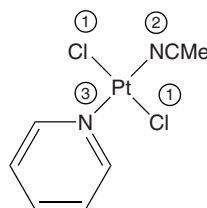
Examples:

1. Priority sequence:  $a > b > c > d$

Priority number sequence:  $1 < 2 < 3 < 4$



2.

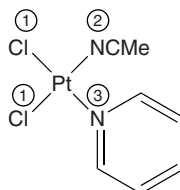


(SP-4-1)-(acetonitrile)dichlorido(pyridine)platinum(II)

If there are two possibilities, as in Example 3, the configuration index is the priority number with the higher numerical value. Both the priority 2 ligand (acetonitrile) and the priority 3 ligand (pyridine) are *trans* to a priority 1 ligand (chloride). The higher numerical value (3) is chosen for the configuration index. This choice is sometimes referred to as having been made according to the principle of *trans* maximum difference, *i.e.* that the difference between the numerical values of the priority numbers of the ligands should be as large as possible.

Example:

3.



(SP-4-3)-(acetonitrile)dichlorido(pyridine)platinum(II)

## IR-9.3.3.4 Octahedral coordination systems (OC-6)

The terms *cis* and *trans* are used commonly as prefixes to distinguish between stereoisomers in octahedral systems of the form  $[\text{Ma}_2\text{b}_4]$ , where M is the central atom, and 'a' and 'b' are different types of donor atom, and in certain similar systems. The 'a' donors occupy adjacent coordination sites in the *cis* isomer, and opposite coordination sites in the *trans* isomer (Example 1).

The terms *mer* (meridional) and *fac* (facial) are used commonly to distinguish between stereoisomers of complexes of the form  $[\text{Ma}_3\text{b}_3]$ . In the *mer* isomer (Example 2) the two groups of three similar donors each lie on a meridian of the coordination octahedron, in planes that also contain the central atom. In the *fac* isomer (Example 3) the two groups of three similar donors each occupy coordination sites on the corners of a face of the coordination octahedron.

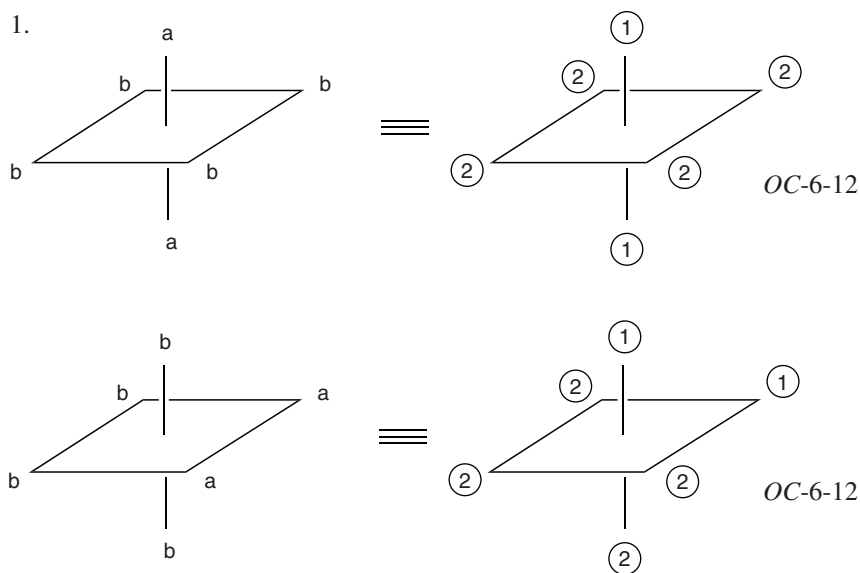
The configuration index of an octahedral system follows the polyhedral symbol (OC-6) and consists of two digits.

The first digit is the priority number of the ligating atom *trans* to the ligating atom of priority number 1, *i.e.* the priority number of the ligating atom *trans* to the most preferred ligating atom. If there is more than one ligating atom of priority 1, then the first digit is the priority number of the *trans* ligand with the highest numerical value (remembering that a primed number will be of higher numerical value than the corresponding unprimed number).

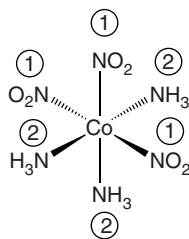
These two ligating atoms, the priority 1 atom and the (lowest priority) atom *trans* to it, define the *reference axis* of the octahedron.

The second digit of the configuration index is the priority number of the ligating atom *trans* to the most preferred ligating atom in the plane that is perpendicular to the reference axis. If there is more than one such ligating atom in that plane, the priority number of the *trans* atom having the largest numerical value is selected.

Examples:

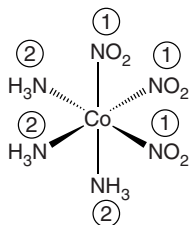


2.



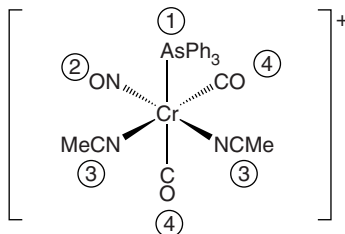
*mer*-[Co(NH<sub>3</sub>)<sub>3</sub>(NO<sub>2</sub>)<sub>3</sub>]  
(OC-6-21)-triamminetrinitrito- $\kappa^3N$ -cobalt(III)

3.



*fac*-[Co(NH<sub>3</sub>)<sub>3</sub>(NO<sub>2</sub>)<sub>3</sub>]  
(OC-6-22)-triamminetrinitrito- $\kappa^3N$ -cobalt(III)

4.



(OC-6-43)-bis(acetonitrile)dicarbonylnitrosyl(triphenylarsane)chromium(1+)

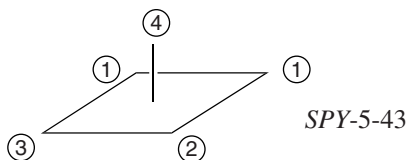
#### IR-9.3.3.5 Square pyramidal coordination systems (SPY-4, SPY-5)

The configuration index of an *SPY-5* system consists of two digits. The first digit is the priority number of the ligating atom on the  $C_4$  symmetry axis (the reference axis) of the idealized pyramid. The second digit is the priority number of the ligating atom *trans* to the ligating atom with the lowest priority number in the plane perpendicular to the  $C_4$  symmetry axis. If there is more than one such atom in the perpendicular plane, then the second digit is chosen to have the highest numerical value.

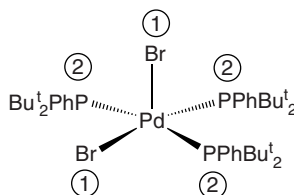
The configuration index of an *SPY-4* system is a single digit that is chosen in the same way as the second digit of *SPY-5* systems. The configuration index of a four-coordinate square pyramidal system will therefore be the same as that for the square planar structure that would result from the ligands and the central atom being coplanar. The difference between the structures is described by the polyhedral symbol rather than by the configuration index.

Examples:

1.



2.



(SPY-5-12)-dibromidotris[di-*tert*-butyl(phenyl)phosphane]palladium

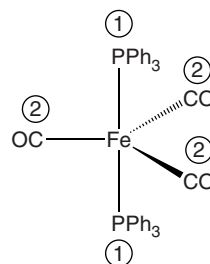
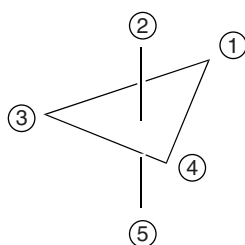
#### IR-9.3.3.6 Bipyramidal coordination systems (TBPY-5, PBPY-7, HBPY-8 and HBPY-9)

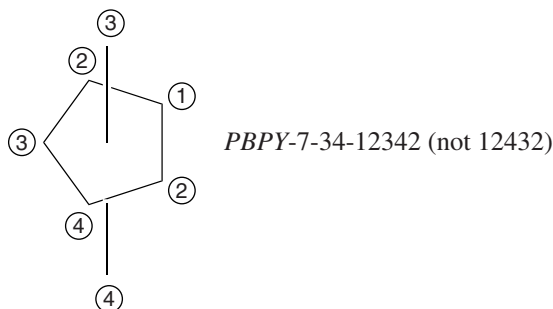
The configuration index for bipyramidal coordination systems follows the appropriate polyhedral symbol, and consists of two segments separated by a hyphen, except for the trigonal bipyramid where the second segment is not required and is therefore omitted. The first segment has two digits which are the priority numbers of the ligating atoms on the highest order rotational symmetry axis, the reference axis. The lower number is cited first.

The second segment consists of the priority numbers of the ligating atoms in the plane perpendicular to the reference axis. The first digit is the priority number for the preferred ligating atom, *i.e.* the lowest priority number in the plane. The remaining priority numbers are cited in sequential order proceeding around the projection of the structure either clockwise or anticlockwise, in whichever direction gives the lower numerical sequence. The lowest numerical sequence is that having the lower number at the first point of difference when the numbers are compared digit by digit from one end to the other.

Examples:

1. Trigonal bipyramid (TBPY-5)



2. Pentagonal bipyramid (*PBPY*-7)IR-9.3.3.7 *T-shaped systems (TS-3)*

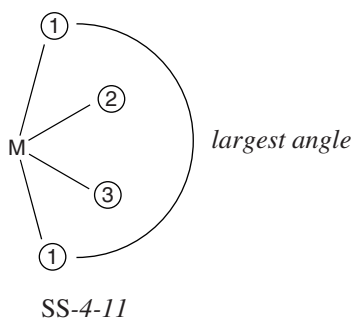
The configuration index for T-shaped systems follows the polyhedral symbol and consists of a single digit, the priority number of the ligating atom on the stem of the T (as opposed to the crosspiece of the T).

IR-9.3.3.8 *See-saw systems (SS-4)*

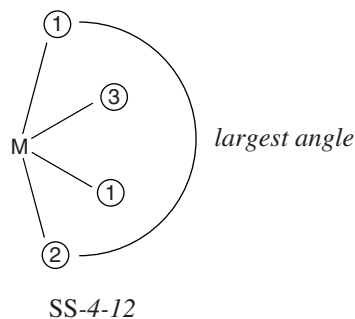
The configuration index for see-saw systems consists of two digits, the priority numbers of the two ligating atoms separated by the largest angle. The number of lower numerical value is cited first.

*Examples:*

1.



2.



## IR-9.3.4

**Describing absolute configuration – distinguishing between enantiomers**

## IR-9.3.4.1

*General*

There are two well-established, but fundamentally different, systems for distinguishing between two enantiomers (stereoisomers that are mirror images of one another). The first, based on the chemical constitution of the compound, involves the *R/S* convention used for describing tetrahedral centres and the closely related *C/A* convention used for other polyhedra. The *R/S* and *C/A* conventions use the priority sequence referred to in Section IR-9.3.3.2, and detailed in Section IR-9.3.5, where the ligating atoms are assigned a priority number based (usually) on their atomic number and their substituents.

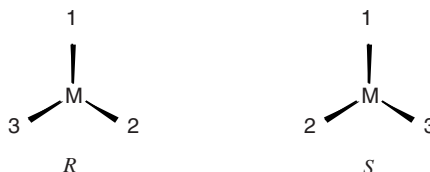
The second is based on the geometry of the molecule and makes use of the skew-lines convention; it is usually applied only to octahedral complexes. The two enantiomers are identified by the symbols  $\Delta$  and  $\Lambda$  in this system. The *C/A* nomenclature is not required for those chelate complexes where the skew-lines convention is completely unambiguous (see Sections IR-9.3.4.11 to 9.3.4.14).



IR-9.3.4.2 *The R/S convention for tetrahedral centres*

The convention used to describe the absolute configurations of tetrahedral centres was originally developed for carbon atom centres (see Ref. 13 and Section P-91 of Ref. 1) but can be used for any tetrahedral centre. There is no need to alter the rules in treating tetrahedral metal complexes.

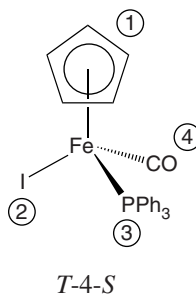
The symbol *R* is assigned if the cyclic sequence of priority numbers, proceeding from highest priority, is clockwise when the viewer is looking down the vector from the tetrahedral centre to the least preferred substituent (the substituent having the priority number with the highest numerical value, *i.e.* 4). An anticlockwise cyclic sequence is assigned the symbol *S*.



This system is most often used in conjunction with configuration internally in ligands but can be applied equally well to tetrahedral metal centres. It has also been useful for pseudotetrahedral organometallic complexes when, for example, cyclopentadienyl ligands are treated as if they were monodentate ligands of high priority.

*Example:*

1.

IR-9.3.4.3 *The R/S convention for trigonal pyramidal centres*

Molecules containing a trigonal pyramidal centre (TPY-3) may exist as a pair of stereoisomers. The configuration of this centre can be described in a similar way to that of a tetrahedral centre. This is achieved through notional placement of a 'phantom atom' of low priority in the coordination site that would create a tetrahedral centre from a trigonal pyramidal centre. The centre can then be identified as *R* or *S* by the methods described above.

The use of some bonding theories leads to the placement of a lone pair on a trigonal pyramidal centre. If this is done, the absolute configuration of the centre is also described by the *R/S* convention, in this case by placing the 'phantom atom' in the site that is occupied by the lone pair. Examples of this practice may be found in the description of absolute configurations for sulfoxides in which the alkyl substituents are different.

#### IR-9.3.4.4 *The C/A convention for other polyhedral centres*

The *R/S* convention makes use of priority numbers for the determination of chirality at tetrahedral centres, as detailed above. The same principles are readily extendable to geometries other than tetrahedral.<sup>14</sup> However, in order to avoid confusion, and to emphasize the unique aspects of the priority sequence systems as applied to coordination polyhedra, the symbols *R* and *S* are replaced by the symbols *C* and *A* when applied to other polyhedra.

The procedure for arriving at ligating atom priorities is detailed in Section IR-9.3.5. Once these priorities have been assigned, the reference axis (and direction) appropriate to the geometry is identified. The priority numbers of the ligating atoms coordinated in the plane perpendicular to the reference axis are then considered, viewing from the axial ligating atom of higher priority.

Beginning with the highest priority atom in the plane perpendicular to the reference axis, the clockwise and anticlockwise sequences of priority numbers are compared, and that with the lower number at the first point of difference is chosen. If the chosen sequence results from a clockwise reading of the priority numbers, then the structure is given the chirality symbol *C*, otherwise it is given the symbol *A*.

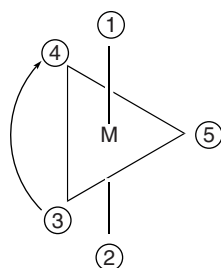
#### IR-9.3.4.5 *The C/A convention for trigonal bipyramidal centres*

The procedure is similar to that used for tetrahedral systems in the *R/S* convention, but it is modified because of the presence of a unique reference axis (running through the two axial donor atoms and the central atom).

The structure is oriented so that the viewer looks down the reference axis, with the more preferred donor atom (having a priority number with lower numerical value) closer to the viewer. Accordingly, the axial donor atom with the lower priority lies beyond the central atom. Using this orientation, the priority sequence of the three ligating atoms in the trigonal plane is examined. If the sequence proceeds from the highest priority to the lowest priority in a clockwise fashion, the chirality symbol *C* is assigned. Conversely, if the sequence from highest to lowest priority (from lowest numerical index to highest numerical index) is anticlockwise, the symbol *A* is assigned.

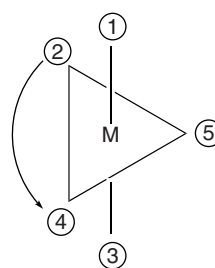
*Examples:*

1.



Chirality symbol = *C*

2.



Chirality symbol = *A*

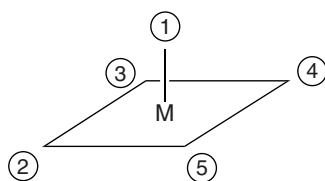
IR-9.3.4.6 *The C/A convention for square pyramidal centres*

A procedure similar to that described in Section IR-9.3.4.4 is used for square pyramidal structures. In the case of *SPY-5* systems, the polyhedron is oriented so that the viewer looks along the formal  $C_4$  axis, from the axial ligand toward the central atom. The priority numbers of the ligating atoms in the perpendicular plane are then considered, beginning with the highest priority atom (the one having the priority number of lowest numerical value). The clockwise and anticlockwise sequences of priority numbers are compared, and the structure is assigned the symbol *C* or *A* according to whether the clockwise (*C*) or anticlockwise (*A*) sequence is lower at the first point of difference.

The chirality of an *SPY-4* system is defined in a similar way. In this case, the viewer looks along the formal  $C_4$  axis in such a way that the ligands are further away than the central atom. The priority numbers are then used to assign the symbol *C* or *A*, as for the *SPY-5* system.

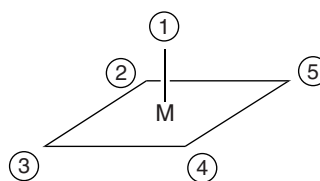
Examples:

1.



Chirality symbol = *C*

2.



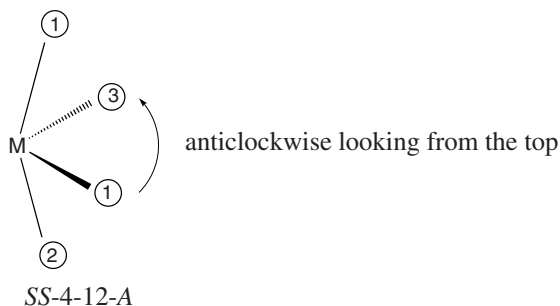
Chirality symbol = *A*

IR-9.3.4.7 *The C/A convention for see-saw centres*

The absolute configurations of see-saw complexes can be described using the *C/A* system. The configuration index for see-saw systems consists of two digits, the priority numbers of the two ligands separated by the largest angle. The higher priority ligand of these two is identified and used as a point from which to view the two ligands not involved in the configuration index. If moving from the higher priority ligand to the lower (through the smaller angle) entails making a clockwise motion, the absolute configuration is assigned *C*. An anticlockwise direction results in the absolute configuration *A*.

Example:

1.

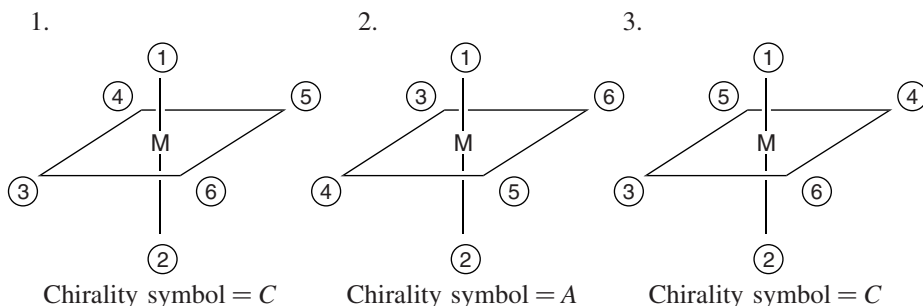


IR-9.3.4.8 *The C/A convention for octahedral centres*

The absolute configurations of some octahedral complexes can be described using either the skew-line reference system (Section IR-9.3.4.11) or the *C/A* system. The first is used more commonly, but the *C/A* system is more general and may be used for most complexes. The skew-line reference system is only applicable to tris(bidentate), bis(bidentate) and closely related systems.

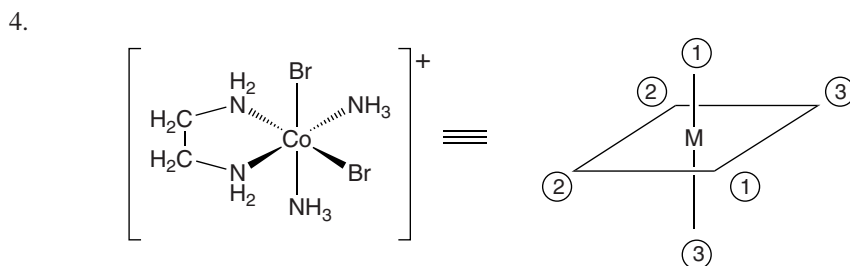
The reference axis for an octahedral centre is that axis containing the ligating atom of CIP priority 1 and the *trans* ligating atom of lowest possible priority (highest numerical value) (see Section IR-9.3.3.4). The atoms in the coordination plane perpendicular to the reference axis are viewed from the ligating atom having that highest priority (CIP priority 1) and the clockwise and anticlockwise sequences of priority numbers are compared. The structure is assigned the symbol *C* or *A*, according to whether the clockwise (*C*) or anticlockwise (*A*) sequence is lower at the first point of difference.

Examples:



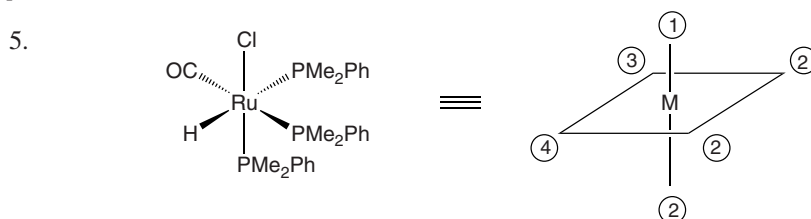
Example 4 shows the compound  $[\text{CoBr}_2(\text{en})(\text{NH}_3)_2]^+$  which has the polyhedral symbol *OC*-6 and the configuration index 32. The chirality symbol is *C*.

Example:



Example 5 shows the complex  $[\text{Ru}(\text{CO})\text{ClH}(\text{PMe}_2\text{Ph})_3]$  which has the descriptor *OC*-6-24-*A*. The chloride ligand has priority 1.

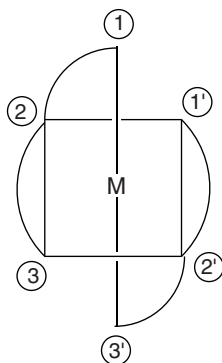
Example:



The *C/A* assignment for polydentate ligands is illustrated by Example 6 which uses the priming convention developed in Section IR-9.3.5. Note that priority number 2 has higher priority than 2'.

*Example:*

6.



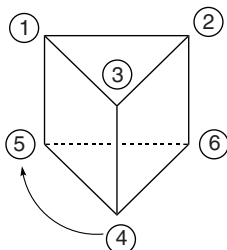
Chirality symbol = A

#### IR-9.3.4.9 *The C/A convention for trigonal prismatic centres*

For the trigonal prismatic system, the configuration index is derived from the CIP priority numbers of the ligating atoms opposite the triangular face containing the greater number of ligating atoms of highest CIP priority. The chirality symbol is assigned by viewing the trigonal prism from above the preferred triangular face and noting the direction of progression of the priority sequence for the less preferred triangular face.

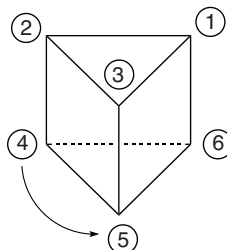
*Examples:*

1.



Chirality symbol = C

2.

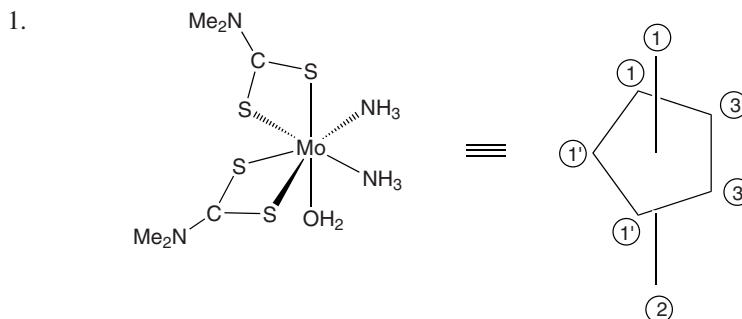


Chirality symbol = A

#### IR-9.3.4.10 *The C/A convention for other bipyramidal centres*

The procedure used for the trigonal bipyramid is appropriate for other bipyramidal structures. The structure is assigned the symbol *C* or *A*, according to whether the clockwise (*C*) or anticlockwise (*A*) sequence is lower at the first point of difference when the numbers are compared digit by digit from one end to the other (see Sections IR-9.3.4.5 and IR-9.3.4.6) and the molecule is viewed from the higher priority ligating atom on the reference axis.

Example:



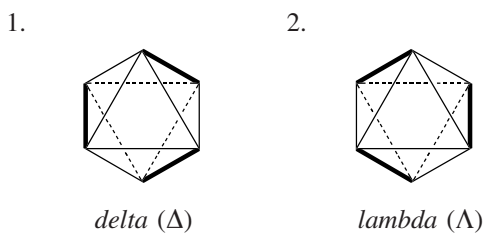
PBPY-7-12-11'1'33-A

#### IR-9.3.4.11 The skew-lines convention

Tris(bidentate) complexes constitute a general family for which a useful, unambiguous convention has been developed based on the orientation of skew lines which define a helix.

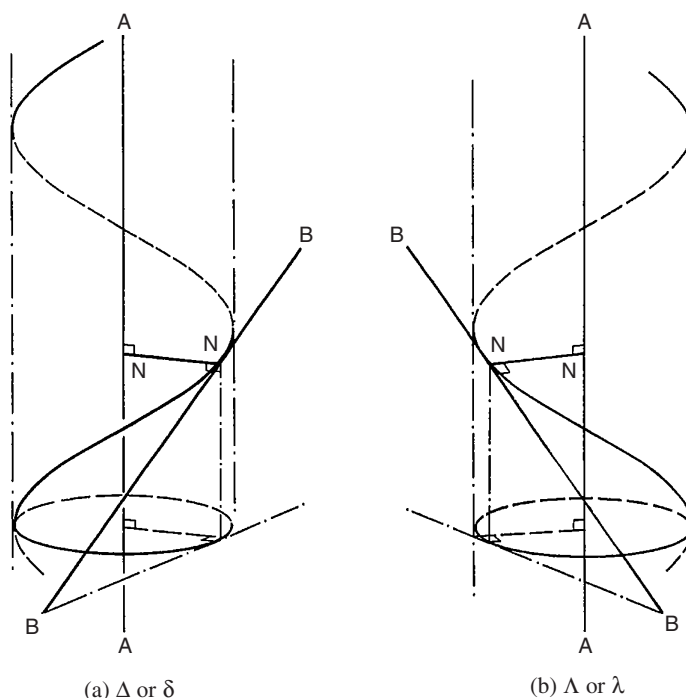
Examples 1 and 2 represent the *delta* ( $\Delta$ ) and *lambda* ( $\Lambda$ ) forms of a complex such as  $[\text{Co}(\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2)_3]^{3+}$ . The rules define the chiralities of two additional families of structures. These are the *cis*-bis(bidentate) octahedral structures and the conformations of certain chelate rings. It is possible to use the system described below for complexes of higher polydentate ligands, but additional rules are required.<sup>15</sup>

Examples:

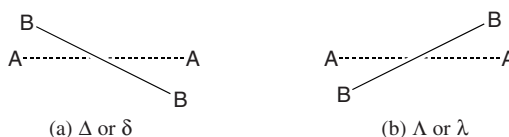


Two skew-lines which are not orthogonal possess the property of having one, and only one, normal in common. They define a helical system, as illustrated in Figures IR-9.1 and IR-9.2 (below). In Figure IR-9.1, one of the skew-lines, AA, determines the axis of a helix upon a cylinder whose radius is equal to the length of the common normal, NN, to the two skew-lines, AA and BB. The other of the skew-lines, BB, is a tangent to the helix at N and determines the pitch of the helix. In Figure IR-9.2, the two skew-lines AA and BB are seen in projection onto a plane orthogonal to their common normal.

Parts (a) of Figures IR-9.1 and IR-9.2 illustrate a right-handed helix to be associated with the Greek letter delta ( $\Delta$  referring to configuration,  $\delta$  to conformation). Parts (b) of Figures IR-9.1 and IR-9.2 illustrate a left-handed helix to be associated with the Greek letter lambda ( $\Lambda$  for configuration,  $\lambda$  for conformation). In view of the symmetry of the representation constituted by two skew-lines, the helix which the first line, say BB, determines around the second, AA, has the same chirality as that which AA determines around BB. As one of the lines is rotated about NN with respect to the other, inversion occurs when the lines are parallel or perpendicular (Figure IR-9.1).



**Figure IR-9.1.** Two skew lines  $AA$  and  $BB$  which are not orthogonal define a helical system. In the Figure,  $AA$  is taken as the axis of a cylinder whose radius is determined by the common normal  $NN$  of the two skew-lines. The line  $BB$  is a tangent to the above cylinder at its crossing point with  $NN$  and defines a helix upon this cylinder. Cases (a) and (b) illustrate a right- and left-handed helix, respectively.



**Figure IR-9.2.** The figure shows pairs of non-orthogonal skew-lines in projection upon a plane parallel to both lines. The full line  $BB$  is above the plane of the paper, the dotted line  $AA$  is below this plane. Case (a) corresponds to (a) of Figure IR-9.1 and defines a right-handed helix. Case (b) corresponds to (b) of Figure IR-9.1 and defines a left-handed helix.

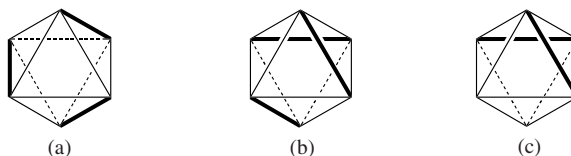
#### IR-9.3.4.12 Application of the skew-lines convention to tris(bidentate) octahedral complexes

Any two of the three chelate rings may be chosen to designate the configuration of tris(bidentate) coordination compounds. The donor atoms of each chelate ring define a line. Two such lines for a pair of chelate rings in the same complex define a helix, one line being the axis of the helix and the other a tangent to the helix at the normal common to the skew-lines. The tangent describes a right-handed ( $\Delta$ ) or a left-handed ( $\Lambda$ ) helix with respect to the axis and thereby defines the chirality of that configuration.

#### IR-9.3.4.13 Application of the skew-lines convention to bis(bidentate) octahedral complexes

Figure IR-9.3(a) shows a common orientation of an octahedral tris(bidentate) structure projected onto a plane orthogonal to the three-fold axis of the structure. Figure IR-9.3(b)

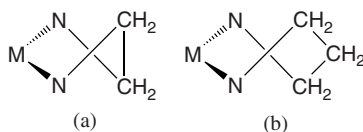
shows the same structure oriented to emphasize the skew-line relationship between a pair of chelate rings that can be used to define chirality. Figure IR-9.3(c) shows that the same convention can be used for the *cis*-bis(bidentate) complex. The two chelate rings define the two skew-lines that, in turn, define the helix and the chirality of the substance. The procedure is precisely the same as that described for the tris(bidentate) case, but only a single pair of chelate rings is available.



**Figure IR-9.3.** Two orientations of a tris(bidentate) structure, (a) and (b), to show the chiral relationship between these two species and the bis(bidentate) structure (c).

#### IR-9.3.4.14 Application of the skew-lines convention to conformations of chelate rings

In order to assign the chirality of a ring conformation, the line AA in Figure IR-9.2 is defined as that line joining the two ligating atoms of the chelate ring. The other line BB is that joining the two ring atoms which are neighbours to each of the ligating atoms. These two skew-lines define a helix in the usual way. The tangent describes a right-handed ( $\delta$ ) or a left-handed ( $\lambda$ ) helix with respect to the axis and thereby defines the conformation in terms of the convention given in Figure IR-9.1. The relationship between the convention of Figure IR-9.2 and the usual representation of chelate ring conformation may be seen by comparing Figures IR-9.2 and IR-9.4.



**Figure IR-9.4.**  $\delta$ -Conformation of chelate rings: (a) five-membered; (b) six-membered.

### IR-9.3.5 Determining ligand priority

#### IR-9.3.5.1 General

The methods for differentiating between stereoisomers outlined earlier in this Chapter require the assignment of priorities for the ligand atoms attached to the central atom (*i.e.* the donor atoms). These priority numbers are then used in the configuration index, which describes the relative positions of the ligands, and in the assignment of the absolute configuration of the compound.



The following sections outline the method used to arrive at the priority numbers for a given set of donor atoms, and the ways that the basic rules have to be modified in order to describe adequately systems that include polydentate ligands. These modifications, which are collectively referred to as the priming convention, make use of primes on the priority numbers to indicate which donor atoms are grouped together within a particular polydentate ligand.

#### IR-9.3.5.2 *Priority numbers*

The procedure for assigning priorities in mononuclear coordination systems is based on the standard sequence rules developed for chiral carbon compounds by Cahn, Ingold and Prelog.<sup>13</sup> (See also Section P-91 of Ref. 1.) These CIP rules can be used quite generally for assigning priorities to groups attached to a central atom.

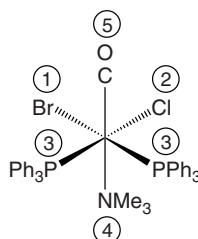
The essence of these rules, when applied to coordination compounds, is that the ligands attached to the central atom are compared to one another, beginning with the donor atom and then moving outwards in the structure. The comparison is made on the basis of atomic number and then, if required (*e.g.* when isotopes are being specified), atomic mass. Other properties may be used for subsequent comparisons, but the need for them is sufficiently rare that they need not be detailed here.

Once the ligands have been compared, the priority numbers are assigned as follows:

- (i) identical ligands are assigned the same priority,
- (ii) the ligand(s) with highest priority is (are) assigned the priority number 1; those with the next highest priority, 2; and so on.

*Examples:*

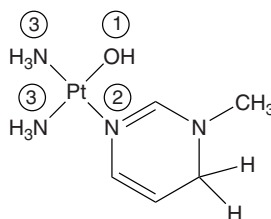
1.



Priority sequence:  $\text{Br} > \text{Cl} > \text{PPh}_3, \text{PPh}_3 > \text{NMe}_3 > \text{CO}$

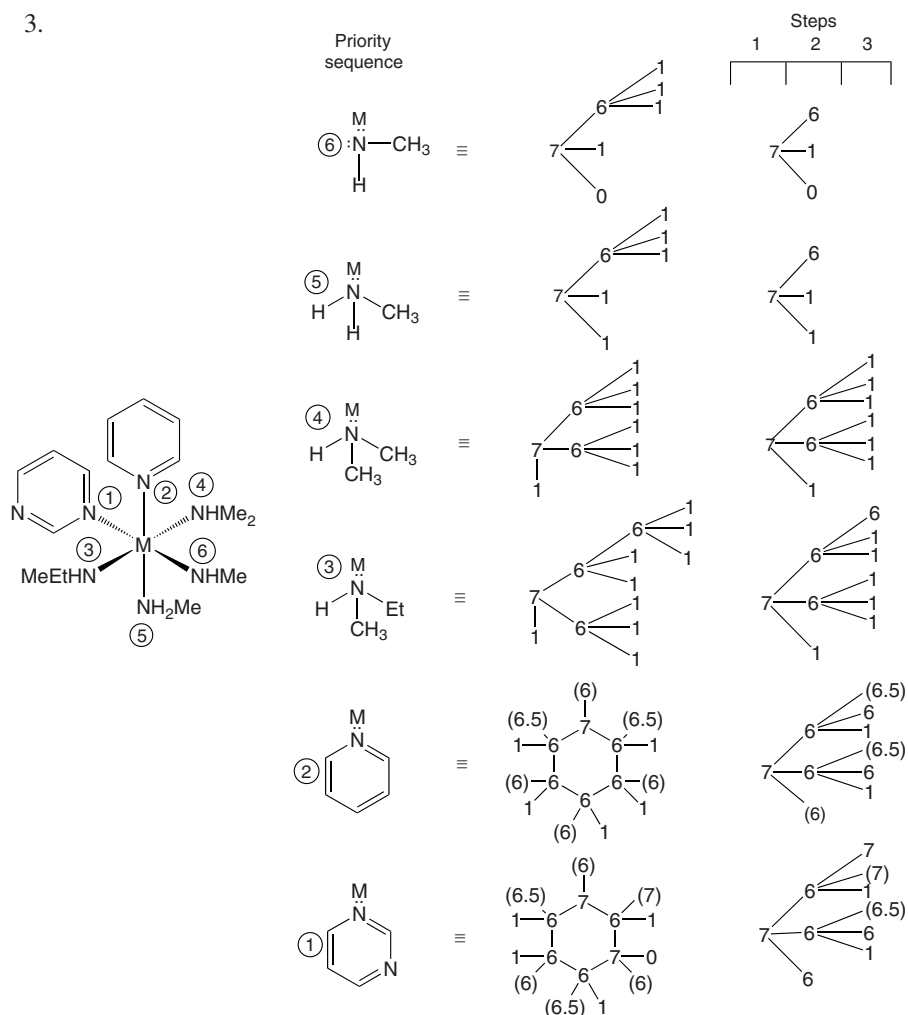
Priority numbers sequence:  $1 > 2 > 3, 3 > 4 > 5$

2.



In Example 2, the heterocyclic ligand is given priority 2 since it has a lower atomic number donor atom than OH, and the substitution of the nitrogen donor ranks it above the ammine ligands.

3.



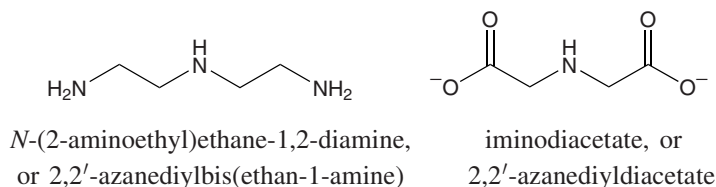
In Example 3, all the ligating atoms are nitrogen atoms. The key illustrates how proceeding along the branches of the ligand constituents allows priorities to be assigned. The numbers in columns 1, 2 and 3 on the right are the atomic numbers of the atoms in the structures, with those in brackets being used to take account of the presence of multiple bonds. The averaging techniques used in the case of resonance structures (last two ligands in the list) are given in the original paper.<sup>13</sup>

## IR-9.3.5.3

*Priming convention*

The priming convention is required in order to avoid ambiguity when using the configuration index to describe the stereochemistry of systems that contain either more than one polydentate ligand of a particular kind, or a polydentate ligand that contains more than one coordinating fragment of a particular kind. This situation is found commonly with bis(tridentate) complexes, but also arises in more complicated cases. The need for this convention is best illustrated by example.

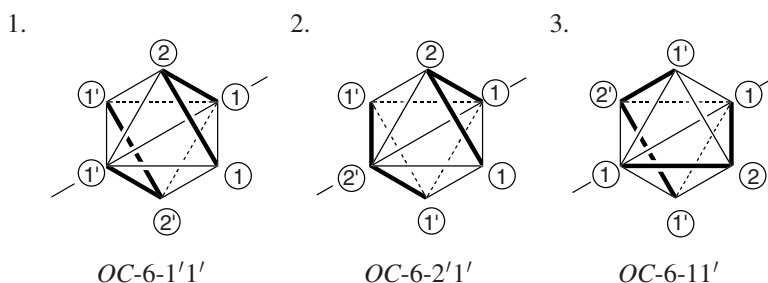
Bis(tridentate) complexes (*i.e.* octahedral complexes containing two identical linear tridentate ligands) may exist in three stereoisomeric forms, and there will be more if the tridentate ligands do not themselves contain some symmetry elements. The three isomers of the simplest case are represented below (Examples 1, 2 and 3), along with their polyhedral symbols (Section IR-9.3.2.1) and configuration indexes (Section IR-9.3.3.4). Complexes of *N*-(2-aminoethyl)ethane-1,2-diamine and iminodiacetate can be described by these diagrams.



The need for the priming convention can be seen by considering what the configuration indexes of Examples 1 and 3 would be in the absence of the priming convention. The two ligands are identical and consist of two similar fragments fused together. If the primes are ignored, the two complexes have the same distributions of ligating atoms (four donors of priority 1 in a square plane, and two of priority 2 *trans* to one another). They would therefore have the same configuration index, even though they are clearly different complexes.

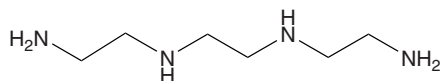
One way to highlight the difference between these two examples is to note that, in Example 1, all the donor atoms are *trans* to donors that are part of the other ligand. This is not true in Example 3. Using primes to indicate the groupings of donor atoms in particular ligands allows these two stereoisomers to be distinguished from one another by their configuration indexes.

Examples:

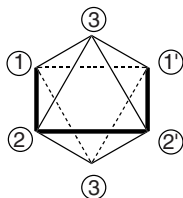


The priority numbers on one of the ligands are arbitrarily primed. The primed number is assigned lower priority than the corresponding unprimed number, but a higher priority than the next higher unprimed number. Thus 1' has lower priority than 1, but higher than 2.

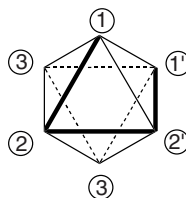
The technique also distinguishes between stereoisomers for complexes of higher polydentate ligands as indicated in Examples 4, 5 and 6 for linear tetradentate ligands such as *N,N'*-bis(2-aminoethyl)ethane-1,2-diamine. In this case, the donor atom priority numbers in half of the tetradentate ligand have been primed.

*N,N'*-bis(2-aminoethyl)ethane-1,2-diamine*Examples:*

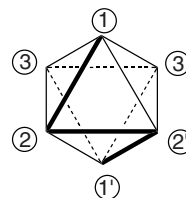
4.

*OC-6-2'2*

5.

*OC-6-32*

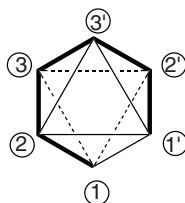
6.

*OC-6-1'3*

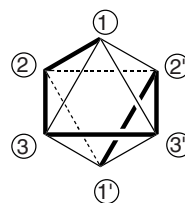
Pentadentate and hexadentate ligands can be treated similarly. Examples 7 and 8 apply to stereoisomers of classic linear hexadentate ligands, whereas Examples 9 and 10 apply to ligands containing a branched structure.

*Examples:*

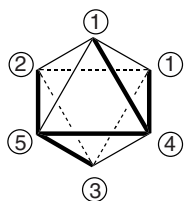
7.

*OC-6-3'3*

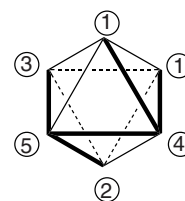
8.

*OC-6-1'3'*

9.

*OC-6-53*

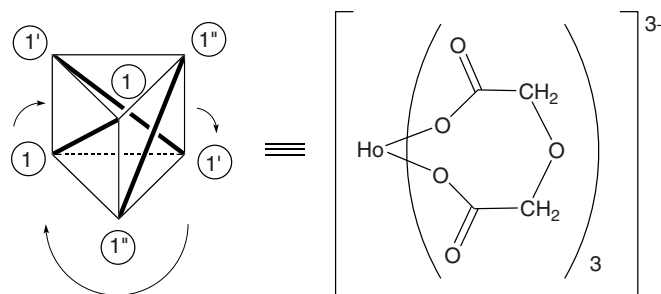
10.

*OC-6-52*

Example 11 illustrates the use of priming for assigning absolute configuration in a non-octahedral structure. The chirality designation is determined by the system of assigning primes to ligands with the extra requirement that the symbol 1 on the top face is placed above the symbol 1'' on the bottom face. This produces the sequence shown and the chirality symbol *C* when viewing the prism from above the top face. The stereochemical descriptor is *TPR-6-1''11'-C*. The skew-lines method (Section I-9.3.4.11) could also be applied and would give in this case the descriptor  $\Delta$ .

Example:

11.



#### IR-9.4

#### FINAL REMARKS

This chapter has described the means by which coordination compounds can be named and formulated. These processes involve firstly identifying the central atom(s) and ligands (by name, formula or abbreviation, depending on the context), and secondly defining the nature of the attachment between the central atom(s) and the ligands. This latter step requires that the coordinating atoms in the ligand be identified (if there is any ambiguity), and that the spatial relationships between the ligands be described. The spatial relationships between the ligands are defined in terms of the coordination polyhedron (giving the polyhedral symbol) and the CIP priorities of the donor atoms (giving the configuration index and the absolute configuration).

#### IR-9.5

#### REFERENCES

1. *Nomenclature of Organic Chemistry, IUPAC Recommendations*, eds. W.H. Powell and H. Favre, Royal Society of Chemistry, in preparation.
2. In *Nomenclature of Inorganic Chemistry, IUPAC Recommendations 1990*, ed. G.J. Leigh, Blackwell Scientific Publications, Oxford, 1990, the term didentate was used rather than bidentate, for reasons of linguistic consistency. Reversion to the previously accepted term, bidentate, reflects common usage.
3. The names of the other hydrogen isotopes are discussed in Section IR-3.3.2.
4. The names of organic ligands should be assigned in accordance with IUPAC recommendations, see Ref. 1.
5. In order to simplify the rules and to resolve ambiguities that may arise when it is not clear whether a ligand is charged or not, the charge on a ligand is no longer considered in determining ligand order in the formulae of coordination compounds. (In *Nomenclature of Inorganic Chemistry, IUPAC Recommendations 1990*, ed. G.J. Leigh, Blackwell Scientific Publications, Oxford, 1990, anionic ligands were listed before neutral ligands.)
6. Chapter II-7 of *Nomenclature of Inorganic Chemistry II, IUPAC Recommendations 2000*, eds. J.A. McCleverty and N.G. Connelly, Royal Society of Chemistry, 2001.
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15. M. Brorson, T. Damhus and C.E. Schaeffer, *Inorg. Chem.*, **22**, 1569–1573 (1983).

# IR-10 Organometallic Compounds

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## IR-10.1 INTRODUCTION

The enormous growth in organometallic chemistry over the last fifty years and the discovery of new classes of compounds with unprecedented bonding modes has resulted in the need for additional nomenclature rules for organometallic compounds. This Chapter is therefore considerably expanded over Section I-10.9 of Ref. 1 and is largely based on the IUPAC recommendations published in 1999 for organometallic compounds of the transition elements.<sup>2</sup>

An organometallic compound is defined as any compound containing at least one bond between a metal atom and a carbon atom. The names of organometallic compounds should therefore accord with the rules of both organic and coordination chemistry nomenclature (even though these have tended to evolve separately).

The major part of this Chapter presents a system of nomenclature for transition element organometallic compounds, based on the additive nomenclature system introduced in Chapter IR-7 and applied to coordination compounds in Chapter IR-9 but incorporating, as far as possible, the rules for naming organic ligands.<sup>3</sup> Most importantly, further rules are formulated which unambiguously designate the special modes of bonding often found in organometallic compounds.

The later part of this Chapter briefly describes aspects of the naming of main group organometallic compounds, where the substitutive system of nomenclature (introduced in Chapter IR-6) is applied by substituting the appropriate parent hydrides of the elements of groups 13–16. The names of organometallic compounds of group 1 and 2 elements are, on the other hand, based on the additive nomenclature system.

It should be emphasized that the nomenclature described in this Chapter is confined to the precise description of the composition of a compound and the connectivity of atoms within a molecule or ion; it is often also important to specify the spatial relationships between the structural components of the molecule or ion (see Section IR-9.3). It is particularly true of organometallic chemistry that nomenclature should not attempt to convey details about the polarity of bonds, patterns of reactivity or methods of synthesis.

## IR-10.2 NOMENCLATURE OF ORGANOMETALLIC COMPOUNDS OF THE TRANSITION ELEMENTS

### IR-10.2.1 Concepts and conventions

The (additive) nomenclature of coordination complexes, the general definitions and rules of which are given in Sections IR-9.1 and IR-9.2, provides the basis for the system presented here for naming organometallic compounds of the transition elements. The general concepts of coordination chemistry can be applied to organometallic compounds but need to be expanded to deal with the additional modes of connectivity afforded by the interaction of metals with, for example, organic ligands containing unsaturated groupings, such as alkenes, alkynes and aromatic compounds. This section examines relevant concepts and conventions from coordination chemistry as they are applied to organometallic compounds, and indicates what new conventions need to be introduced in order to designate unambiguously the special bonding modes of organometallic compounds.

#### IR-10.2.1.1 *Coordination number*

The definition of coordination number as being equal to the number of  $\sigma$ -bonds between the ligands and the central atom (Section IR-9.1.2.6) also applies to ligands such as  $\text{CN}^-$ ,  $\text{CO}$ ,  $\text{N}_2$  and  $\text{PPh}_3$ , where the bonding of a single ligating atom to a metal may involve a combination of  $\sigma$ - and  $\pi$ -components. The  $\pi$ -bond components are not considered in determining the coordination number, and so  $[\text{Ir}(\text{CO})\text{Cl}(\text{PPh}_3)_2]$ ,  $[\text{RhI}_2(\text{Me})(\text{PPh}_3)_2]$  and  $[\text{W}(\text{CO})_6]$  have coordination numbers of four, five and six, respectively.



However, this definition cannot be applied to the many organometallic compounds in which two or more adjacent atoms of a ligand interact with the central metal atom through what is often a combination of  $\sigma$ ,  $\pi$  and  $\delta$  bonding (the labels  $\sigma$ ,  $\pi$  or  $\delta$  referring to the symmetry of the orbital interactions between ligand and central atom).

For example, a ligand such as ethene, consisting of two ligating carbon atoms, nevertheless brings only one pair of electrons to the central atom. Likewise, ethyne, coordinating *via* both carbon atoms, can be thought to bring either one or two pairs of electrons to a single metal atom, depending on the type of coordination involved. Both ligands are normally regarded as monodentate. This changes when ethene or ethyne is considered to add oxidatively to a central metal atom; they are then considered to be bidentate chelating ligands which, on electron counting and dissection of the coordination entity to determine oxidation numbers, are assumed to take two pairs of electrons with them. This different view can be expressed by referring to compounds of such ligands as metallacyclopropanes or metallacycloprenes rather than ethene or ethyne complexes.

#### IR-10.2.1.2 *Chelation*

The concept of chelation (Section IR-9.1.2.7) can again be applied strictly only to those organometallic complexes in which the donor atoms of a ligand are attached to the central metal atom through  $\sigma$ -bonds alone. Otherwise, ambiguities will result, as outlined above, even with a simple ligand such as ethene. Butadiene and benzene supply two and three pairs of electrons upon coordination and are therefore regarded as bi- and tridentate ligands, respectively. In stereochemistry, however, such ligands are often treated as if they were monodentate.

#### IR-10.2.1.3 *Specifying connectivity*

In the event of a ligand containing several different donor atoms, particularly when not all are used, the point or points of attachment to the metal are specified using the kappa ( $\kappa$ ) convention (see Sections IR-9.2.4.1 and IR-9.2.4.2). In organometallic nomenclature the ligating carbon atoms are often sufficiently specified within the ligand name. However, use of the kappa notation becomes necessary to indicate the attachment of heteroatoms, and also to specify the particular points of attachment of a single ligand when bridging different metal centres in a polynuclear complex. The strength of the kappa convention is that its use completely avoids any ambiguities in describing the connectivities between a ligand and one or more metal centres. Its use in organometallic nomenclature is discussed further in Section IR-10.2.3.3.

A complementary notation, the eta ( $\eta$ ) convention, is used to specify the number ('hapticity') of *contiguous* ligating atoms that are involved in bonding to one or more metals. The need for this convention arises from the special nature of the bonding of unsaturated hydrocarbons to metals *via* their  $\pi$ -electrons, and it is used only when there are several contiguous atoms involved in the bond to the metal. The contiguous atoms of the  $\pi$ -coordinated ligand are often the same element, but they need not be, and they may also be atoms other than carbon. The eta convention is defined in Section IR-10.2.5.1, where its use is extensively illustrated. Even though all connectivity can be expressed by the kappa convention alone, the practice in organometallic nomenclature is that the eta convention should be used wherever there are contiguous ligating atoms. Complicated structures may require the use of both conventions (see Section IR-9.2.4.3).

Organic ligands with the ability to form more than one bond to a metal centre may be chelating (if bonding to a single metal), bridging (if bonding to more than one metal), or sometimes even both chelating and bridging. The bridging bonding mode is indicated by the Greek letter  $\mu$  (mu) prefixing the ligand name (Section IR-9.2.5.2). This convention is further exemplified for organometallic compounds in Sections IR-10.2.3.1 and IR-10.2.3.4.

#### IR-10.2.1.4 *Oxidation number and net charge*

The concept of oxidation number or state (see also Sections IR-4.6.1, IR-5.4.2.2 and IR-9.1.2.8) is sometimes difficult to apply to organometallic compounds. This is especially true when it cannot be determined whether complexation by a ligand is better regarded as a Lewis-acid or Lewis-base association or as an oxidative addition. Thus, for nomenclature purposes it is only the net charge on the coordination entity that is important, and formal oxidation numbers will not be assigned to the central atoms of the organometallic complexes in the following sections. The reader is referred to standard textbooks on organometallic chemistry for discussion of the assignment of oxidation number in such compounds.

#### IR-10.2.2 **Compounds with one metal-carbon single bond**

In naming organometallic compounds the usual rules for naming ligands in coordination entities are applied if the ligand coordinates *via* an atom other than carbon (Section IR-9.2.2.3). Thus, the ligand  $\text{MeCOO}^-$  is named acetato,  $\text{Me}_2\text{As}^-$  is named dimethylarsanido, and  $\text{PPh}_3$  is named triphenylphosphane.

If an organic ligand coordinating *via* one carbon atom is regarded as an anion formed by the removal of one hydron from that atom, the ligand name is formed by replacing the ending 'ide' of the anion name by 'ido'.

*Examples:*

- |                                    |                   |
|------------------------------------|-------------------|
| 1. $\text{CH}_3^-$                 | methanido         |
| 2. $\text{CH}_3\text{CH}_2^-$      | ethanido          |
| 3. $(\text{CH}_2=\text{CHCH}_2)^-$ | prop-2-en-1-ido   |
| 4. $\text{C}_6\text{H}_5^-$        | benzenido         |
| 5. $(\text{C}_5\text{H}_5)^-$      | cyclopentadienido |

Although strictly speaking ambiguous, the anion name cyclopentadienide is acceptable as a short form of cyclopenta-2,4-dien-1-ide (and consequently the ligand name cyclopentadienido).

The compound  $[\text{TiCl}_3\text{Me}]$  would be called trichlorido(methanido)titanium using the above type of ligand name.

The alternative for naming an organic ligand attached *via* a single carbon atom is to regard it as a substituent group, its name being derived from a parent hydride from which one hydrogen atom has been removed. This designation is somewhat arbitrary as such ligands in organometallic chemistry are generally treated as anions when deducing oxidation states, although the bonding in reality may be highly covalent. However, it has a long

tradition in organic and organometallic chemistry, and its major advantage is that names used in common practice for organic groups can be applied unchanged.

There are two methods for constructing substituent group names from parent hydride names:

- (a) The suffix 'yl' replaces the ending 'ane' of the parent hydride name. If the parent hydride is a chain, the atom with the free valence is understood to terminate the chain. In all cases that atom has the locant '1' (which is omitted from the name). This method is employed for saturated acyclic and monocyclic hydrocarbon substituent groups and for the mononuclear parent hydrides of silicon, germanium, tin and lead.

*Examples:*

- |                                                                     |                |
|---------------------------------------------------------------------|----------------|
| 6. $\text{CH}_3-$                                                   | methyl         |
| 7. $\text{CH}_3\text{CH}_2-$                                        | ethyl          |
| 8. $\text{C}_6\text{H}_{11}-$                                       | cyclohexyl     |
| 9. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2-$                  | butyl          |
| 10. $\text{CH}_3\text{CH}_2\text{CH}_2\text{C}(\text{Me})\text{H}-$ | 1-methylbutyl  |
| 11. $\text{Me}_3\text{Si}-$                                         | trimethylsilyl |

The compound  $[\text{TiCl}_3\text{Me}]$  would be called trichlorido(methyl)titanium by this method.

- (b) In a more general method, the suffix 'yl' is added to the name of the parent hydride with elision of the terminal 'e', if present. The atom with the free valence is given a number as low as is consistent with the established numbering of the parent hydride. The locant number, including '1', must always be cited. (See Section P-29 of Ref. 3 for a more complete discussion of substituent group names.)

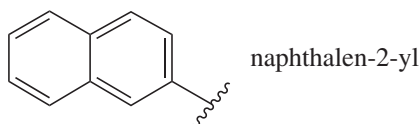
*Examples:*

- |                                                                     |                                            |
|---------------------------------------------------------------------|--------------------------------------------|
| 12. $\text{CH}_3\text{CH}_2\text{CH}_2\text{C}(\text{Me})\text{H}-$ | pentan-2-yl ( <i>cf.</i> Example 10 above) |
| 13. $\text{CH}_2=\text{CHCH}_2-$                                    | prop-2-en-1-yl                             |

In fused polycyclic hydrocarbons as well as in heterocyclic systems, special numbering schemes are adopted (see Section P-25 of Ref. 3).

*Examples:*

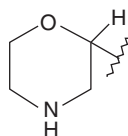
14.



15.



16.



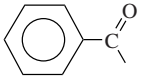
morpholin-2-yl

Table IR-10.1 gives the names used for ligands forming a single bond to a metal, and this is followed by examples illustrating the naming of compounds containing one metal–carbon single bond. In this Table (as well as in Tables IR-10.2 and IR-10.4) the organic ligands are listed both as anions and as neutral species. Acceptable alternative names are given in the final column.

**Table IR-10.1** Names for ligands forming a metal–carbon single bond (or bond to other group 14 element)

Ligand formula	Systematic name as anionic ligand	Systematic name as neutral ligand	Acceptable alternative name
CH <sub>3</sub> –	methanido	methyl	
CH <sub>3</sub> CH <sub>2</sub> –	ethanido	ethyl	
CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> –	propan-1-ido	propyl	
(CH <sub>3</sub> ) <sub>2</sub> CH–	propan-2-ido	propan-2-yl or 1-methylethyl	isopropyl
CH <sub>2</sub> =CHCH <sub>2</sub> –	prop-2-en-1-ido	prop-2-en-1-yl	allyl
CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> –	butan-1-ido	butyl	
$\begin{array}{c} \text{CH}_3 \\   \\ \text{CH}_3\text{CH}_2-\text{C}- \\   \\ \text{H} \end{array}$	butan-2-ido	butan-2-yl or 1-methylpropyl	sec-butyl
$\begin{array}{c} \text{H}_3\text{C} \\   \\ \text{CH}-\text{CH}_2- \\   \\ \text{H}_3\text{C} \end{array}$	2-methylpropan-1-ido	2-methylpropyl	isobutyl
$\begin{array}{c} \text{CH}_3 \\   \\ \text{H}_3\text{C}-\text{C}- \\   \\ \text{CH}_3 \end{array}$	2-methylpropan-2-ido	2-methylpropan-2-yl or 1,1-dimethylethyl	tert-butyl
$\begin{array}{c} \text{CH}_3 \\   \\ \text{H}_3\text{C}-\text{C}-\text{CH}_2- \\   \\ \text{CH}_3 \end{array}$	2,2-dimethylpropan-1-ido	2,2-dimethylpropyl	
$\begin{array}{c} \text{H}_2\text{C} \\   \quad \diagup \\ \text{CH} \\   \quad \diagdown \\ \text{H}_2\text{C} \end{array}$	cyclopropanido	cyclopropyl	
$\begin{array}{c} \text{H}_2 \\   \quad \diagup \\ \text{CH} \\   \quad \diagdown \\ \text{H}_2 \end{array}$	cyclobutanido	cyclobutyl	

**Table IR-10.1** *Continued*

<i>Ligand formula</i>	<i>Systematic name as anionic ligand</i>	<i>Systematic name as neutral ligand</i>	<i>Acceptable alternative name</i>
$\text{C}_5\text{H}_5^-$	cyclopenta-2,4-dien-1-ido	cyclopenta-2,4-dien-1-yl	cyclopentadienyl
$\text{C}_6\text{H}_5^-$	benzenido	phenyl	
$\text{C}_6\text{H}_5\text{CH}_2^-$	phenylmethanido	phenylmethyl	benzyl
$\text{H}_3\text{C}-\text{C}(=\text{O})-$	1-oxoethan-1-ido	ethanoyl <sup>a</sup>	acetyl <sup>a</sup>
$\text{C}_2\text{H}_5-\text{C}(=\text{O})-$	1-oxopropan-1-ido	propanoyl <sup>a</sup>	propionyl <sup>a</sup>
$\text{C}_3\text{H}_7-\text{C}(=\text{O})-$	1-oxobutan-1-ido	butanoyl <sup>a</sup>	butyryl <sup>a</sup>
	oxo(phenyl)methanido	benzenecarbonyl <sup>a</sup>	benzoyl <sup>a</sup>
$\text{H}_2\text{C}=\text{CH}-$	ethenido	ethenyl	vinyl
$\text{HC}\equiv\text{C}-$	ethynido	ethynyl	
$\text{H}_3\text{Si}-$	silanido	silyl	
$\text{H}_3\text{Ge}-$	germanido	germyl	
$\text{H}_3\text{Sn}-$	stannanido	stannyl	
$\text{H}_3\text{Pb}-$	plumbanido	plumbyl	

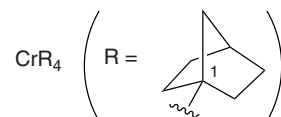
<sup>a</sup> These acyl names are preferred to 1-oxoethyl, *etc.*

*Examples:*

17.  $[\text{OsEt}(\text{NH}_3)_5]\text{Cl}$  pentaammine(ethyl)osmium(1+) chloride

18.  $\text{Li}[\text{CuMe}_2]$  lithium dimethylcuprate(1-)

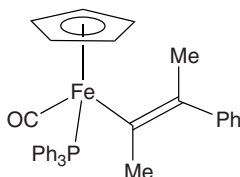
19.



tetrakis(bicyclo[2.2.1]heptan-1-yl)chromium

20.  $[\text{Pt}\{\text{C}(\text{O})\text{Me}\}\text{Me}(\text{PEt}_3)_2]$  acetyl(methyl)bis(triethylphosphane)platinum

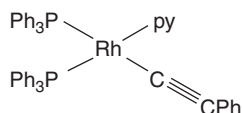
21.



carbonyl( $\eta^5$ -cyclopentadienyl)[(*E*)-3-phenylbut-2-en-2-yl](triphenylphosphane)iron

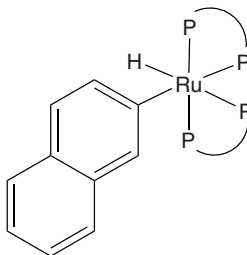
(The  $\eta$  term used here is explained in Section IR-10.2.5.1.)

22.

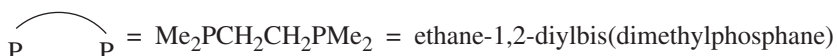


(phenylethynyl)(pyridine)bis(triphenylphosphane)rhodium

23.



bis[ethane-1,2-diylbis(dimethylphosphane- $\kappa P$ )]hydrido(naphthalen-2-yl)ruthenium



## IR-10.2.3

**Compounds with several metal–carbon single bonds from one ligand**

When an organic ligand forms more than one metal–carbon single bond (to one or more metal atoms), the ligand name may be derived from the name of the parent hydrocarbon from which the appropriate number of hydrogen atoms have been removed. In the systematic substitutive name, the suffix ‘diyl’ or ‘triyl’ is attached to the name of the parent hydrocarbon if two or three hydrogen atoms, respectively, are replaced by one or more metal atoms. There is no removal of the terminal ‘e’. The locant ‘1’ is assigned so as to create the longest chain of carbon atoms, and the direction of numbering is chosen to give the lowest possible locants to side chains or substituents. The locant number(s) must always be cited, except for ligands derived from methane.

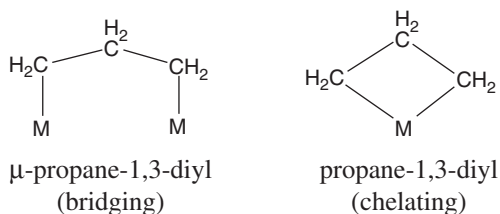
Alternatively, when considering these ligands as anions, the endings ‘diido’ and ‘triido’ should be used. This nomenclature also applies to hypervalent coordination modes, *e.g.* for bridging methyl groups. Typical ligands forming two or three metal–carbon single bonds are listed in Table IR-10.2.

**Table IR-10.2** Names for ligands forming several metal–carbon single bonds

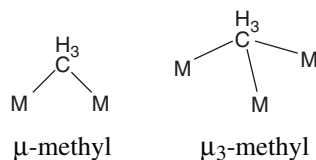
Ligand formula	Systematic name as anionic ligand	Systematic name as neutral ligand	Acceptable alternative name
–CH <sub>2</sub> –	methanediido	methanediyl	methylene
–CH <sub>2</sub> CH <sub>2</sub> –	ethane-1,2-diido	ethane-1,2-diyl	ethylene
–CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> –	propane-1,3-diido	propane-1,3-diyl	
–CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> –	butane-1,4-diido	butane-1,4-diyl	
$\begin{array}{c}   \\ \text{HC} - \\   \end{array}$	methanetriido	methanetriyl	
CH <sub>3</sub> CH<	ethane-1,1-diido	ethane-1,1-diyl	
$\begin{array}{c}   \\ \text{CH}_3\text{C} - \\   \end{array}$	ethane-1,1,1-triido	ethane-1,1,1-triyl	
–CH=CH–	ethene-1,2-diido	ethene-1,2-diyl	
H <sub>2</sub> C=C<	ethene-1,1-diido	ethene-1,1-diyl	
–C≡C–	ethyne-1,2-diido	ethyne-1,2-diyl	
–C <sub>6</sub> H <sub>4</sub> –	benzenediido (-1,2-diido, etc.)	benzenediyl (-1,2-diyl, etc.)	phenylene (1,2-, etc.)

IR-10.2.3.1 The *mu* (μ) convention

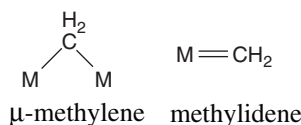
Organic ligands forming more than one metal–carbon bond can be either chelating, if coordinating to one metal atom, or bridging, if coordinating to two or more metal atoms. A bridging bonding mode is indicated by the Greek letter μ (Sections IR-9.2.5.2 and IR-10.2.3.4).



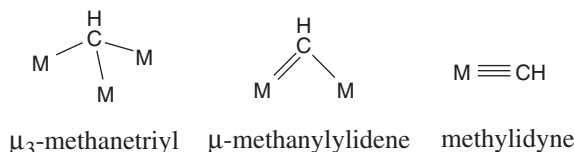
The number of metal atoms connected by a bridging ligand is indicated by a right subscript, μ<sub>*n*</sub>, where *n* ≥ 2, though the bridging index 2 is not normally indicated.



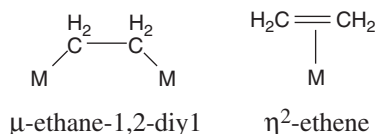
The name methylene for CH<sub>2</sub> can only be used in connection with a bridging bonding mode (μ-methylene), whereas a CH<sub>2</sub> ligand bonding to one metal only has a metal–carbon double bond and should be named as methyldene (see Section IR-10.2.4).



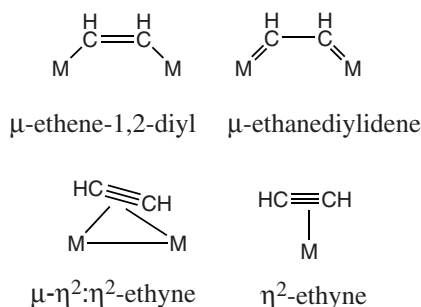
Likewise, the ligand HC will have at least three different bonding modes: bridging three metals ( $\mu_3$ -methanetriyl), bridging two metals ( $\mu$ -methanylylidene) and coordinating to one metal (methylidyne, see Section IR-10.2.4).



In a bridging mode the ligand  $\text{CH}_2\text{CH}_2$  should be called  $\mu$ -ethane-1,2-diyl, while the same ligand coordinating through both carbon atoms to a single metal centre should be called  $\eta^2$ -ethene (see Section IR-10.2.5).



A similar situation arises with  $\text{CHCH}$  which, when bridging with the carbon atoms individually bonded to each of two metals, should be called  $\mu$ -ethene-1,2-diyl or, when the metal-carbon bonds are double,  $\mu$ -ethanediylidene (see Section IR-10.2.4). The same ligand coordinating through both carbon atoms to both metal centres should be called  $\mu$ -ethyne; when coordinated through both carbons to one metal it is named  $\eta^2$ -ethyne (see Section IR-10.2.5).



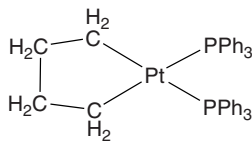
### IR-10.2.3.2 Chelating ligands

Where a chelating ligand is formed by removing two or more hydrogen atoms from a parent compound, the atoms with free valencies, understood to form the bonds to the central atoms, are indicated by using the appropriate ligand name (such as propane-1,3-diyl), *cf.* Section IR-10.2.3. This is demonstrated in Examples 1–3 below. Note that an alternative nomenclature for such metallacycles is currently being developed.



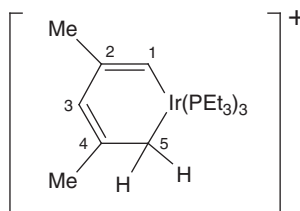
Examples:

1.



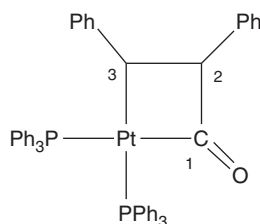
(butane-1,4-diyl)bis(triphenylphosphane)platinum

2.



(2,4-dimethylpenta-1,3-diene-1,5-diyl)tris(triethylphosphane)iridium(1+)

3.



(1-oxo-2,3-diphenylpropane-1,3-diyl)bis(triphenylphosphane)platinum

### IR-10.2.3.3 *The kappa (κ) convention*

Chelate rings that contain a coordinate (dative) bond from a heteroatom in addition to a carbon attachment should be named using the  $\kappa$  convention. In this convention (see Section IR-9.2.4.2) the coordinating atoms of a polydentate ligand bonding to a metal centre are indicated by the Greek letter kappa,  $\kappa$ , preceding the italicized element symbol of each ligating atom. A right superscript numeral may be added to the symbol  $\kappa$  to indicate the number of identical bonds from a type of ligating atom to the central atom(s); non-equivalent ligating atoms should each be indicated by an italicized element symbol preceded by  $\kappa$ .

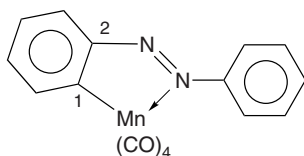
In simple cases one or more superscript primes on the element symbol may be used to differentiate between donor atoms of the same element. Otherwise a right superscript numeral corresponding to the conventional numbering of the atoms in the ligand is used to define unambiguously the identity of the ligating atom. These symbols are placed after that portion of the ligand name which represents the particular functionality, substituent group, ring or chain in which the ligating atom is found.

Often it is only necessary for the coordinating heteroatom to be specified using the  $\kappa$  convention, the ligating carbon atom being adequately specified by the appropriate substitutive suffix. For illustrative purposes only, an arrow is used in the examples that

follow to indicate a coordinate bond in the chelate ring. In Example 1 the  $\kappa C^1$  specification is included for clarity but is not strictly necessary as the bonding from carbon atom number 1 is implied by the name 'phenyl'.

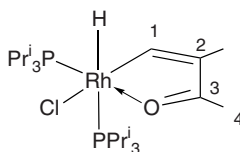
*Examples:*

1.



tetracarbonyl[2-(2-phenyldiazen-1-yl- $\kappa N^2$ )phenyl- $\kappa C^1$ ]manganese

2.



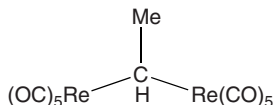
chloridohydrido(2-methyl-3-oxo- $\kappa O$ -but-1-en-1-yl)bis(triisopropylphosphane)rhodium

#### IR-10.2.3.4 Bridging ligands

A bridging ligand is indicated by the Greek letter  $\mu$  (mu) prefixing the ligand name (see Sections IR-9.2.5.2 and IR-10.2.3.1). Bridging ligands are listed in alphabetical order along with the other ligands, but in names a bridging ligand is cited before a corresponding non-bridging ligand, and multiple bridging is listed in decreasing order of complexity, *e.g.*  $\mu_3$  bridging before  $\mu_2$  bridging.

*Example:*

1.



( $\mu$ -ethane-1,1-diyl)bis(pentacarbonylrhenium)

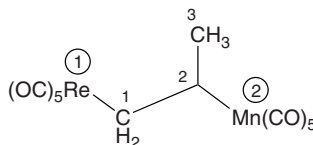
The metal centres in heterodinuclear coordination entities are numbered and listed according to the element sequence given in Table VI\*, the central atom arrived at last when traversing this table being numbered '1' and listed in the name first (see Section IR-9.2.5).

The numerical locants of the central atoms are used in conjunction with the  $\kappa$  notation to indicate the distribution of the ligating atoms. Such locants are placed before the  $\kappa$  symbol which, as before, may be followed by a right superscript numeral to denote the number of equivalent bonds to the central atom specified by the locant (see Section IR-9.2.5.5). Thus, decacarbonyl-1 $\kappa^5 C$ ,2 $\kappa^5 C$  indicates that the carbon atoms of five carbonyl ligands are bonded to central atom number 1 and another five to central atom number 2. In the names of bridging ligands, the  $\kappa$  terms indicating the bonding to each of the central atoms are separated by a colon, *e.g.*  $\mu$ -propane-1,2-diyl-1 $\kappa C^1$ :2 $\kappa C^2$ .

\* Tables numbered with a Roman numeral are collected together at the end of this book.

Example:

2.



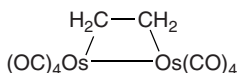
decacarbonyl-1 $\kappa^5$ C,2 $\kappa^5$ C-( $\mu$ -propane-1,2-diyl-1 $\kappa$ C<sup>1</sup>:2 $\kappa$ C<sup>2</sup>)rheniummanganese

### IR-10.2.3.5 Metal-metal bonding

Metal-metal bonding is indicated by the italicized element symbols of the appropriate metal atoms, separated by an 'em' dash and enclosed in parentheses, placed after the list of central atom names and before the ionic charge. The element symbols are placed in the same order as the central atoms appear in the name, *i.e.* with the element met last in the sequence of Table VI given first. The number of such metal-metal bonds is indicated by an arabic numeral placed before the first element symbol and separated from it by a space. For the purpose of nomenclature, no distinction is made between different metal-metal bond orders.

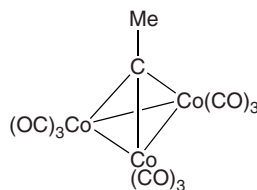
Examples:

1.



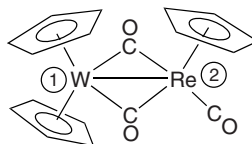
( $\mu$ -ethane-1,2-diyl)bis(tetracarbonylosmium)(*Os—Os*)

2.



( $\mu_3$ -ethane-1,1,1-triyl)-*triangulo*-tris(tricarbonylcobalt)(3 *Co—Co*)

3.



di- $\mu$ -carbonyl-carbonyl-2 $\kappa$ C-bis(1 $\eta^5$ -cyclopentadienyl)(2 $\eta^5$ -cyclopentadienyl)tungstenrhenium(*W—Re*)

The  $\eta$  terms involved here are explained in Section IR-10.2.5.1. For a more detailed discussion of dinuclear compounds and larger polynuclear clusters, with further examples, see Section IR-9.2.5.

### IR-10.2.4 Compounds with metal–carbon multiple bonds

Ligands regarded as forming metal–carbon double or triple bonds may also be given substituent prefix names derived from the parent hydrides, the ligand names ending with ‘ylidene’ for a double bond and with ‘ylidyne’ for a triple bond. These suffixes are used according to two methods (see Section P-29 of Ref. 3).

(a) The suffix ‘ylidene’ or ‘ylidyne’ replaces the ending ‘ane’ of the parent hydride name. If the parent hydride is a chain, the atom with the free valencies is understood to terminate the chain. This atom has, in all cases, the locant ‘1’ (which is omitted from the name). This method is used only for saturated acyclic and monocyclic hydrocarbon substituent groups and for the mononuclear parent hydrides of silicon, germanium, tin and lead. Note that the suffix ‘ylene’ should only be used in conjunction with  $\mu$  to designate bridging  $-\text{CH}_2-$  (methylene) or  $-\text{C}_6\text{H}_4-$  (phenylene) (see Section IR-10.2.3.1).

(b) In a more general method, the suffix ‘ylidene’ or ‘ylidyne’ is added to the name of the parent hydride with elision of the terminal ‘e’, if present. The atom with the free valence is given a number as low as is consistent with the established numbering of the parent hydride. For ligand names with the suffix ‘ylidene’, this locant must always be cited, except if it is the only locant in the name and there is no ambiguity.

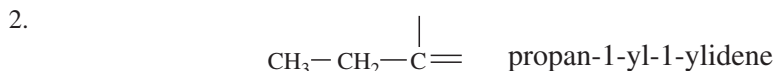
*Example:*

- |                    |                               |
|--------------------|-------------------------------|
| 1. EtCH=           | propylidene [method (a)]      |
| Me <sub>2</sub> C= | propan-2-ylidene [method (b)] |

Note that in numbering a ligand that has several points of attachment, the longest chain of carbon atoms is chosen as the parent chain before assigning the lowest possible locant to the atom with the free valence. In a metallacycle, the direction of numbering is chosen so as to give the lowest possible locants to side chains or substituents. Once again, special numbering schemes apply to heterocyclic and polycyclic systems (see Sections P-25 and P-29 of Ref. 3).

If a ligand forms one or more metal–carbon single bonds as well as metal–carbon multiple bonds, the order of endings is ‘yl’, ‘ylidene’, ‘ylidyne’. Method (b) should then be used to give the lowest possible set of locants for the free valencies. If a choice remains, lower numbers are selected for the ‘yl’ positions before the ‘ylidene’ positions and then for any side chains or substituents.


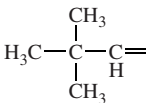

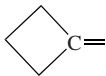
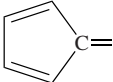

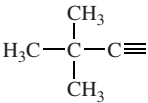
*Example:*



Typical ligands forming a metal–carbon double or triple bond are listed in Table IR-10.3, and this is followed by examples illustrating the naming of compounds containing one or more metal–carbon multiple bonds. The  $\eta$  term in Example 5 is explained in Section IR-10.2.5.1.

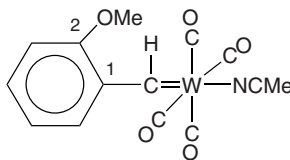
Note that the anion names given in Table IR-10.2 (methanediido, ethane-1,1-diido, *etc.*) may also be used for these ligands, but it is then not possible to communicate the concept of the carbon–metal bond as being a double or triple bond.

**Table IR-10.3** Names for ligands forming metal–carbon multiple bonds

<i>Ligand formula</i>	<i>Systematic name</i>	<i>Acceptable alternative name</i>
$\text{H}_2\text{C}=\text{}$	methylidene	
$\text{MeCH}=\text{}$	ethylidene	
$\text{H}_2\text{C}=\text{C}=\text{}$	ethenylidene	vinylidene
$\text{H}_2\text{C}=\text{HC}-\text{HC}=\text{}$	prop-2-en-1-ylidene	allylidene
$\text{H}_2\text{C}=\text{C}=\text{C}=\text{}$	propa-1,2-dien-1-ylidene	allenylidene
	propan-2-ylidene	isopropylidene
	2,2-dimethylpropylidene	
	cyclopropylidene	
	cyclobutylidene	
	cyclopenta-2,4-dien-1-ylidene	
$\text{PhHC}=\text{}$	phenylmethylidene	benzylidene
	methanylylidene	
$\text{HC}\equiv\text{}$	methylidyne	
$\text{MeC}\equiv\text{}$	ethylidyne	
$\text{EtC}\equiv\text{}$	propylidyne	
	2,2-dimethylpropylidyne	
$\text{PhC}\equiv\text{}$	phenylmethylidyne	benzylidyne

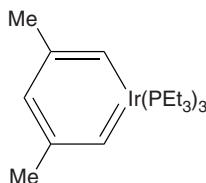
Examples:

3.



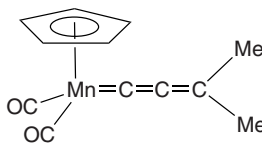
(acetonitrile)tetracarbonyl[(2-methoxyphenyl)methylidene]tungsten

4.



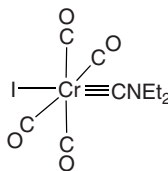
(2,4-dimethylpenta-1,3-dien-1-yl-5-ylidene)tris(triethylphosphane)iridium

5.



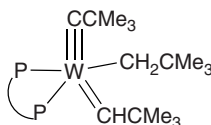
dicarbonyl(η<sup>5</sup>-cyclopentadienyl)(3-methylbuta-1,2-dien-1-ylidene)manganese

6.




tetracarbonyl[(diethylamino)methylidyne]iodidochromium

7.



(2,2-dimethylpropyl)(2,2-dimethylpropylidene)(2,2-dimethylpropylidyne)⌐  
[ethane-1,2-diylbis(dimethylphosphane-κP)]tungsten\*

 = Me<sub>2</sub>PCH<sub>2</sub>CH<sub>2</sub>PMe<sub>2</sub> = ethane-1,2-diylbis(dimethylphosphane)

#### IR-10.2.5

#### Compounds with bonds to unsaturated molecules or groups

Since the discovery of Zeise's salt, K[Pt(η<sup>2</sup>-C<sub>2</sub>H<sub>4</sub>)Cl<sub>3</sub>], the first organometallic complex of a transition element, and particularly since the first reported synthesis of ferrocene, [Fe(η<sup>5</sup>-C<sub>5</sub>H<sub>5</sub>)<sub>2</sub>], the number and variety of organometallic compounds with unsaturated organic ligands has increased enormously.

Complexes containing ligands which coordinate to a central atom with at least two adjacent atoms in a 'side-on' fashion require a special nomenclature. These ligands normally contain

\*The symbol '⌐' is used to divide the name, necessitated by the line break. In the absence of the line break this symbol is omitted. Note that all *hyphens* are true parts of the name.

groups that coordinate *via* the  $\pi$ -electrons of their multiple bonds, such as alkenes, alkynes and aromatic compounds, but they may also be carbon-free entities containing bonds between heteroelements; the complexes are then generally referred to as ' $\pi$ -complexes'. However, the exact nature of the bonding ( $\sigma$ ,  $\pi$ ,  $\delta$ ) is often uncertain. The atoms bonded to the metal atom are therefore indicated in a manner independent of theoretical implications. Thus, the use of the prefixes  $\sigma$  and  $\pi$  is not recommended in nomenclature; these symbols refer to the symmetry of orbitals and their interactions, which are irrelevant for nomenclature purposes.

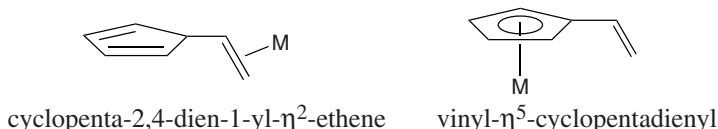
Ligands such as alkenes, alkynes, nitriles and diazenes, and others such as allyl ( $C_3H_5$ ), butadiene ( $C_4H_6$ ), cyclopentadienyl ( $C_5H_5$ ), cycloheptatrienyl ( $C_7H_7$ ) and cyclooctatetraene ( $C_8H_8$ ), may be formally regarded as anionic, neutral (or sometimes cationic). The structures of, and bonding in, their complexes may also be complicated or ill-defined. Names for such ligands are therefore chosen that indicate stoichiometric composition and are derived in a similar way to those for the ligands discussed in preceding Sections.

Ligands considered as neutral molecules are given a name according to the rules of Ref. 3, including the special nomenclature and numbering applied to fused polycyclic or unsaturated heterocyclic ligands (see Section P-25 of Ref. 3).

Ligands regarded as substituent groups derived by removing hydrogen atoms from (substituted) parent hydrides are given the substituent names ending in 'yl', 'diyl', 'ylidene', *etc.*, depending on the number of hydrogen atoms removed, again following Ref. 3 (in particular Section P-29). Ligands regarded as anions obtained by removing hydrons from (substituted) parent hydrides are given the endings 'ido', 'diido', *etc.*, depending on the number of hydrons removed.

#### IR-10.2.5.1 The eta ( $\eta$ ) convention

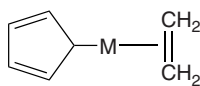
The special nature of the bonding of unsaturated hydrocarbons to metals *via* their  $\pi$ -electrons has led to the development of the 'hapto' nomenclature to designate unambiguously the unique bonding modes of the compounds so formed.<sup>4</sup> (See also Section IR-9.2.4.3.) The Greek symbol  $\eta$  (eta) provides a topological description by indicating the connectivity between the ligand and the central atom. The number of contiguous atoms in the ligand coordinated to the metal is indicated by a right superscript numeral, *e.g.*  $\eta^3$  ('eta three' or 'trihapto'),  $\eta^4$  ('eta four' or 'tetrahapto'),  $\eta^5$  ('eta five' or 'pentahapto'), *etc.* The symbol  $\eta$  is added as a prefix to the ligand name, or to that portion of the ligand name most appropriate to indicate the connectivity, as in cyclopenta-2,4-dien-1-yl- $\eta^2$ -ethene *versus* vinyl- $\eta^5$ -cyclopentadienyl:



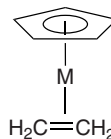
The ligand name  $\eta^5$ -cyclopentadienyl, although strictly speaking ambiguous, is acceptable as a short form of  $\eta^5$ -cyclopenta-2,4-dien-1-yl, due to common usage.

These ligand names are enclosed in parentheses in the full name of a complex. Note the importance of making rigorous use of enclosing marks, *etc.* to distinguish the above bonding modes from the other four cases below. Note also that when cyclopenta-2,4-dien-1-yl coordinates at the carbon with the free valence, a  $\kappa$  term is added for explicit indication of that bonding. In general, this is necessary with names of unsaturated ligands which may participate

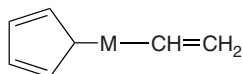
in several types of bonding (see Example 17 below, where the ligand name ends in 'yl', but the bonding is described using an  $\eta$  term placed elsewhere in the name, and Example 24, where the  $C^1$  atoms in the cyclopentadienyl ligands are involved in binding to both central atoms).



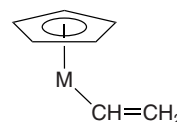
(cyclopenta-2,4-dien-1-yl- $\kappa C^1$ )( $\eta^2$ -ethene)



( $\eta^5$ -cyclopentadienyl)( $\eta^2$ -ethene)



(cyclopenta-2,4-dien-1-yl- $\kappa C^1$ )(vinyl)



( $\eta^5$ -cyclopentadienyl)(vinyl)

Complexes of unsaturated systems incorporating heteroatoms may be designated in the same manner if both the carbon atoms and adjacent heteroatoms are coordinated. Names for typical unsaturated molecules and groups acting as ligands are listed in Table IR-10.4, and this is followed by examples illustrating the naming of compounds containing such ligands. Note that when using the  $\eta$  prefixes, shorthand forms of anion and substituent group names are acceptable, *e.g.*  $\eta^5$ -cyclohexadienido instead of  $\eta^5$ -cyclohexa-2,4-dien-1-ido and  $\eta^5$ -cyclohexadienyl instead of  $\eta^5$ -cyclohexa-2,4-dien-1-yl.

**Table IR-10.4** *Ligand names for unsaturated molecules and groups*

Ligand <sup>a</sup>	Systematic name as anionic ligand	Systematic name as neutral ligand	Acceptable alternative name
	$\eta^3$ -propenido	$\eta^3$ -propenyl	$\eta^3$ -allyl
	$\eta^3$ -(Z)-butenido	$\eta^3$ -(Z)-butenyl	
	$\eta^3$ -2-methylpropenido	$\eta^3$ -2-methylpropenyl	$\eta^3$ -2-methylallyl
	$\eta^4$ -2-methylidenepropane-1,3-diido	$\eta^4$ -2-methylidenepropane-1,3-diyl	
	$\eta^3, \eta^3$ -2,3-dimethylidenebutane-1,4-diido	$\eta^3, \eta^3$ -2,3-dimethylidenebutane-1,4-diyl	$\eta^3, \eta^3$ -2,2'-bialllyl
	$\eta^5$ -(Z,Z)-pentadienido	$\eta^5$ -(Z,Z)-pentadienyl	
	$\eta^5$ -cyclopentadienido	$\eta^5$ -cyclopentadienyl	



Table IR-10.4 *Continued*

Ligand <sup>a</sup>	Systematic name as anionic ligand	Systematic name as neutral ligand	Acceptable alternative name
	pentamethyl-η <sup>5</sup> -cyclopentadienido	pentamethyl-η <sup>5</sup> -cyclopentadienyl	
	η <sup>5</sup> -cyclohexadienido	η <sup>5</sup> -cyclohexadienyl	
	η <sup>7</sup> -cycloheptatrienido	η <sup>7</sup> -cycloheptatrienyl <sup>b</sup>	
	η <sup>7</sup> -cyclooctatrienido	η <sup>7</sup> -cyclooctatrienyl <sup>c</sup>	
		1-methyl-η <sup>5</sup> -1 <i>H</i> -borole	
	η <sup>5</sup> -azacyclopentadienido	η <sup>5</sup> -azacyclopentadienyl	η <sup>5</sup> -1 <i>H</i> -pyrrolyl
	η <sup>5</sup> -phosphacyclopentadienido	η <sup>5</sup> -phosphacyclopentadienyl	η <sup>5</sup> -1 <i>H</i> -phospholyl
	η <sup>5</sup> -arsacyclopentadienido	η <sup>5</sup> -arsacyclopentadienyl	η <sup>5</sup> -1 <i>H</i> -arsolyl
	η <sup>6</sup> -borinin-1-ido		η <sup>6</sup> -boranuidabenzene <sup>d</sup>
	η <sup>6</sup> -1,4-diborinine-1,4-diido		η <sup>6</sup> -1,4-diboranuidabenzene <sup>e</sup>

<sup>a</sup> The ligands are drawn as if complexed to a metal, *i.e.* these are depictions of bonded entities, not free ligands. The arcs used in these and later examples indicate delocalization (by analogy with the circle in benzene).

<sup>b</sup> The name η<sup>7</sup>-troyl has been used previously but is no longer acceptable.

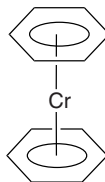
<sup>c</sup> The name η<sup>7</sup>-homotroyl has been used previously but is no longer acceptable.

<sup>d</sup> The name η<sup>6</sup>-boratabenzene has been used previously but is no longer acceptable.

<sup>e</sup> The name η<sup>6</sup>-1,4-diboratabenzene has been used previously but is no longer acceptable.

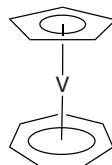
Examples:

1.



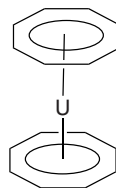
bis( $\eta^6$ -benzene)chromium

2.



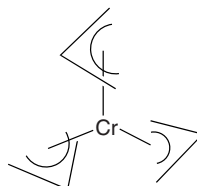
( $\eta^7$ -cycloheptatrienyl)( $\eta^5$ -cyclopentadienyl)vanadium

3.



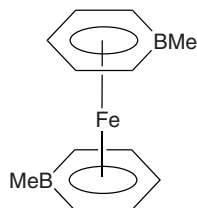
bis( $\eta^8$ -cyclooctatetraene)uranium (*cf.* Section IR-10.2.6)

4.



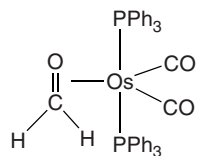
tris( $\eta^3$ -allyl)chromium

5.



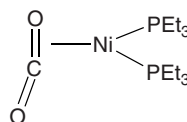
bis( $\eta^6$ -1-methyl-1-boranidabenzene)iron

6.

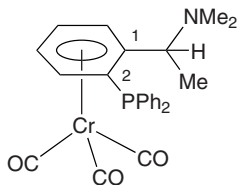


dicarbonyl( $\eta^2$ -formaldehyde)bis(triphenylphosphane)osmium

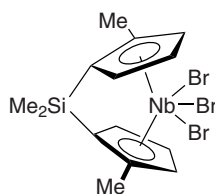
7.

(η<sup>2</sup>-carbon dioxide)bis(triethylphosphane)nickel

8.

tricarbonyl{*N,N*-dimethyl-1-[2-(diphenylphosphanyl)- $\eta^6$ -phenyl]ethane-1-amine}chromium

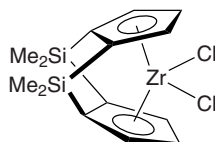
9.

tribromido[1,1'-(dimethylsilanediyl)bis(2-methyl- $\eta^5$ -cyclopentadienyl)]niobium

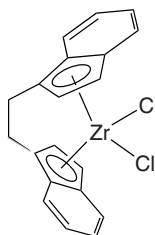
If not all unsaturated atoms of a ligand are involved in bonding, if a ligand can adopt several bonding modes, or if a ligand bridges several metal atoms, the locants of the ligating atoms appear in a numerical sequence before the symbol  $\eta$ , which is preceded by a hyphen. Extended coordination over more than two contiguous carbon atoms should be indicated by, for example, (1–4- $\eta$ ) rather than by (1,2,3,4- $\eta$ ). The locants and the symbol  $\eta$  are enclosed in parentheses. No superscript on the symbol  $\eta$  is then necessary.

*Examples:*

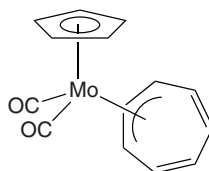
10.

dichlorido[(1–3,3a,8a:4a,5–7,7a- $\eta$ )-4,4,8,8-tetramethyl-1,4,5,8-tetrahydro-4,8-disila-*s*-indacene-1,5-diyl]zirconium

11.

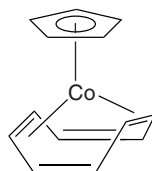
dichlorido[1,1'-(ethane-1,2-diyl)bis(1–3,3a,7a- $\eta$ -1*H*-inden-1-yl)]zirconium

12.



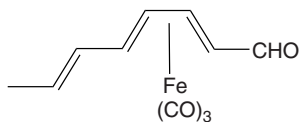
dicarbonyl[(1-3- $\eta$ )-cyclohepta-2,4,6-trien-1-yl]( $\eta^5$ -cyclopentadienyl)molybdenum

13.



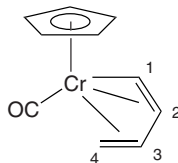
[(1,2,5,6- $\eta$ )-cyclooctatetraene]( $\eta^5$ -cyclopentadienyl)cobalt

14.



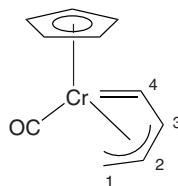
tricarbonyl[(2-5- $\eta$ )-(E,E,E)-octa-2,4,6-trienal]iron

15.



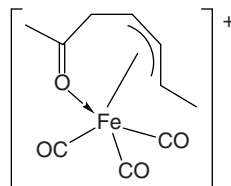
( $\eta^4$ -buta-1,3-dien-1-yl- $\kappa C^1$ )carbonyl( $\eta^5$ -cyclopentadienyl)chromium

16.



[(1-3- $\eta$ )-but-2-en-1-yl-4-ylidene- $\kappa C^4$ ]carbonyl( $\eta^5$ -cyclopentadienyl)chromium

17.



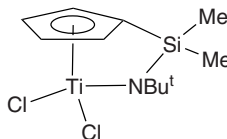
tricarbonyl[6-oxo- $\kappa O$ -(2-4- $\eta$ )-hept-3-en-2-yl]iron(1+)

As indicated in the previous example, the  $\eta$  symbol can, if necessary, be combined with the  $\kappa$  symbol (see Section IR-10.2.3.3). The symbol  $\eta$  then precedes the ligand name while the  $\kappa$  symbol is either placed at the end of the ligand name or, for more complicated structures,

after that portion of the ligand name which denotes the particular function in which the ligating atom is found.

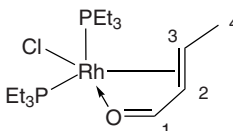
*Examples:*

18.



*[N-tert-butyl(η<sup>5</sup>-cyclopentadienyl)dimethylsilanaminido-κN]dichloridotitanium*

19.

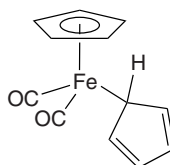


*[(E)-η<sup>2</sup>-but-2-enal-κO]chloridobis(triethylphosphane)rhodium*

The symbol  $\eta^1$  is not used. For a cyclopentadienyl ligand bonded by only one  $\sigma$ -bond one uses cyclopenta-2,4-dien-1-yl or cyclopenta-2,4-dien-1-yl- $\kappa C^1$ .

*Example:*

20.

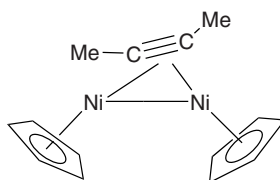


*dicarbonyl(η<sup>5</sup>-cyclopentadienyl)(cyclopenta-2,4-dien-1-yl-κC<sup>1</sup>)iron*

If an unsaturated hydrocarbon serves as a bridging ligand, the prefix  $\mu$  (see Sections IR-10.2.3.1 and IR-10.2.3.4) is combined with both  $\eta$  and  $\kappa$ , where necessary. The colon is used to separate the locants of the bridging ligand which indicate binding to different metal atoms. The metal atoms are numbered according to the rules given in Section IR-9.2.5.6, and their numbers are placed before the  $\eta$  and  $\kappa$  symbols with no hyphens. If ligand locants are also specified, these are separated from the  $\eta$  symbol by a hyphen and the whole expression is enclosed in parentheses, as in 1(2-4- $\eta$ ).

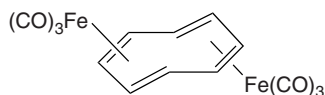
*Examples:*

21.



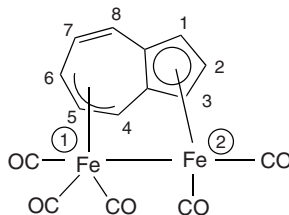
*(μ-η<sup>2</sup>:η<sup>2</sup>-but-2-yne)bis[(η<sup>5</sup>-cyclopentadienyl)nickel](Ni—Ni)*

22.



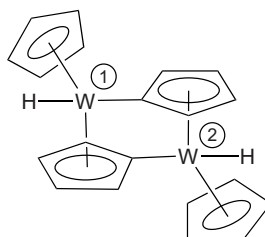
*trans*-[μ-(1-4-η:5-8-η)-cyclooctatetraene]bis(tricarbonyliron)

23.



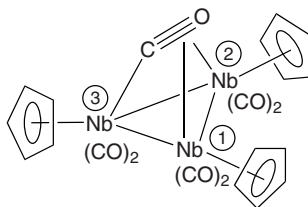
{μ-[2(1-3,3a,8a-η):1(4-6-η)]azulene}(pentacarbonyl-1κ<sup>3</sup>C,2κ<sup>2</sup>C)diiron(*Fe*—*Fe*)

24.



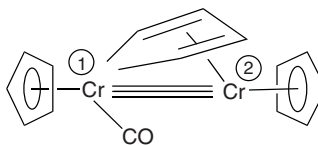
(μ-1η<sup>5</sup>-cyclopenta-2,4-diene-1,1-diyl-2κC)(μ-2η<sup>5</sup>-cyclopenta-2,4-diene-1,1-diyl-1κC)bis[(η<sup>5</sup>-cyclopentadienyl)hydridotungsten]

25.



μ<sub>3</sub>-1η<sup>2</sup>:2η<sup>2</sup>-carbonyl-3κC-*triangular*-tris[dicarbonyl(η<sup>5</sup>-cyclopentadienyl)niobium](3 *Nb*—*Nb*)

26.

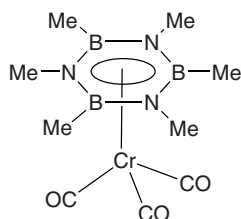


(μ-2η<sup>4</sup>-buta-1,3-diene-1,4-diyl-1κ<sup>2</sup>C<sup>1</sup>,C<sup>4</sup>)carbonyl-1κC-bis[(η<sup>5</sup>-cyclopentadienyl)chromium](*Cr*—*Cr*)

The eta convention can also be extended to π-coordinated ligands containing no carbon atoms, such as cyclotriborazane and pentaphosphole ligands.

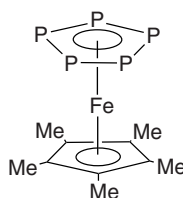
Examples:

27.



tricarbonyl( $\eta^6$ -hexamethyl-1,3,5,2,4,6-triazatriborinane)chromium,  
or tricarbonyl( $\eta^6$ -hexamethylcyclotriborazane)chromium

28.

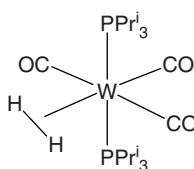


(pentamethyl- $\eta^5$ -cyclopentadienyl)( $\eta^5$ -pentaphospholyl)iron

This convention may also be used for ligands in which  $\sigma$ -bonds are coordinated in a side-on fashion, such as the H-H bond in complexes of dihydrogen (*i.e.*  $\eta^2$ -H<sub>2</sub>)<sup>5</sup> or the saturated C-H bonds in 'agostic' interactions.<sup>6</sup> The  $\eta$  symbol and locants for agostic interactions are placed separately from other locants at the end of the ligand name. In Example 30 the agostic bond is denoted by a half arrow.

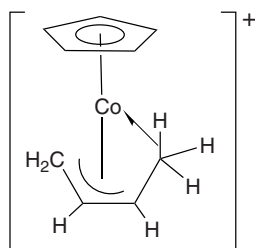
Examples:

29.



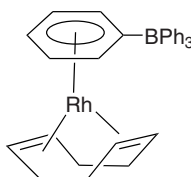
tricarbonyl( $\eta^2$ -dihydrogen)bis(triisopropylphosphane)tungsten

30.



[(1-3- $\eta$ )-but-2-en-1-yl- $\eta^2$ -C<sup>4</sup>,H<sup>4</sup>]( $\eta^5$ -cyclopentadienyl)cobalt(1+)

31.



( $\eta^2, \eta^2$ -cycloocta-1,5-diene)( $\eta^6$ -phenyltriphenylborato)rhodium, or  
 [(1,2,5,6- $\eta$ )-cycloocta-1,5-diene]( $\eta^6$ -phenyltriphenylboranuido)rhodium

## IR-10.2.6

**Metallocene nomenclature**

The first transition element compound containing only carbocyclic rings as ligands was bis( $\eta^5$ -cyclopentadienyl)iron,  $[\text{Fe}(\eta^5\text{-C}_5\text{H}_5)_2]$ , which has a 'sandwich' structure with two parallel  $\eta^5$ - or  $\pi$ -bonded rings. The recognition that this compound was amenable to electrophilic substitution, similar to the aromatic behaviour of benzene, led to the suggestion of the non-systematic name 'ferrocene' and to similar names for other 'metallocenes'.

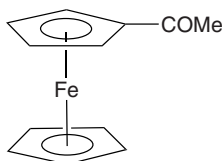
*Examples:*

- |                                                 |             |
|-------------------------------------------------|-------------|
| 1. $[\text{V}(\eta^5\text{-C}_5\text{H}_5)_2]$  | vanadocene  |
| 2. $[\text{Cr}(\eta^5\text{-C}_5\text{H}_5)_2]$ | chromocene  |
| 3. $[\text{Co}(\eta^5\text{-C}_5\text{H}_5)_2]$ | cobaltocene |
| 4. $[\text{Ni}(\eta^5\text{-C}_5\text{H}_5)_2]$ | nickelocene |
| 5. $[\text{Ru}(\eta^5\text{-C}_5\text{H}_5)_2]$ | ruthenocene |
| 6. $[\text{Os}(\eta^5\text{-C}_5\text{H}_5)_2]$ | osmocene    |

Metallocene derivatives may be named either by the standard organic suffix (functional) nomenclature or by prefix nomenclature. The organic functional suffix system is described in Section P-33 of Ref. 3. Metallocene substituent group names have endings 'ocenyl', 'ocenediyl', 'ocenetriyl', *etc.*

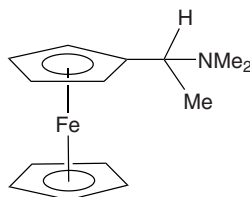
*Examples:*

7.



acetylferrocene, or 1-ferrocenylethan-1-one

8.



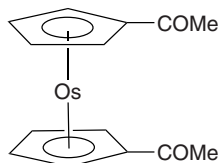
1-[1-(dimethylamino)ethyl]ferrocene, or  
 1-ferrocenyl-*N,N*-dimethylethan-1-amine



Substituents on the equivalent cyclopentadienyl rings of the metallocene entity are given the lowest possible numerical locants in the usual manner. The first ring is numbered 1–5 and the second ring 1'–5' (see Examples 9 and 10).

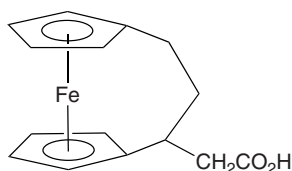
*Examples:*

9.



1,1'-diacetylosmocene, or 1,1'-(osmocene-1,1'-diyl)bis(ethan-1-one)

10.



1,1'-(4-carboxybutane-1,3-diyl)ferrocene, or  
3,5-(ferrocene-1,1'-diyl)pentanoic acid

11.  $[\text{Ru}(\eta^5\text{-C}_5\text{Me}_5)_2]$

decamethylruthenocene, or  
bis(pentamethyl- $\eta^5$ -cyclopentadienyl)ruthenium

12.  $[\text{Cr}(\eta^5\text{-C}_5\text{Me}_4\text{Et})_2]$

1,1'-diethyloctamethylchromocene, or  
bis(1-ethyl-2,3,4,5-tetramethyl- $\eta^5$ -cyclopentadienyl)chromium

13.  $[\text{Co}(\eta^5\text{-C}_5\text{H}_4\text{PPh}_2)_2]$

1,1'-bis(diphenylphosphanyl)cobaltocene, or  
(cobaltocene-1,1'-diyl)bis(diphenylphosphane)

Metallocene nomenclature does not, however, apply to all transition elements. For example, there are at least two isomers with the empirical formula  $\text{C}_{10}\text{H}_{10}\text{Ti}$  but neither has the regular sandwich structure analogous to that of ferrocene, and so neither should be named 'titanocene'. Similarly, 'manganocene' is a misnomer for  $[\text{Mn}(\eta^5\text{-C}_5\text{H}_5)_2]$  since it has a chain structure in the solid state, with no individual sandwich entities. However, decamethylmanganocene,  $[\text{Mn}(\eta^5\text{-C}_5\text{Me}_5)_2]$ , has a normal sandwich structure, as does decamethylrhencene,  $[\text{Re}(\eta^5\text{-C}_5\text{Me}_5)_2]$ . With increasing atomic number, the occurrence of the classic ferrocene-type bis( $\eta^5$ -cyclopentadienyl) sandwich structure becomes rare.

The name-ending 'ocene' should therefore be confined to discrete molecules of the form bis( $\eta^5$ -cyclopentadienyl)metal (and ring-substituted analogues), where the cyclopentadienyl rings are essentially parallel, and the metal is in the d-block [*i.e.* the terminology does not apply to compounds of the s- or p-block elements such as  $\text{Ba}(\text{C}_5\text{H}_5)_2$  or  $\text{Sn}(\text{C}_5\text{H}_5)_2$ ].

The oxidized species have been referred to as metallocenium( $n+$ ) salts, although it should be noted that in this case the ending 'ium' does not carry the usual meaning it has in substitutive nomenclature, *i.e.* the addition of a hydron to a neutral parent compound.

To avoid this ambiguity, the name bis( $\eta^5$ -cyclopentadienyl)iron(1+), for example, is strongly preferred to ferrocenium(1+) for  $[\text{Fe}(\eta^5\text{-C}_5\text{H}_5)_2]^+$ . The same comment applies to substituted derivatives.

*Examples:*

14.  $[\text{Co}(\eta^5\text{-C}_5\text{H}_5)_2][\text{PF}_6]$   
bis( $\eta^5$ -cyclopentadienyl)cobalt(1+) hexafluoridophosphate
15.  $[\text{Co}(\eta^5\text{-C}_5\text{H}_5)(\eta^5\text{-C}_5\text{H}_4\text{COMe})][\text{BF}_4]$   
(acetyl- $\eta^5$ -cyclopentadienyl)( $\eta^5$ -cyclopentadienyl)cobalt(1+)  
tetrafluoridoborate

The oxidized form of osmocene is dinuclear in the solid state, with a long Os–Os bond, so should not in any case be named using the ‘ocenium’ nomenclature. However,  $[\text{Os}(\eta^5\text{-C}_5\text{Me}_5)_2]^+$  has a mononuclear sandwich structure and may be described as the decamethyl-osmocenium(1+) ion, although bis(pentamethyl- $\eta^5$ -cyclopentadienyl)osmium(1+) is strongly preferred.

In strong protic acid media, ferrocene is hydronated to  $[\text{Fe}(\eta^5\text{-C}_5\text{H}_5)_2\text{H}]^+$ . To avoid ambiguities, this should be named by the additive procedure, *i.e.* bis( $\eta^5$ -cyclopentadienyl)hydridoiron(1+).

Transition element complexes derived from ligands with additional rings fused to the cyclopentadienyl rings are also known. The names of these complexes are derived from the retained common or semisystematic names of the hydrocarbon ligands, *e.g.* 1*H*-inden-1-yl ( $\text{C}_9\text{H}_7$ ), fluoren-9-yl ( $\text{C}_{13}\text{H}_9$ ), and azulene ( $\text{C}_{10}\text{H}_8$ ). Thus,  $[\text{Fe}(\eta^5\text{-C}_9\text{H}_7)_2]$  is named bis( $\eta^5$ -indenyl)iron or, more specifically, bis[(1-3,3a,7a- $\eta$ )-1*H*-inden-1-yl]iron. To avoid possible ambiguities, the use of fusion nomenclature, such as ‘benzoferrrocene’, is strongly discouraged.

Many compounds have ligands in addition to two  $\eta^5$ -cyclopentadienyl rings. They are often referred to as metallocene di(ligand) species, *e.g.*  $[\text{Ti}(\eta^5\text{-C}_5\text{H}_5)_2\text{Cl}_2]$  is frequently named ‘titanocene dichloride’. This practice is discouraged since metallocene nomenclature applies only to compounds in which the two rings are parallel. Thus,  $[\text{Ti}(\eta^5\text{-C}_5\text{H}_5)_2\text{Cl}_2]$  is named dichloridobis( $\eta^5$ -cyclopentadienyl)titanium, and  $[\text{W}(\eta^5\text{-C}_5\text{H}_5)_2\text{H}_2]$ ,  $[\text{Ti}(\text{CO})_2(\eta^5\text{-C}_5\text{H}_5)_2]$  and  $[\text{Zr}(\eta^5\text{-C}_5\text{H}_5)_2\text{Me}_2]$  should be named bis( $\eta^5$ -cyclopentadienyl)dihydridotungsten, dicarbonylbis( $\eta^5$ -cyclopentadienyl)titanium and bis( $\eta^5$ -cyclopentadienyl)dimethylzirconium, respectively.

The bis(cyclooctatetraene) compound  $[\text{U}(\eta^8\text{-C}_8\text{H}_8)_2]$  has sometimes been described as ‘uranocene’. Related species are obtained from zirconium,  $[\text{Zr}(\eta^8\text{-C}_8\text{H}_8)_2]$ , and the lanthanoids, *e.g.*  $[\text{Ce}(\eta^8\text{-C}_8\text{H}_8)_2]^-$ . In such complexes, the carbocyclic rings are parallel and there are certain similarities to ferrocene in the molecular orbital descriptions of their bonding. However, some lanthanoids also form metal(II) cyclopentadienyl complexes, such as  $[\text{Sm}(\eta^5\text{-C}_5\text{Me}_5)_2]$ . Extension of the ‘ocene’ nomenclature to  $[\text{U}(\eta^8\text{-C}_8\text{H}_8)_2]$  and similar compounds can therefore lead to confusion and is strongly discouraged.

Furthermore, the cyclooctatetraene ring can also function as an  $\eta^4$ -ligand, as in  $[\text{Ti}(\eta^4\text{-C}_8\text{H}_8)(\eta^8\text{-C}_8\text{H}_8)]$ . Compounds of cyclooctatetraene should therefore be named using standard organometallic nomenclature, *e.g.* bis( $\eta^8$ -cyclooctatetraene)uranium and [(1-4- $\eta$ )-cyclooctatetraene]( $\eta^8$ -cyclooctatetraene)titanium. The ligand  $\text{C}_8\text{H}_8^{2-}$  is occasionally

referred to as ‘cyclooctatetraenyl’. This name is incorrect as it can only be used for the (as yet hypothetical) ligand  $C_8H_7$ .

## IR-10.3 NOMENCLATURE OF ORGANOMETALLIC COMPOUNDS OF THE MAIN GROUP ELEMENTS

### IR-10.3.1 Introduction

The nomenclature of organometallic compounds of the main group elements is an area of current and ongoing development. This section briefly describes key aspects of the naming of such compounds, leaving a full treatment of the subject to a future IUPAC project. Detailed information on the nomenclature of organic compounds containing the elements of groups 13–16 may be found in Sections P-68 and P-69 of Ref. 3.

In principle, all organometallic compounds, whether of the transition or main group elements, can be given names based on the additive system of nomenclature that is applied to coordination compounds, provided the constitution of the compound is known. Examples of such names were given in Sections IR-7.2 and IR-7.3. In addition, compounds of elements such as boron, silicon, arsenic and selenium are often considered to be organometallic, and are commonly named by notionally substituting the hydrogen atoms of the parent hydride with the appropriate substituent groups.

If a choice must be made, it is recommended here that organometallic compounds derived from the elements of groups 13–16 be named by a substitutive process, while those derived from the elements of groups 1 and 2 be named using the additive system of nomenclature or in some cases just compositional nomenclature if less structural information is to be conveyed. Where an organometallic compound contains two or more central atoms (which may be associated with different nomenclature systems according to the above recommendation), a choice must again be made to provide the basis of the name. A general rule is recommended in Section IR-10.4.

### IR-10.3.2 Organometallic compounds of groups 1 and 2

Organometallic compounds of the elements of groups 1 and 2 with a defined coordination structure are named according to the additive system of nomenclature, the general definitions and rules of which are given in Chapter IR-7 and Sections IR-9.1 and IR-9.2. Thus, prefixes denoting the organic groups and any other ligands are placed in alphabetical order before the name of the metal. These prefixes may adopt either the additive ‘ido’, ‘diido’, *etc.* endings or, in the case of hydrocarbyl groups, the substitutive ‘yl’, ‘diyl’, *etc.* endings (see Sections IR-10.2.2 and IR-10.2.3). The latter practice allows names in common usage for organic groups to be applied unchanged. The presence of a hydrogen atom attached to the metal centre must always be indicated (by the prefix ‘hydrido’) and the name of a cyclic compound with the central atom in the ring may be formed using appropriate locants of a divalent ‘diido’ or ‘diyl’ group to indicate chelate-type bonding to the metal, as in Example 5 below.

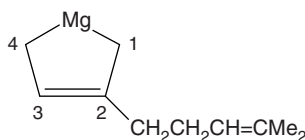
Many organometallic compounds of groups 1 and 2 exist in associated molecular form (as aggregates) or contain structural solvent, or both. However, their names are often based solely on the stoichiometric compositions of the compounds, unless it is specifically desired to draw attention to the extent of aggregation or the nature of any structural solvent, or both (see Example 3 below). In the examples below, note how the different types of name reflect the different structural content implied by the formulae shown. As usual, the formulae enclosed in square brackets designate coordination entities.

Note that metallocene terminology (Section IR-10.2.6) is not recommended for bis(cyclopentadienyl) compounds of the main group metals (see Examples 6 and 7).

*Examples:*

1. [BeEtH]  
ethylhydridoberyllium, or ethanidohydridoberyllium
2. Na(CHCH<sub>2</sub>)  
sodium ethenide (compositional name)  
Na-CH=CH<sub>2</sub>, or [Na(CH=CH<sub>2</sub>)]  
ethenidosodium, ethenylsodium, or vinylsodium
3. [{Li(OEt<sub>2</sub>)(μ<sub>3</sub>-Ph)}<sub>4</sub>]  
tetrakis[(ethoxyethane)(μ<sub>3</sub>-phenyl)lithium], or  
tetrakis[(μ<sub>3</sub>-benzenido)(ethoxyethane)lithium]
4. 2Na<sup>+</sup>(Ph<sub>2</sub>CCPh<sub>2</sub>)<sup>2-</sup>  
disodium 1,1,2,2-tetraphenylethane-1,2-diide (compositional name)  
Ph<sub>2</sub>C(Na)-C(Na)Ph<sub>2</sub>  
(μ-1,1,2,2-tetraphenylethane-1,2-diyl)disodium, or  
(μ-1,1,2,2-tetraphenylethane-1,2-diido-κ<sup>2</sup>C<sup>1</sup>,C<sup>2</sup>)disodium

5.



[2-(4-methylpent-3-en-1-yl)but-2-ene-1,4-diyl]magnesium, or  
[2-(4-methylpent-3-en-1-yl)but-2-ene-1,4-diido-κ<sup>2</sup>C<sup>1</sup>,C<sup>4</sup>]magnesium

6. [Mg(η<sup>5</sup>-C<sub>5</sub>H<sub>5</sub>)<sub>2</sub>]  
bis(η<sup>5</sup>-cyclopentadienyl)magnesium, or  
bis(η<sup>5</sup>-cyclopentadienido)magnesium
7. [PPh<sub>4</sub>][Li(η<sup>5</sup>-C<sub>5</sub>H<sub>5</sub>)<sub>2</sub>]  
tetraphenylphosphonium bis(η<sup>5</sup>-cyclopentadienyl)lithate(1-), or  
tetraphenylphosphonium bis(η<sup>5</sup>-cyclopentadienido)lithate(1-)
8. LiMe                      lithium methanide (compositional name)  
[LiMe]                    methyllithium  
[(LiMe)<sub>4</sub>]                tetra-μ<sub>3</sub>-methyl-tetalithium  
(LiMe)<sub>n</sub>                    poly(methyllithium)

9. MgI<sub>2</sub>

magnesium iodide methanide (compositional name)



iodido(methanido)magnesium (additive name of coordination type)



methylmagnesium iodide (compositional name with formally electropositive component named using additive nomenclature)



poly[iodido(methanido)magnesium], or poly[iodido(methyl)magnesium]

## IR-10.3.3 Organometallic compounds of groups 13–16

Organometallic compounds of the elements of groups 13–16 are named according to the substitutive system of nomenclature, dealt with in Chapter IR-6. Thus, the name of the parent hydride (formed in accordance with the rules of Section IR-6.2) is modified by a prefix for each substituent replacing a hydrogen atom of the parent hydride. The prefix should be in appropriate substituent form (chloro, methyl, sulfanylidene, *etc.*) and not in ligand form (chlorido, methanido, sulfido, *etc.*).

Where there is more than one kind of substituent, the prefixes are cited in alphabetical order before the name of the parent hydride, parentheses being used to avoid ambiguity, and multiplicative prefixes being used as necessary. Non-standard bonding numbers are indicated using the  $\lambda$ -convention (see Section IR-6.2.2.2). An overview of the rules for naming substituted derivatives of parent hydrides is given in Section IR-6.3, while a detailed exposition may be found in Ref. 3.

*Examples:*

1.  $\text{AlH}_2\text{Me}$  methylalumane
2.  $\text{AlEt}_3$  triethylalumane
3.  $\text{Me}_2\text{CHCH}_2\text{CH}_2\text{In}(\text{H})\text{CH}_2\text{CH}_2\text{CHMe}_2$   
bis(3-methylbutyl)indigane
4.  $\text{Sb}(\text{CH}=\text{CH}_2)_3$  triethenylstibane, or trivinylstibane
5.  $\text{SbMe}_5$  pentamethyl- $\lambda^5$ -stibane
6.  $\text{PhSb}=\text{SbPh}$  diphenyldistibene
7.  $\text{GeCl}_2\text{Me}_2$  dichlorodimethylgermane
8.  $\text{GeMe}(\text{SMe})_3$  methyltris(methylsulfanyl)germane
9.  $\text{BiI}_2\text{Ph}$  diiodo(phenyl)bismuthane
10.  $\text{Et}_3\text{PbPbEt}_3$  hexaethyldiplumbane
11.  $\text{SnMe}_2$  dimethyl- $\lambda^2$ -stannane
12.  $\text{BrSnH}_2\text{SnCl}_2\text{SnH}_2(\text{CH}_2\text{CH}_2\text{CH}_3)$   
1-bromo-2,2-dichloro-3-propyltristannane
13.  $\text{Me}_3\text{SnCH}_2\text{CH}_2\text{C}\equiv\text{CSnMe}_3$   
but-1-yne-1,4-diylbis(trimethylstannane)

In the presence of one or more characteristic groups that may be expressed using one or more suffixes ( $-\text{NH}_2$ ,  $-\text{OH}$ ,  $-\text{COOH}$ , *etc.*), the name of the parent hydride carrying the highest-ranking such group is modified by the suffix, and other substituents are then denoted by prefixes as described in Section IR-6.3.1. If acting as a substituent, the group 13–16 parent hydride name in question is modified by changing the ending ‘ane’ to ‘anyl’ (or ‘yl’ for the group 14 elements), ‘anediyl’, *etc.*

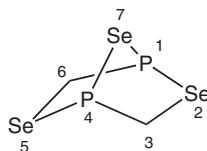
*Examples:*

14.  $(\text{EtO})_3\text{GeCH}_2\text{CH}_2\text{COOMe}$   
methyl 3-(triethoxygermyl)propanoate
15.  $\text{H}_2\text{As}(\text{CH}_2)_4\text{SO}_2\text{Cl}$   
4-arsanylbutane-1-sulfonyl chloride
16.  $\text{OCHCH}_2\text{CH}_2\text{GeMe}_2\text{GeMe}_2\text{CH}_2\text{CH}_2\text{CHO}$   
3,3'-(1,1,2,2-tetramethyldigermane-1,2-diyl)dipropenal
17.  $\text{SiMe}_3\text{NH}_2$                       trimethylsilanamine

Sometimes it may be necessary or preferable to consider a parent hydride in which several (four or more) skeletal carbon atoms of a hydrocarbon have been replaced by main group elements. In this method of skeletal replacement the heteroatoms are designated by the ‘a’ terms of replacement nomenclature (Table X) cited in the order given by Table VI and preceded by the appropriate locant(s). The rules for locant numbering are specified in Section IR-6.2.4.1 and this nomenclature is fully described in Sections P-21.2 and P-22.2 of Ref. 3.

*Examples:*

18.  $\overset{2}{\text{Me}}\overset{3}{\text{SiH}_2}\overset{4}{\text{CH}_2}\overset{5}{\text{CH}_2}\overset{6}{\text{SiH}_2}\overset{7}{\text{CH}_2}\overset{8}{\text{CH}_2}\overset{9}{\text{SiH}_2}\overset{10}{\text{CH}_2}\overset{11}{\text{CH}_2}\overset{11}{\text{SiH}_2}\text{Me}$   
2,5,8,11-tetrasiladodecane
19.  $\overset{2}{\text{Me}}\overset{3}{\text{SiH}_2}\overset{4}{\text{OP}}(\text{H})\overset{5}{\text{OCH}_2}\text{Me}$   
3,5-dioxa-4-phospha-2-silaheptane
20.  $\overset{1}{\text{HSCH}}=\overset{2}{\text{NO}}\overset{3}{\text{CH}_2}\overset{4}{\text{Se}}\overset{5}{\text{CH}_2}\overset{6}{\text{ONH}}\overset{7}{\text{Me}}$   
3,7-dioxa-5-selena-2,8-diazanon-1-ene-1-thiol
- 21.



2,5,7-triselena-1,4-diphosphabicyclo[2.2.1]heptane

When elements from groups 13–16 replace carbon atoms in monocyclic systems, the resulting structures may be named using the extended Hantzsch–Widman procedures. This

nomenclature is fully described in Section IR-6.2.4.3 and in Section P-22.2 of Ref. 3 and will not be elaborated further here.

Sections P-68 and P-69 of Ref. 3 offer a more comprehensive treatment of the nomenclature of organic compounds containing the elements of groups 13–16.

## IR-10.4 ORDERING OF CENTRAL ATOMS IN POLYNUCLEAR ORGANOMETALLIC COMPOUNDS

When an organometallic compound contains two or more different metal atoms, a choice must be made to provide the basis of the name. It is thus convenient to classify the possible central atoms as belonging to either (i) the elements of groups 1–12 (whose compounds are named according to the additive system of nomenclature) or (ii) the elements of groups 13–16 (whose compounds are named according to the substitutive system).

### IR-10.4.1 Central atoms from groups 1–12 only

If both or all potential central atoms belong to class (i), then the compound is named additively using the methodology described in Section IR-9.2.5, including the rules given there for ordering the central atoms. Ferrocenyllithium (ferrocenyl, see Section IR-10.2.6) could thus be systematically named:



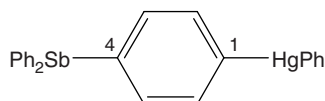
a name which also illustrates the use of the  $\kappa$  and  $\eta$  conventions. Further examples in which both or all central atoms belong to class (i) are given in Sections IR-10.2.3.4, IR-10.2.3.5 and IR-10.2.5.1.

### IR-10.4.2 Central atoms from both groups 1–12 and groups 13–16

If at least one possible central atom belongs to class (i) and one or more others to class (ii), then the compound is named additively using the metal atom(s) of class (i) as central atom(s). The remaining atoms of the complex are named as ligands by rules already presented (Sections IR-9.1, IR-9.2 and IR-10.2.1 to IR-10.2.5).

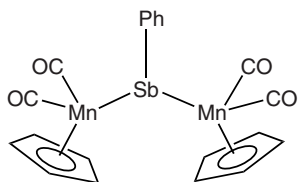
*Examples:*

1.  $[\text{Li}(\text{GePh}_3)]$  (triphenylgermyl)lithium
2.  $(\text{Me}_3\text{Si})_3\text{CMgC}(\text{SiMe}_3)_3$   
bis[tris(trimethylsilyl)methyl]magnesium
3.  $[\text{Mo}(\text{CO})_5(=\text{Sn}\{\text{CH}(\text{SiMe}_3)_2\}_2)]$   
{bis[bis(trimethylsilyl)methyl]- $\lambda^2$ -stannylidene}pentacarbonylmolybdenum
- 4.



[4-(diphenylstibanyl)phenyl](phenyl)mercury

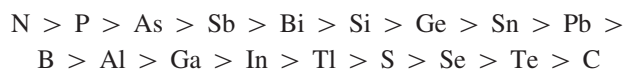
5.

(phenylstibanediy)bis[dicarbonyl( $\eta^5$ -cyclopentadienyl)manganese]

## IR-10.4.3

**Central atoms from groups 13–16 only**

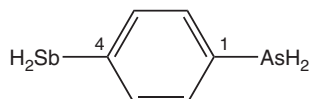
If the possible central atoms are both or all from class (ii), then the compound is named substitutively as described in Section IR-10.3.3 (and in more detail in Section IR-6.3). The parent hydride is chosen on the basis of the following element order ('>' meaning 'chosen before', cf. Section P-41 of Ref. 3):



Thus, for a compound containing both arsenic and lead, the parent hydride would be selected as  $\text{AsH}_3$ , rather than  $\text{PbH}_4$ , the lead atom then appearing in the name as a prefixed substituent, often with its own substituent groups.

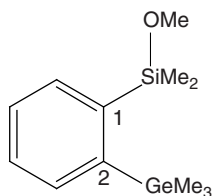
*Examples:*1.  $\text{As}(\text{PbEt}_3)_3$  tris(triethylplumbyl)arsane

2.



(4-stibanylphenyl)arsane

3.



methoxydimethyl[2-(trimethylgermyl)phenyl]silane

4.  $\text{Et}_3\text{PbCH}_2\text{CH}_2\text{CH}_2\text{BiPh}_2$ 

diphenyl[3-(triethylplumbyl)propyl]bismuthane

5.  $\text{SiClH}_2\text{Sn}(\text{Me})=\text{Sn}(\text{Me})\text{SiClH}_2$ *Si, Si'*-(1,2-dimethyldistannene-1,2-diyl)bis(chlorosilane)

## IR-10.5

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# IR-11 Solids

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## IR-11.1 INTRODUCTION

IR-11.1.1 **General**

This chapter deals with some aspects of terminology, nomenclature and notation for solids. However, in cases where detailed structural information is to be conveyed, fully systematic names can be difficult to construct. An attempt to deal with this problem is described in Ref. 1.

IR-11.1.2 **Stoichiometric and non-stoichiometric phases**

In binary and multi-component systems, intermediate crystalline phases (stable or metastable) may occur. Thermodynamically, the composition of any such phase is variable. In some cases, such as sodium chloride, the possible variation in composition is very small. Such phases are called stoichiometric. However, in other phases appreciable variations in composition can occur, for example in wustite (nominally FeO).

These are called non-stoichiometric phases. In general, it is possible to define an ideal composition relative to which the variations occur. This composition, called the stoichiometric composition, is usually that in which the ratio of the numbers of different atoms corresponds to the ratio of the numbers of normal crystallographic sites of different types in the ideal (ordered) crystal.

This concept can be used even when the stoichiometric composition is not included in the homogeneity range of the phase. The term 'non-stoichiometric' does not mean phases with complex formulae, but those with *variable composition*, for which the term *solid mixture* is an alternative. Formerly, the term *solid solution* was used, but this term is recommended to apply only in the following sense.<sup>2-4</sup> *Mixture* is used to describe a solid phase containing more than one substance, when all substances are treated in the same way. *Solution* is used to describe a liquid or solid phase containing more than one substance when, for convenience, one (or more) of the substances, called the *solvent*, is treated differently from the other substances, called *solutes*. For non-stoichiometric phases, each atom or group of atoms that contributes to the non-stoichiometry is treated equally, so the term *mixture* is appropriate.

## IR-11.2 NAMES OF SOLID PHASES

IR-11.2.1 **General**

Names for stoichiometric phases, such as NaCl, are derived simply as in Chapter IR-5, whereas formulae are derived as presented in Chapter IR-4. Although NaCl in the solid state consists of an infinite network of units,  $(\text{NaCl})_\infty$ , the compound is named sodium chloride and represented symbolically as NaCl.

However, for non-stoichiometric phases and solid solutions, formulae are preferable to names, since strictly systematic names tend to be inconveniently cumbersome. They should be used only when unavoidable (*e.g.* for indexing) and should be constructed in the following style.

*Examples:*

1. iron(II) sulfide (iron deficient)
2. molybdenum dicarbide (carbon excess)

**IR-11.2.2 Mineral names**

Mineral names should be used only to designate actual minerals and not to define chemical composition. Thus, the name calcite refers to a particular mineral (contrasted with other minerals of similar composition) and is not a term for the chemical compound the composition of which is properly expressed by the name calcium carbonate.

A mineral name may, however, be used to indicate the structure type. Where possible, a name that refers to a general group should replace a more specific name. For example, large numbers of minerals have been named that are all spinels, but which have widely differing atomic constituents. In this case, the generic name '*spinel* type' should be used rather than the more specific names chromite, magnetite, *etc.* The generic mineral name, printed in italics, should be accompanied by a representative chemical formula. This is particularly important for *zeolite* types.<sup>5</sup>

*Examples:*

1.  $\text{FeCr}_2\text{O}_4$  (*spinel* type)
2.  $\text{BaTiO}_3$  (*perovskite* type)

**IR-11.3 CHEMICAL COMPOSITION****IR-11.3.1 Approximate formulae**

The formula used in any given case depends upon how much information is to be conveyed. A general notation, which can be used even when the mechanism of the variation in composition is unknown, is to put the sign  $\sim$  (read as *circa*, or 'approximately') before the formula.

*Examples:*

1.  $\sim\text{FeS}$
2.  $\sim\text{CuZn}$

If it is desirable to give more information, one of the notations described below may be used.

**IR-11.3.2 Phases with variable composition**

For a phase where the variation in composition is caused solely or partially by isovalent substitution, the symbols of the atoms or groups that replace each other may be separated by a comma and placed together between parentheses. If possible, the formula is written so that the limits of the homogeneity range, when one or the other of the two atoms or groups is lacking, are represented.

*Examples:*

1. (Cu,Ni) denotes the complete range of compositions from pure Cu to pure Ni.
2. K(Br,Cl) comprises the range from pure KBr to pure KCl.

Phases for which substitution also results in vacant positions are denoted in the same way.

*Examples:*

3.  $(\text{Li}_2, \text{Mg})\text{Cl}_2$  denotes a solid mixture intermediate in composition between  $\text{LiCl}$  and  $\text{MgCl}_2$ .
4.  $(\text{Al}_2, \text{Mg}_3)\text{Al}_6\text{O}_{12}$  represents a solid mixture intermediate in composition between  $\text{MgAl}_2\text{O}_4$  ( $= \text{Mg}_3\text{Al}_6\text{O}_{12}$ ) and  $\text{Al}_2\text{O}_3$  (*spinel* type) ( $= \text{Al}_2\text{Al}_6\text{O}_{12}$ ).

In general, however, a notation in which there are variables which define composition should be used. The ranges of the variables can also be indicated. Thus, a phase involving substitution of atom A for B is written  $A_{m+x}B_{n-x}C_p$  ( $0 \leq x \leq n$ ). The commas and parentheses called for above are not then required.

*Examples:*

5.  $\text{Cu}_x\text{Ni}_{1-x}$  ( $0 \leq x \leq 1$ ) is equivalent to  $(\text{Cu}, \text{Ni})$ .
6.  $\text{KBr}_x\text{Cl}_{1-x}$  ( $0 \leq x \leq 1$ ) is equivalent to  $\text{K}(\text{Br}, \text{Cl})$ .
7.  $\text{Li}_{2-2x}\text{Mg}_x\text{Cl}_2$  ( $0 \leq x \leq 1$ ) is equivalent to  $(\text{Li}_2, \text{Mg})\text{Cl}_2$  but shows explicitly that one vacant cation position appears for every 2  $\text{Li}^+$  replaced by  $\text{Mg}^{2+}$ .
8.  $\text{Co}_{1-x}\text{O}$  indicates that there are vacant cation sites; for  $x=0$  the formula corresponds to the stoichiometric composition  $\text{CoO}$ .
9.  $\text{Ca}_x\text{Zr}_{1-x}\text{O}_{2-x}$  indicates that Zr has been partly replaced by Ca, resulting in vacant anion sites; for  $x=0$  the formula corresponds to the stoichiometric composition  $\text{ZrO}_2$ .

If the variable  $x$  is limited this may be shown by using  $\delta$  or  $\varepsilon$  instead of  $x$ . A specific composition or composition range can be indicated by stating the actual value of the variable  $x$  (or  $\delta$ , or  $\varepsilon$ ). This value can be written in parentheses after the general formula. However, the value of the variable may also be introduced in the formula itself. This notation can be used both for substitutional and for interstitial solid solutions.<sup>6</sup>

*Examples:*

10.  $\text{Fe}_{3x}\text{Li}_{4-x}\text{Ti}_{2(1-x)}\text{O}_6$  ( $x = 0.35$ ), or  $\text{Fe}_{1.05}\text{Li}_{3.65}\text{Ti}_{1.30}\text{O}_6$
11.  $\text{LaNi}_5\text{H}_x$  ( $0 < x < 6.7$ )
12.  $\text{Al}_4\text{Th}_8\text{H}_{15.4}$
13.  $\text{Ni}_{1-\delta}\text{O}$

## IR-11.4 POINT DEFECT (KRÖGER–VINK) NOTATION

### IR-11.4.1 General

As well as the chemical composition, information about point defects, site symmetry, and site occupancy can be given by using additional symbols. These symbols may also be used to write quasi-chemical equilibria between point defects.<sup>6</sup>

### IR-11.4.2 Indication of site occupancy

In a formula, the main symbols indicate the species present at a certain site, defined with respect to empty space. This will generally be the symbol of an element. If a site is vacant this is denoted by the italicized symbol *V*. (In certain contexts other symbols, such as a square box,  $\square$ , are used for vacancies, but the use of italicized *V* is preferred, the element vanadium being written with the upright letter *V*).

The site and its occupancy in a structure of ideal composition are represented by right lower indexes. The first index indicates the type of site, and the second index (if used), separated from the first by a comma, indicates the number of atoms on this site. Thus, an atom A on a site normally occupied by A in the ideal structure is expressed by  $A_A$ ; an atom A on a site normally occupied by B is expressed  $A_B$ ; and  $M_{M,1-x}N_{M,x}M_{N,x}N_{N,1-x}$  stands for a disordered alloy, where the ideal composition is  $M_MN_N$  with all M atoms on one type of crystallographic site and all N atoms on a second type of crystallographic site. An alternative description is  $(M_{1-x}N_x)_M(M_xN_{1-x})_N$ . A species occupying an interstitial site (*i.e.* a site which is unoccupied in the ideal structure) is indicated by the subscript 'i'.

*Examples:*

1.  $Mg_{Mg,2-x}Sn_{Mg,x}Mg_{Sn,x}Sn_{Sn,1-x}$  shows that in  $Mg_2Sn$  some of the Mg atoms are present on Sn sites and *vice versa*.
2.  $(Bi_{2-x}Te_x)_{Bi}(Bi_xTe_{3-x})_{Te}$  shows that in  $Bi_2Te_3$  some of the Bi atoms are present on Te sites and *vice versa*.
3.  $Na_{Na,1-x}V_{Na,x}Cl_{Cl,1-x}V_{Cl,x}$  shows that  $x$  Na and  $x$  Cl sites in NaCl are vacant, giving Schottky defects.
4.  $Ca_{Ca,1}F_{F,2-x}V_{F,x}F_{i,x}$  shows that in  $CaF_2$ ,  $x$  F sites are vacant, while  $x$  F ions are situated on interstitial sites, creating Frenkel defects.
5.  $(Ca_{0.15}Zr_{0.85})_{Zr}(O_{1.85}V_{0.15})_O$ , or  $Ca_{Zr,0.15}Zr_{Zr,0.85}O_{O,1.85}V_{O,0.15}$ , shows that in CaO-stabilized  $ZrO_2$ , 0.85 of the Zr sites are occupied by Zr, 0.15 of the Zr sites are occupied by Ca, and that, of the two oxygen sites, 1.85 sites are occupied by oxygen ions, leaving 0.15 sites vacant.
6.  $V_{V,1}C_{C,0.8}V_{C,0.2}$  shows that 0.2 C-sites are vacant in vanadium carbide, VC.

The defect symbols can be used in writing quasi-chemical reactions.

*Examples:*

7.  $Na_{Na} \rightarrow V_{Na} + Na(g)$  indicates the evaporation of a Na atom, leaving behind a sodium vacancy in the lattice.
8.  $0.5Cl_2(g) + V_{Cl} \rightarrow Cl_{Cl}$  indicates the incorporation of a chlorine atom, from a dichlorine molecule, on a vacant chlorine site in the lattice.

### IR-11.4.3 Indication of crystallographic sites

Crystallographic sites can be distinguished by subscripts, *e.g.* tet, oct and dod, denoting tetrahedrally, octahedrally and dodecahedrally coordinated sites, respectively. The use of

subscripts such as a, b, ... , which are not self-explanatory, is not approved. In some cases, such as oxides and sulfides, the number of subscripts can be reduced by defining specific symbols to indicate site symmetries, *e.g.* ( ) for tetrahedral sites, [ ] for octahedral sites, { } for dodecahedral sites. To avoid confusion, such enclosing marks should be restricted to cases where they are not being used to express multiplication. The meaning of the symbols should be clearly stated in the text.

*Examples:*

1.  $\text{Mg}_{\text{tet}}\text{Al}_{\text{oct},2}\text{O}_4$  or  $(\text{Mg})[\text{Al}_2]\text{O}_4$  denotes a normal spinel.
2.  $\text{Fe}_{\text{tet}}\text{Fe}_{\text{oct}}\text{Ni}_{\text{oct}}\text{O}_4$  or  $(\text{Fe})[\text{FeNi}]\text{O}_4$  denotes  $\text{NiFe}_2\text{O}_4$  (*inverse spinel type*).

#### IR-11.4.4

#### Indication of charges

Charges are indicated by a right upper index. When formal charges are given, the usual convention holds: one unit of positive charge is indicated by a superscript +, *n* units of positive charge by a superscript  $n+$ , one unit of negative charge by a superscript  $-$ , *n* units of negative charge by a superscript  $n-$ . Thus  $\text{A}^{n+}$  denotes *n* units of formal positive charge on an atom of symbol A. In defect chemistry, charges are defined preferably with respect to the ideal unperturbed crystal. In this case, they are called *effective charges*. One unit of positive effective charge is shown by a superscript dot,  $\bullet$ , (not to be confused with the radical dot described in Section IR-4.6.2) and one unit of negative effective charge by a prime,  $'$ ; *n* units of effective charge are indicated by superscript  $n\bullet$  or  $n'$ . The use of double dots  $\bullet\bullet$  or double primes  $''$  in the case of two effective charges is also allowed. Thus  $\text{A}^{2\bullet}$  and  $\text{A}^{\bullet\bullet}$  indicate that an atom of symbol A has two units of effective positive charge. Sites that have no effective charge relative to the unperturbed lattice may be indicated explicitly by a superscript cross, *i.e.*  $\times$ .

*Examples:*

1.  $\text{Li}_{\text{Li},1-2x}\text{Mg}_{\text{Li},x}^{\bullet}\text{V}_{\text{Li},x}'\text{Cl}_{\text{Cl}}$  and  $\text{Li}_{\text{Li},1-2x}^{\times}\text{Mg}_{\text{Li},x}^{\bullet}\text{V}_{\text{Li},x}'\text{Cl}_{\text{Cl}}^{\times}$  are equivalent expressions for a substitutional solid solution of  $\text{MgCl}_2$  in  $\text{LiCl}$ .
2.  $\text{Y}_{\text{Y},1-2x}\text{Zr}_{\text{Y},2x}^{\bullet}\text{O}_{\text{i},x}''\text{O}_3$  and  $\text{Y}_{\text{Y},1-2x}^{\times}\text{Zr}_{\text{Y},2x}^{\bullet}\text{O}_{\text{i},x}''\text{O}_3^{\times}$  are equivalent expressions for an interstitial solid solution of  $\text{ZrO}_2$  in  $\text{Y}_2\text{O}_3$ .
3.  $\text{Ag}_{\text{Ag},1-x}\text{V}_{\text{Ag},x}'\text{Ag}_{\text{i},x}^{\bullet}\text{Cl}_{\text{Cl}}$  indicates that a fraction *x* of the  $\text{Ag}^+$  ions is removed from the Ag sites to interstitial sites, leaving the silver site vacant.

Formal charges may be preferred in cases where the unperturbed crystal contains an element in more than one oxidation state.

*Examples:*

4.  $\text{La}_{\text{La},1-3x}^{2+}\text{La}_{\text{La},2+2x}^{3+}\text{V}_{\text{La},x}(\text{S}^{2-})_4$  ( $0 < x < 1/3$ )
5.  $\text{Cu}_{\text{Cu},2-x}^{+}\text{Fe}_{\text{Cu},x}^{3+}\text{Tl}_{\text{Tl}}^{+}\text{Se}_{\text{Se},1+2x}^{2-}\text{Se}_{\text{Se},1-2x}^{-}$  ( $0 < x < 1/2$ ) shows that  $\text{Fe}^{3+}$  partly replaces  $\text{Cu}^{+}$  in  $\text{Cu}^{+}_2\text{Tl}^{+}\text{Se}^{2-}_2\text{Se}^{-}$ .

Free electrons are denoted by  $e'$ , free holes by  $h^{\bullet}$ . As crystals are macroscopically neutral bodies, the sums of the formal charges and of the effective charges must be zero.

Key aspects of the Kröger–Vink point defect notation are summarized in Table IR-11.1.

**Table IR-11.1** Examples<sup>a</sup> of defect notation in  $M^{2+}(X^-)_2$  containing a foreign ion  $Q$

interstitial $M^{2+}$ ion	$M_i^\bullet$	M atom vacancy	$V_M^x$
interstitial $X^-$ ion	$X_i'$	X atom vacancy	$V_X^x$
$M^{2+}$ ion vacancy	$V_M''$	normal $M^{2+}$ ion	$M_M^x$
$X^-$ ion vacancy	$V_X^\bullet$	normal $X^-$ ion	$X_X^x$
interstitial M atom	$M_i^x$	$Q^{3+}$ ion at $M^{2+}$ site	$Q_M^\bullet$
interstitial X atom	$X_i^x$	$Q^{2+}$ ion at $M^{2+}$ site	$Q_M^x$
interstitial $M^+$ ion	$M_i^\bullet$	$Q^+$ ion at $M^{2+}$ site	$Q_M'$
$M^+$ ion vacancy	$V_M'$	free electron	$e'$
		free hole	$h^\bullet$

<sup>a</sup> Consider an ionic compound  $M^{2+}(X^-)_2$ . The formal charge on M is 2+, the formal charge on X is 1-. If an atom X is removed, one negative unit of charge remains on the vacant X site. The vacancy is neutral with respect to the ideal  $MX_2$  lattice and is therefore indicated by  $V_X$  or  $V_X^x$ . If the electron is also removed from this site, the resultant vacancy is effectively positive, *i.e.*  $V_X^\bullet$ . Similarly, removal of an M atom leaves  $V_M$ , removal of an  $M^+$  ion leaves  $V_M'$ , removal of an  $M^{2+}$  ion leaves  $V_M''$ . If an impurity with a formal charge of three positive units  $Q^{3+}$  is substituted on the  $M^{2+}$  site, its effective charge is one positive unit. Therefore it is indicated by  $Q_M^\bullet$ .

#### IR-11.4.5 Defect clusters and use of quasi-chemical equations

Pairs or more complicated clusters of defects can be present in a solid. Such a defect cluster is indicated between parentheses. The effective charge of the cluster is indicated as an upper right index.

*Examples:*

1.  $(Ca_K^\bullet V_K')^x$  denotes a neutral defect pair in a solid solution, for example of  $CaCl_2$  in KCl.
2.  $(V_{Pb}'' V_{Cl}')^x$  or  $(V_{Pb} V_{Cl})'$  indicates a charged vacancy pair in  $PbCl_2$ .

Quasi-chemical reactions may be written for the formation of such defect clusters.

*Examples:*

3.  $Cr_{Mg}^\bullet + V_{Mg}'' \rightarrow (Cr_{Mg} V_{Mg})'$  describes the association reaction of a  $Cr^{3+}$  impurity in MgO with magnesium vacancies.
4.  $2Cr_{Mg}^\bullet + V_{Mg}'' \rightarrow (Cr_{Mg} V_{Mg} Cr_{Mg})^x$  gives another possible association reaction in the system of Example 3.
5.  $Gd_{Ca}^\bullet + F_i' \rightarrow (Gd_{Ca} F_i)^x$  describes the formation of a dipole between a  $Gd^{3+}$  impurity and a fluorine interstitial in  $CaF_2$ .

#### IR-11.5 PHASE NOMENCLATURE

##### IR-11.5.1 Introduction

The use of the Pearson notation<sup>7</sup> (see also Section IR-3.4.4) is recommended for the designation of the structures of metals and solid solutions in binary and more complex



systems. The use of Greek letters, which do not convey the necessary information, and of the *Strukturbericht* designations, which are not self-explanatory, is not acceptable.

### IR-11.5.2 Recommended notation

The Pearson symbol consists of three parts: first, a lower-case italic letter (*a, m, o, t, h, c*) designating the crystal system; second, an italic capital letter (*P, S, F, I, R*) designating the lattice setting and, finally, a number designating the number of atoms or ions in the conventional unit cell. Table IR-3.1 summarizes the system.

*Examples:*

1. Cu, symbol (*cF4*), indicates copper of cubic symmetry, with face-centred lattice, containing 4 atoms per unit cell.
2. NaCl, symbol (*cF8*), indicates a cubic face-centred lattice with 8 ions per unit cell.
3. CuS(*hP12*), indicates a hexagonal primitive lattice with 12 ions per unit cell.

If required, the Pearson symbol can be followed by the space group and a prototype formula.

*Example:*

4.  $\text{CaMg}_{0.5}\text{Ag}_{1.5}(\text{hP12}, \text{P6}_3/\text{mmc})$  ( $\text{MgZn}_2$  type).

## IR-11.6 NON-STOICHIOMETRIC PHASES

### IR-11.6.1 Introduction

Several special problems of nomenclature for non-stoichiometric phases have arisen with the improvements in the precision with which their structures can be determined. Thus, there are references to homologous series, non-commensurate and semi-commensurate structures, Vernier structures, crystallographic shear phases, Wadsley defects, chemical twinned phases, infinitely adaptive phases and modulated structures. Many of the phases that fall into these classes have no observable composition ranges although they have complex structures and formulae; an example is  $\text{Mo}_{17}\text{O}_{47}$ . These phases, despite their complex formulae, are essentially stoichiometric and possession of a complex formula must not be taken as an indication of a non-stoichiometric compound (*cf.* Section IR-11.1.2).

### IR-11.6.2 Modulated structures

Modulated structures possess two or more periodicities in the same direction of space. If the ratio of these periodicities is a rational number, the structures are called *commensurate*;

if the ratio is irrational, the structures are called *non-commensurate* or *incommensurate*. Commensurately modulated structures exist in many stoichiometric and non-stoichiometric compounds; they may be regarded as superstructures and be described by the usual rules. Non-commensurately modulated structures occur in several stoichiometric compounds (and some elements), usually in a limited temperature range, *e.g.* U, SiO<sub>2</sub>, TaS<sub>2</sub>, NbSe<sub>3</sub>, NaNO<sub>2</sub>, Na<sub>2</sub>CO<sub>3</sub> and Rb<sub>2</sub>ZnBr<sub>4</sub>.

Many modulated structures can be regarded as being composed of two or more substructures. The substructure with the shortest periodicity often represents a simple *basic structure*, while the other periodicities cause modulations of the basic structure. The basic structure often remains unchanged within a certain composition range, while the other substructures take up the change in stoichiometry. If this change takes place continuously, a non-stoichiometric phase with a non-commensurate structure results. If the change occurs discontinuously, a series of (essentially stoichiometric) *homologous compounds* with commensurate structures (superstructures of the basic structure) may result or, in the intermediate case, a series of compounds with *semi-commensurate* or *Vernier* structures.

*Examples:*

1. Mn<sub>n</sub>Si<sub>2n-m</sub>

The structure is of the *TiSi<sub>2</sub>* type which has two atom substructures, the Mn array being identical to that of the Ti array in TiSi<sub>2</sub> and the Si<sub>2</sub> array being identical to that of the Si<sub>2</sub> array in TiSi<sub>2</sub>. Removal of Si leads to a composition Mn<sub>n</sub>Si<sub>2n-m</sub> in which the Mn array is completely unchanged. The Si atoms are arranged in rows and, as the Si content falls, the Si atoms in the rows spread out. In this case there will be a Vernier relationship between the Si atom rows and the static Mn positions which will change as the composition varies, giving rise to non-commensurate structures.

2. YF<sub>2+x</sub>O

The structure is of the *fluorite* type with extra sheets of atoms inserted into the parent YX<sub>2</sub> structure. When these are ordered, a homologous series of phases results. When they are disordered, there is a non-commensurate, non-stoichiometric phase, while partial ordering will give a Vernier or semi-commensurate effect. Other layer structures can be treated in the same way.

*Misfit structures* consist of two or more different, often mutually non-commensurate, units which are held together by electrostatic or other forces; no basic structure can be defined. The composition of compounds with misfit structures is determined by the ratio of the periodicities of their structural units and by electroneutrality.

*Examples:*

3. Sr<sub>1-p</sub>Cr<sub>2</sub>S<sub>4-p</sub> with  $p = 0.29$ , where chains of compositions Sr<sub>3</sub>CrS<sub>3</sub> and Sr<sub>3-x</sub>S lie in tunnels of a framework of composition Cr<sub>21</sub>S<sub>36</sub>; the three units are mutually non-commensurate.

4. LaCrS<sub>3</sub>, which is built from non-commensurate sheets of (LaS)<sup>+</sup> and (CrS<sub>2</sub>)<sup>-</sup>.

### IR-11.6.3 Crystallographic shear structures

Crystallographic shear planes (CS planes) are planar faults in a crystal that separate two parts of the crystal which are displaced with respect to each other. The vector describing the displacement is called the crystallographic shear vector (CS vector). Each CS plane causes the composition of the crystal to change by a small increment because the sequence of crystal planes that produces the crystal matrix is changed at the CS plane. (From this it follows that the CS vector must be at an angle to the CS plane. If it were parallel to the plane, the succession of crystal planes would not be altered and no composition change would result. A planar boundary where the displacement vector is parallel to the plane is more properly called an *antiphase boundary*.)

Because each CS plane changes the composition of the crystal slightly, the overall composition of a crystal containing a population of CS planes will depend upon the number of CS planes present and their orientation. If the CS planes are disordered, the crystals will be non-stoichiometric, the stoichiometric variation being due to the CS plane 'defect'. If the CS planes are ordered into a parallel array, a stoichiometric phase with a complex formula results. In this case, a change in the separation of the CS planes in the ordered array will produce a new phase with a new composition. The series of phases produced by changes in the spacing between CS planes forms an *homologous* series. The general formula of a particular series will depend upon the type of CS plane in the array and the separation between the CS planes. A change in the CS plane may change the formula of the homologous series.

*Examples:*

1.  $\text{Ti}_n\text{O}_{2n-1}$

The parent structure is  $\text{TiO}_2$  (*rutile* type). The CS planes are the (121) planes. Ordered arrays of CS planes can exist, producing an homologous series of oxides with formulae  $\text{Ti}_4\text{O}_7$ ,  $\text{Ti}_5\text{O}_9$ ,  $\text{Ti}_6\text{O}_{11}$ ,  $\text{Ti}_7\text{O}_{13}$ ,  $\text{Ti}_8\text{O}_{15}$  and  $\text{Ti}_9\text{O}_{17}$ . The series formula is  $\text{Ti}_n\text{O}_{2n-1}$ , with  $n$  between 4 and 9.

2.  $(\text{Mo,W})_n\text{O}_{3n-1}$

The parent structure is  $\text{WO}_3$ . The CS planes are the (102) planes. Ordered arrays of CS planes can form, producing oxides with formulae  $\text{Mo}_8\text{O}_{23}$ ,  $\text{Mo}_9\text{O}_{26}$ ,  $(\text{Mo,W})_{10}\text{O}_{29}$ ,  $(\text{Mo,W})_{11}\text{O}_{32}$ ,  $(\text{Mo,W})_{12}\text{O}_{35}$ ,  $(\text{Mo,W})_{13}\text{O}_{38}$  and  $(\text{Mo,W})_{14}\text{O}_{41}$ . The series formula is  $(\text{Mo,W})_n\text{O}_{3n-1}$ , with  $n$  between 8 and 14.

3.  $\text{W}_n\text{O}_{3n-2}$

The parent structure is  $\text{WO}_3$ . The CS planes are the (103) planes. Ordered arrays of CS planes can form, producing oxides with formulae  $\text{W}_n\text{O}_{3n-2}$ , with  $n$  between approximately 16 and 25.

### IR-11.6.4 Unit cell twinning or chemical twinning

This is a structure-building component in which two constituent parts of the structure are twin-related across the interface. The twin plane changes the composition of the host crystal by a definite amount (which may be zero). Ordered, closely spaced arrays of twin planes will lead to homologous series of phases. Disordered twin planes will lead to non-stoichiometric phases in which the twin planes serve as the defects. There is a close parallel between chemical twinning and crystallographic shear (see Section IR-11.6.3).

*Example:*

1.  $(\text{Bi,Pb})_n\text{S}_{n-4}$

The parent structure is PbS which has the *cF8* (*NaCl* type) structure. The twin planes are (311) with respect to the PbS unit cell. Two members of the homologous series are known,  $\text{Bi}_8\text{Pb}_{24}\text{S}_{36}$  and  $\text{Bi}_8\text{Pb}_{12}\text{S}_{24}$ , but other members are found in the quaternary Ag-Bi-Pb-S system. The difference between compounds lies in the separation of the twin planes; each structure is built from slabs of PbS of varying thickness, alternate slabs being twinned across (311) with respect to the parent structure.

#### IR-11.6.5 **Infinitely adaptive structures**

In some systems it would appear that any composition can yield a fully ordered crystal structure over certain temperature and composition ranges. As the composition changes, so the structure changes to meet this need. The term *infinitely adaptive structures* has been applied to this group of substances.<sup>8</sup>

*Examples:*

1. Compounds in the  $\text{Cr}_2\text{O}_3$ - $\text{TiO}_2$  system between the composition ranges  $(\text{Cr,Ti})\text{O}_{2.93}$  and  $(\text{Cr,Ti})\text{O}_{2.90}$ .
2. Compounds in the  $\text{Nb}_2\text{O}_5$ - $\text{WO}_3$  system with block-type structure between the composition limits  $\text{Nb}_2\text{O}_5$  and  $8\text{WO}_3 \cdot 9\text{Nb}_2\text{O}_5$  ( $\text{Nb}_{18}\text{W}_8\text{O}_{69}$ ).

#### IR-11.6.6 **Intercalation compounds**

There are several materials in which a guest species is inserted into a host matrix. The process is called intercalation, and the product is called an *intercalation compound*. Common examples of intercalated materials are found in the clay silicates, layered dichalcogenides and electrode materials for lithium batteries; graphite intercalation is considered in detail in Ref. 9. Intercalated materials can be designated by conventional chemical formulae such as  $\text{Li}_x\text{TaS}_2$  ( $0 < x < 1$ ) or by host-guest designations, such as  $\text{TaS}_2 \cdot x\text{Li}$  ( $0 < x < 1$ ). If the stoichiometry is definite, ordinary compound designations may be used, e.g.  $3\text{TaS}_2 \cdot 4\text{N}_2\text{H}_4$ ,  $\text{C}_5\text{H}_5\text{N} \cdot 2\text{TiSe}_2$  and  $\text{KC}_8$ .

Many intercalation compounds are layered structures and intercalation is a two-dimensional reaction. The term *insertion* is sometimes used for three-dimensional examples, as in the tungsten bronzes, e.g.  $\text{Na}_x\text{WO}_3$ , and the spinels, e.g.  $\text{Li}_x\text{Mn}_2\text{O}_4$ , and also as a general term for a reaction involving the transfer of a guest atom, ion or molecule into a host crystal lattice<sup>4</sup> instead of intercalation. More specifically, *intercalation* is used for an insertion reaction that does not cause a major structural modification of the host.<sup>4</sup> If the structure of the host is modified significantly, for example by breaking of bonds, then the insertion can be referred to as *topochemical* or *topotactic*.<sup>4</sup>

### IR-11.7 **POLYMORPHISM**

#### IR-11.7.1 **Introduction**

A number of chemical compounds and elements change their crystal structure with external conditions such as temperature and pressure. These various structures are termed polymorphic

forms or modifications, and in the past have been designated using a number of labelling systems, including Greek letters and Roman numerals; the use of such non-systematic labels is not acceptable. A rational system based upon crystal structure should be used wherever possible (*cf.* Sections IR-3.4.4 and IR-4.2.5).

Polytypes and polytypoids can be regarded as a special form of polymorphism and are treated in more detail in Ref. 10.

#### IR-11.7.2 Use of crystal systems

Polymorphs are indicated by adding an italicized symbol denoting the crystal system after the name or formula. The symbols used are given in Table IR-3.1. For example, ZnS(*c*) corresponds to the zinc blende structure or sphalerite, and ZnS(*h*) to the wurtzite structure. Slightly distorted lattices may be indicated by using the *circa* sign  $\sim$ . Thus, a slightly distorted cubic lattice would be expressed as ( $\sim c$ ). In order to give more information, simple well-known structures should be designated by giving the type compound in parentheses whenever possible. For example, AuCd above 343 K should be designated AuCd (*CsCl* type) rather than AuCd(*c*).

Properties which strongly depend on lattice and point symmetries may require the addition of the space group to the crystal system abbreviation. For more details see Ref. 11.

#### IR-11.8 FINAL REMARKS

This Chapter deals with some basic notation and nomenclature of solid-state chemistry. In some areas, such as amorphous systems and glasses, the nomenclature needs further development. The reader is also referred to the work of the International Union of Crystallography.

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# TABLES

**Table I** Names, symbols and atomic numbers of the elements (see also Section IR-3.1)

<i>Name</i>	<i>Symbol</i>	<i>Atomic number</i>	<i>Name</i>	<i>Symbol</i>	<i>Atomic number</i>
actinium	Ac	89	indium	In	49
aluminium <sup>a</sup>	Al	13	iodine	I	53
americium	Am	95	iridium	Ir	77
antimony	Sb <sup>b</sup>	51	iron	Fe <sup>g</sup>	26
argon	Ar	18	krypton	Kr	36
arsenic	As	33	lanthanum	La	57
astatine	At	85	lawrencium	Lr	103
barium	Ba	56	lead	Pb <sup>h</sup>	82
berkelium	Bk	97	lithium	Li	3
beryllium	Be	4	lutetium	Lu	71
bismuth	Bi	83	magnesium	Mg	12
bohrium	Bh	107	manganese	Mn	25
boron	B	5	meitnerium	Mt	109
bromine	Br	35	mendelevium	Md	101
cadmium	Cd	48	mercury	Hg <sup>i</sup>	80
caesium <sup>c</sup>	Cs	55	molybdenum	Mo	42
calcium	Ca	20	neodymium	Nd	60
californium	Cf	98	neon	Ne	10
carbon	C	6	neptunium	Np	93
cerium	Ce	58	nickel	Ni	28
chlorine	Cl	17	niobium	Nb	41
chromium	Cr	24	nitrogen <sup>j</sup>	N	7
cobalt	Co	27	nobelium	No	102
copper	Cu <sup>d</sup>	29	osmium	Os	76
curium	Cm	96	oxygen	O	8
darmstadtium	Ds	110	palladium	Pd	46
dubnium	Db	105	phosphorus	P	15
dysprosium	Dy	66	platinum	Pt	78
einsteinium	Es	99	plutonium	Pu	94
erbium	Er	68	polonium	Po	84
europium	Eu	63	potassium	K <sup>k</sup>	19
fermium	Fm	100	praseodymium	Pr	59
fluorine	F	9	promethium	Pm	61
francium	Fr	87	protactinium	Pa	91
gadolinium	Gd	64	radium	Ra	88
gallium	Ga	31	radon	Rn	86
germanium	Ge	32	rhenium	Re	75
gold	Au <sup>e</sup>	79	rhodium	Rh	45
hafnium	Hf	72	roentgenium	Rg	111
hassium	Hs	108	rubidium	Rb	37
helium	He	2	ruthenium	Ru	44
holmium	Ho	67	rutherfordium	Rf	104
hydrogen	H <sup>f</sup>	1	samarium	Sm	62

**Table I** *Continued*

<i>Name</i>	<i>Symbol</i>	<i>Atomic number</i>	<i>Name</i>	<i>Symbol</i>	<i>Atomic number</i>
scandium	Sc	21	thorium	Th	90
seaborgium	Sg	106	thulium	Tm	69
selenium	Se	34	tin	Sn <sup>o</sup>	50
silicon	Si	14	titanium	Ti	22
silver	Ag <sup>l</sup>	47	tungsten	W <sup>p</sup>	74
sodium	Na <sup>m</sup>	11	uranium	U	92
strontium	Sr	38	vanadium	V	23
sulfur <sup>n</sup>	S	16	xenon	Xe	54
tantalum	Ta	73	ytterbium	Yb	70
technetium	Tc	43	yttrium	Y	39
tellurium	Te	52	zinc	Zn	30
terbium	Tb	65	zirconium	Zr	40
thallium	Tl	81			

<sup>a</sup> The alternative spelling ‘aluminum’ is commonly used.

<sup>b</sup> The element symbol Sb derives from the name stibium.

<sup>c</sup> The alternative spelling ‘cesium’ is commonly used.

<sup>d</sup> The element symbol Cu derives from the name cuprum.

<sup>e</sup> The element symbol Au derives from the name aurum.

<sup>f</sup> The hydrogen isotopes <sup>2</sup>H and <sup>3</sup>H are named deuterium and tritium, respectively, for which the symbols D and T may be used. However, <sup>2</sup>H and <sup>3</sup>H are preferred (see Section IR-3.3.2).

<sup>g</sup> The element symbol Fe derives from the name ferrum.

<sup>h</sup> The element symbol Pb derives from the name plumbum.

<sup>i</sup> The element symbol Hg derives from the name hydrargyrum.

<sup>j</sup> The name azote provides the root ‘az’ for nitrogen.

<sup>k</sup> The element symbol derives K from the name kalium.

<sup>l</sup> The element symbol Ag derives from the name argentum.

<sup>m</sup> The element symbol Na derives from the name natrium.

<sup>n</sup> The name theion provides the root ‘thi’ for sulfur.

<sup>o</sup> The element symbol Sn derives from the name stannum.

<sup>p</sup> The element symbol W derives from the name wolfram.



**Table II** *Temporary names and symbols for elements of atomic number greater than 111*<sup>a</sup>

<i>Atomic number</i>	<i>Name</i> <sup>b</sup>	<i>Symbol</i>
112	ununbium	Uub
113	ununtrium	Uut
114	ununquadium	Uuq
115	ununpentium	Uup
116	ununhexium	Uuh
117	ununseptium	Uus
118	ununoctium	Uuo
119	ununennium	Uue
120	unbinilium	Ubn
121	unbiunium	Ubu
130	untrinilium	Utn
140	unquadnilium	Uqn
150	unpentnilium	Upn
160	unhexnilium	Uhn
170	unseptnilium	Usn
180	unocnilium	Uon
190	unennilium	Uen
200	binilnilium	Bnn
201	binilunium	Bnu
202	binilbium	Bnb
300	trinilnilium	Tnn
400	quadnilnilium	Qnn
500	pentnilnilium	Pnn
900	ennilnilium	Enn

<sup>a</sup> These names are used only when the permanent name has not yet been assigned by IUPAC (see Section IR-3.1.1).  
<sup>b</sup> One may also write, for example, ‘element 112’.

**Table III** *Suffixes and endings*<sup>a</sup>

a	<p>Terminal vowel of prefixes indicating replacement of:</p> <p>carbon atoms by atoms of other elements in skeletal replacement nomenclature (Section IR-6.2.4.1) and Hantzsch–Widman nomenclature (Section IR-6.2.4.3), <i>e.g.</i> ‘oxa’, ‘aza’;</p> <p>boron atoms by atoms of other elements in boron hydride-based nomenclature (Section IR-6.2.4.4), <i>e.g.</i> ‘carba’, ‘thia’;</p> <p>heteroatoms by carbon atoms in natural product nomenclature (prefix ‘carba’).</p> <p>See Table X for ‘a’ prefixes for all elements.</p>
ane	<p>Ending of names of neutral saturated parent hydrides of elements of Groups 13–17, <i>e.g.</i> thallane, cubane, cyclohexane, cyclohexasilane, diphosphane, tellane, <math>\lambda^4</math>-tellane. <i>Cf.</i> Section IR-6.2.2 and Table IR-6.1.</p> <p>Last part of endings of a number of parent names of saturated heteromonocycles in Hantzsch–Widman nomenclature, <i>i.e.</i> of ‘irane’, ‘etane’, ‘olane’, ‘ane’, ‘inane’, ‘epane’, ‘ocane’, ‘onane’ and ‘ecane’ (see Section IR-6.2.4.3).</p>
anide	Combined ending of names of anions resulting from the removal of a hydron from a parent hydride with an ‘ane’ name, formed by adding the suffix ‘ide’, <i>e.g.</i> methanide, $\text{CH}_3^-$ . <i>Cf.</i> Section IR-6.4.4.
anium	Combined ending of names of cations resulting from the addition of a hydron to a parent structure with an ‘ane’ name, formed by adding the suffix ‘ium’, <i>e.g.</i> phosphanium, $\text{PH}_4^+$ . <i>Cf.</i> Section IR-6.4.1.
ano	Ending resulting from the change of the ‘ane’ ending in names of parent hydrides to form prefixes denoting bridging divalent substituent groups, <i>e.g.</i> diazano, $-\text{HNNH}-$ .
ate	<p>General ending of additive names of anions, <i>e.g.</i> tetrahydridoaluminate(1–), <math>[\text{AlH}_4]^-</math>. <i>Cf.</i> Section IR-7.1.4 and Table X.</p> <p>Ending of names of anions and esters of inorganic oxoacids having the ‘ic’ ending in the acid name, <i>e.g.</i> nitrate, phosphonate, trimethyl phosphate, and of anions and esters of organic acids, <i>e.g.</i> acetate, methyl acetate, thiocyanate. See Tables IR-8.1 and IR-8.2 and Table IX for more examples of ‘ate’ anion names. See also ‘inate’, ‘onate’.</p>
ato	<p>Ending of name of any anion with an ‘ate’ name (see above) acting as a ligand, <i>e.g.</i> tetrahydridoaluminato(1–), nitrato, acetato. <i>Cf.</i> Sections IR-7.1.3 and IR-9.2.2.3 and Table IX. See also ‘inato’, ‘onato’.</p> <p>Ending of prefixes for certain anionic substituent groups, <i>e.g.</i> carboxylato, <math>-\text{C}(=\text{O})\text{O}^-</math>; phosphato, <math>-\text{O}-\text{P}(=\text{O})(\text{O}^-)_2</math>. See also ‘onato’.</p>
diene	See ‘ene’.
diide	See ‘ide’.
diido	See ‘ido’.
dium	See ‘ium’.
diyl	Combined suffix composed of the suffix ‘yl’ and the multiplicative prefix ‘di’, indicating the loss of two hydrogen atoms from a parent hydride resulting in a diradical, or a substituent group with two single bonds, if necessary accompanied by locants, <i>e.g.</i> hydrazine-1,2-diyl, $\bullet\text{HNNH}\bullet$ or $-\text{HNNH}-$ ; phosphanediyli, $\text{HP}<$ . See also ‘ylidene’.
diylum	See ‘ylum’.
ecane	Ending of parent names of ten-membered saturated heteromonocycles in Hantzsch–Widman nomenclature, <i>cf.</i> Section IR-6.2.4.3.

Table III *Continued*

ecine	Ending of parent names of ten-membered heteromonocycles with the maximum number of non-cumulative double bonds in Hantzsch–Widman nomenclature, <i>cf.</i> Section IR-6.2.4.3.
ene	Ending of systematic names of acyclic and cyclic parent structures with double-bond unsaturation, replacing ‘ane’ in the name of the corresponding saturated parent hydride, and if necessary accompanied by locants and multiplicative prefixes specifying the locations and number of double bonds, <i>e.g.</i> diazene, triazene, pentasil-1-ene, cyclopenta-1,3-diene. <i>Cf.</i> Sections IR-6.2.2.3 and IR- 6.2.2.4.  Ending of certain acceptable non-systematic names of unsaturated cyclic parent hydrides, <i>e.g.</i> benzene, azulene.  See also ‘irene’, ‘ocene’.
enide	Combined ending of names of anions resulting from the removal of a hydron from a parent hydride with an ‘ene’ name, formed by adding the suffix ‘ide’, <i>e.g.</i> diazenide, $\text{HN}=\text{N}^-$ . <i>Cf.</i> Section IR-6.4.4.
enium	Combined ending of names of cations resulting from the addition of a hydron to a parent structure with an ‘ene’ name, formed by adding the suffix ‘ium’, <i>e.g.</i> diazenium. <i>Cf.</i> Section IR-6.4.1.  Combined ending resulting from the addition of the suffix ‘ium’ to a metallocene name. This leads to ambiguous names, see Section IR-10.2.6.
eno	Ending resulting from the change of the ‘ene’ ending in names of cyclic mancude ring systems to ‘eno’ to form prefixes in fusion nomenclature. (See Section P-25.3 of the Blue Book <sup>b</sup> .)  Ending resulting from the change of the ‘ene’ ending in names of parent hydrides to form prefixes denoting bridging divalent substituent groups, <i>e.g.</i> diazeno, $-\text{N}=\text{N}-$ .
epane	Ending of parent names of seven-membered saturated heteromonocycles in Hantzsch–Widman nomenclature, <i>cf.</i> Section IR-6.2.4.3.
epine	Ending of parent names of seven-membered heteromonocycles with the maximum number of non-cumulative double bonds in Hantzsch–Widman nomenclature, <i>cf.</i> Section IR-6.2.4.3.
etane	General ending of parent names of four-membered saturated heteromonocycles in Hantzsch–Widman nomenclature, <i>cf.</i> Section IR-6.2.4.3. See also ‘etidine’.
ete	Ending of parent names of four-membered heteromonocycles with the maximum number of non-cumulative double bonds in Hantzsch–Widman nomenclature, <i>cf.</i> Section IR-6.2.4.3.
etidine	Ending of parent names of four-membered nitrogen-containing saturated heteromonocycles in Hantzsch–Widman nomenclature, <i>cf.</i> Section IR-6.2.4.3.
ic	Ending of names of many acids, both inorganic and organic, <i>e.g.</i> sulfuric acid, acetic acid, benzoic acid. For more examples, particularly of inorganic ‘ic’ acid names, see Tables IR-8.1 and IR-8.2, and Table IX. See also ‘inic’ and ‘onic’.  Ending formerly added to stems of element names to indicate a higher oxidation state, <i>e.g.</i> ferric chloride, cupric oxide, ceric sulfate. Such names are no longer acceptable.
ide	Ending of names of monoatomic and homopolyatomic anions, <i>e.g.</i> chloride, sulfide, disulfide(2–), triiodide(1–). <i>Cf.</i> Sections IR-5.3.3.2 and IR-5.3.3.3 and Table IX.  Ending of names of formally electronegative homoatomic constituents in compositional names, <i>e.g.</i> disulfur dichloride. <i>Cf.</i> Section IR-5.4.

Table III Continued

	Ending of some acceptable non-systematic names of heteropolyatomic anions: cyanide, hydroxide.
	Suffix for names of anions formed by removal of one or more hydrons from a parent hydride, accompanied by locants and multiplicative prefixes as appropriate, <i>e.g.</i> hydrazinide, $\text{H}_2\text{NNH}^-$ ; hydrazine-1,2-diide, $^-\text{HNNH}^-$ ; disulfanediide, $\text{S}_2^{2-}$ ; methanide, $\text{CH}_3^-$ .
ido	Ending of name of any anion with an 'ide' name (see above) acting as a ligand, <i>e.g.</i> chlorido, disulfido(2-) or disulfanediido, hydrazinido, hydrazine-1,2-diido, methanido. <i>Cf.</i> Sections IR-7.1.3 and IR-9.2.2.3 and Table IX.
	Ending of certain prefixes for anionic substituent groups, <i>e.g.</i> oxido for $-\text{O}^-$ .
inane	Ending of parent names of six-membered saturated heteromonocycles in Hantzsch–Widman nomenclature, <i>cf.</i> Section IR-6.2.4.3.
inate	Ending of names of anions and esters of 'inic' oxoacids, <i>e.g.</i> borinate, phosphinate.
inato	Modification of the 'inate' ending of an anion name (see above) used when the anion acts as a ligand.
ine	Ending of the non-systematic, but still acceptable, parent name hydrazine ( $\text{N}_2\text{H}_4$ ) and of the now obsolete names of other Group 15 hydrides, <i>e.g.</i> phosphine ( $\text{PH}_3$ ).  Ending of names of large heteromonocycles (more than 10 ring atoms) with the maximum number of non-cumulative double bonds for use in fusion nomenclature, <i>e.g.</i> 2 <i>H</i> -1-oxa-4,8,11-triazacyclotetradecine.  Last part of endings of a number of parent names in Hantzsch–Widman nomenclature of heteromonocycles, <i>i.e.</i> of 'irine', 'iridine', 'etidine', 'olidine', 'ine', 'inine', 'epine', 'ocine', 'onine' and 'ecine' (see Section IR-6.2.4.3).  Ending of a number of parent names of nitrogenous heterocyclic parent hydrides, <i>e.g.</i> pyridine, acridine.
inic	Ending of the parent names of acids of the types $\text{H}_2\text{X}(=\text{O})(\text{OH})$ ( $\text{X}=\text{N}, \text{P}, \text{As}, \text{Sb}$ ), <i>e.g.</i> stibinic acid; $\text{HX}(=\text{O})(\text{OH})$ ( $\text{X}=\text{S}, \text{Se}, \text{Te}$ ), <i>e.g.</i> sulfinic acid; and of borinic acid, $\text{H}_2\text{BOH}$ .
inide	Combined ending of names of anions resulting from the removal of a hydron from a parent hydride with an 'ine' name, formed by adding the suffix 'ide', <i>e.g.</i> hydrazinide, $\text{H}_2\text{NNH}^-$ . <i>Cf.</i> Section IR-6.4.4.
inine	Ending of parent names of six-membered heteromonocycles with the maximum number of non-cumulative double bonds in Hantzsch–Widman nomenclature, <i>cf.</i> Section IR-6.2.4.3.
inite	Ending of names of anions and esters of oxoacids with an 'inous' name, <i>e.g.</i> phosphinite, $\text{H}_2\text{PO}^-$ , from phosphinous acid.
inito	Modification of the 'inite' ending of an anion name (see above) used when the anion acts as a ligand.
inium	Combined ending of names of cations resulting from the addition of a hydron to a parent structure with an 'ine' name, formed by adding the suffix 'ium', <i>e.g.</i> hydrazinium, pyridinium. <i>Cf.</i> Section IR-6.4.1.
ino	Ending of some non-systematic substituent group prefixes, <i>e.g.</i> amino, $\text{NH}_2-$ ; hydrazino, $\text{H}_2\text{NNH}-$ .  Ending resulting from the change of the 'ine' ending in names of cyclic mancude ring systems to 'ino' to form prefixes in fusion nomenclature. (See Section P-25.3 of the Blue Book <sup>b</sup> .)

Table III *Continued*

inous	Ending of the parent names of acids of the types $H_2X(OH)$ ( $X = N, P, As, Sb$ ), <i>e.g.</i> stibinous acid. See Table IR-8.1 for other such names.
inoyl	Ending of prefixes for substituent groups formed by removing all hydroxy groups from 'inic' acids (see above), <i>e.g.</i> phosphinoyl, $H_2P(O)-$ ; seleninoyl, $HSe(O)-$ . (See Table IR-8.1 for phosphinic and seleninic acids.)
inyl	Ending of prefixes for the divalent substituent groups $>X=O$ (sulfinyl, seleninyl and tellurinyl for $X = S, Se$ and $Te$ , respectively).
io	Ending of acceptable alternative prefixes for certain cationic substituent groups, <i>e.g.</i> ammonio for azaniumyl, pyridinio for pyridiniumyl ( <i>cf.</i> Section IR-6.4.9).  Now abandoned ending of prefixes for substituent groups consisting of a single atom, <i>e.g.</i> mercurio, $-Hg-$ .
irane	General ending of parent names of three-membered saturated heteromonocycles in Hantzsch–Widman nomenclature, <i>cf.</i> Section IR-6.2.4.3. See also 'iridine'.
irene	General ending of parent names of three-membered heteromonocycles with the maximum number of non-cumulative double bonds ( <i>i.e.</i> one double bond) in Hantzsch–Widman nomenclature, <i>cf.</i> Section IR-6.2.4.3. See also 'irine'.
iridine	Ending of parent names of three-membered nitrogen-containing saturated heteromonocycles in Hantzsch–Widman nomenclature, <i>cf.</i> Section IR-6.2.4.3.
irine	Ending of parent names of three-membered heteromonocycles with the maximum number of non-cumulative double bonds ( <i>i.e.</i> one double bond) and N as the only heteroatom(s) in Hantzsch–Widman nomenclature, <i>cf.</i> Section IR-6.2.4.3.
ite	Ending of names of anions and esters of oxoacids having the 'ous' or the 'orous' ending in the acid name, <i>e.g.</i> hypochlorite (from hypochlorous acid), methyl sulfite (from sulfurous acid). <i>Cf.</i> Table IR-8.1. See also 'inite', 'onite'.
ito	Ending of name of any anion with an 'ite' name (see above) acting as a ligand, <i>e.g.</i> nitrito, sulfito. <i>Cf.</i> Sections IR-7.1.3 and IR-9.2.2.3 and Table IX. See also 'inito', 'onito'.
ium	Ending of names of many elements and their cations, <i>e.g.</i> helium, seaborgium, thallium(1+), and of the name of any new element ( <i>cf.</i> Ref. 1 of Chapter IR-3).  Suffix to indicate addition of hydrons to a parent hydride or other parent structure (see 'anium', 'enium', 'inium', 'onium', 'ynium'), accompanied by multiplying prefixes and locants as appropriate, <i>e.g.</i> hydrazinium, $H_2NNH_3^+$ ; hydrazine-1,2-dium, $^+H_3NNH_3^+$ .
o	Terminal vowel indicating a negatively charged ligand; see 'ato', 'ido', 'ito'.  Terminal vowel of prefixes for many inorganic and organic substituent groups, <i>e.g.</i> amino, chloro, oxido, sulfo, thiolato.  Terminal vowel of prefixes for fusion components. (See Section P-25.3 of the Blue Book <sup>b</sup> .) See also 'eno', 'ino'.  Terminal vowel of infixes used in functional replacement nomenclature (Section IR-8.6) to indicate replacement of oxygen atoms and/or hydroxy groups, <i>e.g.</i> 'amido', 'nitrido', 'thio'.
ocane	Ending of parent names of eight-membered saturated heteromonocycles in Hantzsch–Widman nomenclature, <i>cf.</i> Section IR-6.2.4.3.
ocene	Ending of the names of certain bis(cyclopentadienyl)metal compounds, <i>e.g.</i> ferrocene. <i>Cf.</i> Section IR-10.2.6.

Table III Continued

ocene	Ending of parent names of eight-membered heteromonocycles with the maximum number of non-cumulative double bonds in Hantzsch–Widman nomenclature, <i>cf.</i> Section IR-6.2.4.3.
ol	Suffix specifying substitution of a hydrogen atom in a parent hydride for the group –OH, accompanied by locants and multiplicative prefixes if appropriate, <i>e.g.</i> silanol, SiH <sub>3</sub> OH; trisilane-1,3-diol, SiH <sub>2</sub> (OH)SiH <sub>2</sub> SiH <sub>2</sub> OH.  Ending of corresponding suffixes ‘thiol’, ‘selenol’, ‘tellurol’ for –SH, –SeH and –TeH, respectively.
olane	General ending of parent names of five-membered saturated heteromonocycles in Hantzsch–Widman nomenclature, <i>cf.</i> IR-6.2.4.3. See also ‘olidine’.
olate	Suffix specifying substitution of a hydrogen atom in a parent hydride for the substituent –O <sup>–</sup> , accompanied by locants and multiplicative prefixes if appropriate, <i>e.g.</i> silanolate, SiH <sub>3</sub> O <sup>–</sup> ; trisilane-1,3-diolate, SiH <sub>2</sub> (O <sup>–</sup> )SiH <sub>2</sub> SiH <sub>2</sub> O <sup>–</sup> .  Ending of corresponding suffixes ‘thiolate’, ‘selenolate’, ‘tellurolate’ for –S <sup>–</sup> , –Se <sup>–</sup> and –Te <sup>–</sup> , respectively.
olato	Modification of the suffix ‘olate’ used when the anion in question acts as a ligand.
ole	Ending of parent names of five-membered heteromonocycles with the maximum number of non-cumulative double bonds in Hantzsch–Widman nomenclature, <i>cf.</i> Section IR-6.2.4.3.
olidine	Ending of parent names of five-membered nitrogen-containing saturated heteromonocycles in Hantzsch–Widman nomenclature, <i>cf.</i> Section IR-6.2.4.3.
onane	Ending of parent names of nine-membered saturated heteromonocycles in Hantzsch–Widman nomenclature, <i>cf.</i> Section IR-6.2.4.3.
onate	Ending of names of anions and esters of ‘onic’ oxoacids, <i>e.g.</i> boronate, phosphonate, tetrathionate.
onato	Modification of the ‘onate’ ending of an anion used when the anion acts as a ligand.  Ending of prefixes of certain anionic substituent groups, <i>e.g.</i> phosphonato, –P(=O)(O <sup>–</sup> ) <sub>2</sub> ; sulfonato, –S(=O) <sub>2</sub> (O <sup>–</sup> ).
one	Suffix specifying the substitution of two hydrogen atoms on the same skeletal atom in a parent hydride for the substituent =O, accompanied by locants and multiplicative prefixes as appropriate, <i>e.g.</i> phosphanone, HP=O; pentane-2,4-dione, CH <sub>3</sub> C(=O)CH <sub>2</sub> C(=O)CH <sub>3</sub> .  Ending of corresponding suffixes ‘thione’, ‘selenone’, ‘tellurone’ for =S, =Se and =Te, respectively.
onic	Ending of the parent names of acids of the types HXO(OH) <sub>2</sub> (X=N, P, As, Sb), <i>e.g.</i> stibonic acid; HXO <sub>2</sub> (OH) (X=S, Se, Te), <i>e.g.</i> sulfonic acid; and of boronic acid, HB(OH) <sub>2</sub> . See Table IR-8.1.  Ending of the parent names dithionic, trithionic, <i>etc.</i> , acids (see Table IR-8.1).
onine	Ending of parent names of nine-membered heteromonocycles with the maximum number of non-cumulative double bonds in Hantzsch–Widman nomenclature, <i>cf.</i> Section IR-6.2.4.3.
onite	Ending of names of anions and esters of ‘onous’ oxoacids, <i>e.g.</i> phosphonite, tetrathionite.
onito	Modification of the ‘onite’ ending of an anion name used when the anion acts as a ligand.

Table III *Continued*

onium	Ending of still acceptable non-systematic names of cations formed by hydron addition to a mononuclear parent hydride: ammonium, oxonium (see Section IR-6.4.1).
ono	Ending of prefixes for substituent groups formed from ‘onic’ acids by removal of a hydrogen atom, <i>e.g.</i> phosphono for $-\text{P}(=\text{O})(\text{OH})_2$ . <i>Exception:</i> note that $-\text{S}(=\text{O})_2\text{OH}$ is ‘sulfo’ rather than ‘sulfono’.
onous	Ending of the parent names of acids of the types $\text{HX}(\text{OH})_2$ ( $\text{X} = \text{N}, \text{P}, \text{As}, \text{Sb}$ ), <i>e.g.</i> stibonous acid.  Ending of the parent names dithionous, trithionous, <i>etc.</i> , acids (see Table IR-8.1).
onoyl	Ending of prefixes for substituent groups formed by removing all hydroxy groups from ‘onic’ acids, <i>e.g.</i> phosphonoyl, $\text{HP}(\text{O})<$ ; selenonoyl, $\text{HSe}(\text{O})_2-$ . (See Table IR-8.1 for phosphonic and selenonic acids.)
onyl	Ending of prefixes for the divalent substituent groups $>\text{X}(=\text{O})_2$ (sulfonyl, selenonyl and telluronyl for $\text{X} = \text{S}, \text{Se}$ and $\text{Te}$ , respectively).
orane	Ending of the acceptable alternative names phosphorane for $\lambda^5$ -phosphane ( $\text{PH}_5$ ), arsorane for $\lambda^5$ -arsane ( $\text{AsH}_5$ ) and stiborane for $\lambda^5$ -stibane ( $\text{SbH}_5$ ).
oryl	Ending of prefixes for substituent groups formed by removing all hydroxy groups from ‘oric’ acids, <i>e.g.</i> phosphoryl, $\text{P}(\text{O})\leftarrow$ , from phosphoric acid.
ous	Ending of parent names of certain inorganic oxoacids, <i>e.g.</i> arsorous acid, seleninous acid. For more examples of ‘ous’ acid names, see Tables IR-8.1 and IR-8.2. See also ‘inous’, ‘onous’.  Ending formerly added to stems of element names to indicate a lower oxidation state, <i>e.g.</i> ferrous chloride, cuprous oxide, cerous hydroxide. Such names are no longer acceptable.
triene	See ‘ene’.
triide	See ‘ide’.
trium	See ‘ium’.
triyl	Combined suffix composed of the suffix ‘yl’ and the multiplying prefix ‘tri’, indicating the loss of three hydrogen atoms from a parent hydride resulting in a triradical or a substituent group forming three single bonds, <i>e.g.</i> the substituent groups boranetriyl, $-\text{B}<$ ; trisilane-1,2,3-triyl, $-\text{SiH}_2\text{SiHSiH}_2-$ ; $\lambda^5$ -phosphanetriyl, $\text{H}_2\text{P}\leftarrow$ . (See also ‘ylidyne’ and ‘ylylidene’.)
uide	Suffix specifying the addition of hydride to a parent structure, accompanied by locants and multiplicative prefixes if appropriate, <i>e.g.</i> tellanuide, $\text{TeH}_3^-$ .
uido	Modification of the ‘uide’ suffix in an anion name used when the anion acts as a ligand.
y	Terminal vowel of prefixes for some substituent groups, <i>e.g.</i> carboxy, $-\text{COOH}$ ; hydroxy, $-\text{OH}$ ; oxy, $-\text{O}-$ .  Terminal vowel in prefixes used in specifying chain and ring atoms in additive nomenclature for inorganic chains and rings, <i>cf.</i> Section IR-7.4. These prefixes are given for all elements in Table X.
yl	Suffix to indicate removal of hydrogen atoms from a parent hydride to form radicals or substituent groups, accompanied by multiplicative prefixes and locants as appropriate, <i>e.g.</i> hydrazinyl, $\text{H}_2\text{NNH}^\bullet$ or $\text{H}_2\text{NNH}-$ ; hydrazine-1,2-diyl, $^\bullet\text{HNNH}^\bullet$ or $-\text{HNNH}-$ . (See also ‘diyl’, ‘ylene’, ‘ylylidene’, ‘triyl’, ‘ylylidene’, ‘ylidyne’.)

Table III *Continued*

	Ending of certain non-systematic names of oxidometal cations, <i>e.g.</i> vanadyl for oxidovanadium(2+). These names are no longer acceptable.
ylene	Ending of a few still acceptable names for divalent substituent groups, meaning the same as 'diyl': methylene for methanediyl, $-\text{CH}_2-$ ; phenylene for benzenediyl, $-\text{C}_6\text{H}_4-$ ; (1,2-phenylene for benzene-1,2-diyl <i>etc.</i> ).
ylidene	Suffix for names of divalent substituent groups formed by the loss of two hydrogen atoms from the same atom of a parent hydride and forming a double bond, <i>e.g.</i> azanylidene, $\text{HN}=\text{}$ , and for names of corresponding diradicals. (See also 'diyl'.)
ylidyne	Suffix for names of trivalent substituent groups formed by the loss of three hydrogen atoms from the same atom of a parent hydride and forming a triple bond, <i>e.g.</i> phosphanylidyne, $\text{P}\equiv$ . (See also 'ylylidene' and 'triyl'.)
ylum	Suffix for names of cations formed by the loss of hydride ions from parent hydrides, accompanied by locants and multiplicative prefixes as appropriate, <i>e.g.</i> azanylium, $\text{NH}_2^+$ ; disilane-1,2-dylium, $^+\text{H}_2\text{SiSiH}_2^+$ .
ylylidene	Combined suffix ('yl' plus 'ylidene') for names of trivalent substituent groups formed by the loss of three hydrogen atoms from the same atom, forming a single bond and a double bond, <i>e.g.</i> azanylylidene, $-\text{N}=\text{}$ . (See also 'ylidyne' and 'triyl'.)
yne	Ending of systematic names of acyclic and cyclic parent structures with triple-bond unsaturation, replacing 'ane' in the name of the corresponding saturated parent hydride, and if necessary accompanied by locants and multiplicative prefixes specifying the locations and number of triple bonds, <i>e.g.</i> diazyne (see 'ynium' for an application of this name), ethyne, penta-1,4-diyne.
ynide	Combined ending of names of anions resulting from the removal of a hydron from a parent hydride with an 'yne' name, formed by adding the suffix 'ide', <i>e.g.</i> ethynide, $\text{CH}\equiv\text{C}^-$ . <i>Cf.</i> Section IR-6.4.4.
ynium	Combined ending of names of cations resulting from the addition of a hydron to a parent structure with an 'yne' name, formed by adding the suffix 'ium', <i>e.g.</i> diazynium ( $\text{N}\equiv\text{NH}^+$ ). <i>Cf.</i> Section IR-6.4.1.

<sup>a</sup> The term 'suffix' is understood here to mean a name part added to a parent name in order to specify a modification of that parent, *e.g.* substitution of a hydrogen atom in a parent hydride by a characteristic group (suffixes such as 'carboxylic acid', 'thiol', *etc.*) or formation of a radical or substituent group by removal of one or more hydrogen atoms (suffixes such as 'yl', 'ylidene', *etc.*). The term 'ending' is used in a broader sense, but also to designate specifically the common last part (last syllable or last few syllables) of systematic names for members of classes of compounds (such as 'ane', 'ene', 'diene', 'yne', *etc.*, for parent hydrides, and 'onic acid', 'inic acid', *etc.*, for inorganic oxoacids).

<sup>b</sup> *Nomenclature of Organic Chemistry, IUPAC Recommendations*, eds. W.H. Powell and H. Favre, Royal Society of Chemistry, in preparation. (The Blue Book.)



**Table IV** *Multiplicative prefixes*

1	mono	21	henicosa
2	di <sup>a</sup> (bis <sup>b</sup> )	22	docosa
3	tri (tris)	23	tricos
4	tetra (tetrakis)	30	triaconta
5	penta (pentakis)	31	hentriaconta
6	hexa (hexakis)	35	pentatriaconta
7	hepta (heptakis)	40	tetraconta
8	octa (octakis)	48	octatetraconta
9	nona (nonakis)	50	pentaconta
10	deca (decakis)	52	dopentaconta
11	undeca	60	hexaconta
12	dodeca	70	heptaconta
13	trideca	80	octaconta
14	tetradeca	90	nonaconta
15	pentadeca	100	hecta
16	hexadeca	200	dicta
17	heptadeca	500	pentacta
18	octadeca	1000	kilia
19	nonadeca	2000	dilia
20	icosa		

<sup>a</sup> In the case of a ligand using two donor atoms, the term 'bidentate' rather than 'didentate' is recommended because of prevailing usage.

<sup>b</sup> The prefixes bis, tris, *etc.* (examples are given for 1–10 but continue throughout) are used with composite ligand names or in order to avoid ambiguity.

**Table V** *Geometrical and structural affixes*

Except for those denoted by Greek letters, geometrical and structural affixes are italicized. All are separated from the rest of the name by hyphens.

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<i>antiprisma</i>	eight atoms bound into a regular antiprism
<i>arachno</i>	a boron structure intermediate between <i>nido</i> and <i>hypho</i> in degree of openness
<i>asym</i>	asymmetrical
<i>catena</i>	a chain structure; often used to designate linear polymeric substances
<i>cis</i>	two groups occupying adjacent positions in a coordination sphere
<i>closo</i>	a cage or closed structure, especially a boron skeleton that is a polyhedron having all faces triangular
<i>cyclo</i>	a ring structure. (Here, <i>cyclo</i> is used as a modifier indicating structure and hence is italicized. In organic nomenclature, 'cyclo' is considered to be part of the parent name since it changes the molecular formula. It is therefore not italicized.)
$\delta$ (delta)	denotes the absolute configuration of chelate ring conformations
$\Delta$ (delta)	a structural descriptor to designate deltahedra, or shows absolute configuration
<i>dodecahedro</i>	eight atoms bound into a dodecahedron with triangular faces
$\eta$ (eta)	specifies the bonding of contiguous atoms of a ligand to a central atom
<i>fac</i>	three groups occupying the corners of the same face of an octahedron
<i>hexahedro</i>	eight atoms bound into a hexahedron ( <i>e.g.</i> cube)
<i>hexaprisma</i>	twelve atoms bound into a hexagonal prism
<i>hypho</i>	an open structure, especially a boron skeleton, more closed than a <i>klado</i> structure but more open than an <i>arachno</i> structure
<i>icosahedro</i>	twelve atoms bound into an icosahedron with triangular faces
$\kappa$ (kappa)	specifies the donor atoms in a ligand
<i>klado</i>	a very open polyboron structure
$\lambda$ (lambda)	signifies, with its superscript, the bonding number, <i>i.e.</i> the sum of the number of skeletal bonds and the number of hydrogen atoms associated with an atom in a parent compound; denotes the absolute configuration of chelate ring conformations
$\Lambda$ (lambda)	shows absolute configuration
<i>mer</i>	meridional; three groups occupying vertices of an octahedron so that one is <i>cis</i> to the other two which are themselves mutually <i>trans</i>
$\mu$ (mu)	signifies that a group so designated bridges two or more coordination centres
<i>nido</i>	a nest-like structure, especially a boron skeleton that is almost closed
<i>octahedro</i>	six atoms bound into an octahedron
<i>pentaprisma</i>	ten atoms bound into a pentagonal prism
<i>quadro</i>	four atoms bound into a quadrangle ( <i>e.g.</i> square)
<i>sym</i>	symmetrical
<i>tetrahedro</i>	four atoms bound into a tetrahedron
<i>trans</i>	two groups occupying positions in a coordination sphere directly opposite each other
<i>triangulo</i>	three atoms bound into a triangle
<i>triprisma</i>	six atoms bound into a triangular prism

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Table VI Element sequence

→ He	Ne	Ar	Kr	Xe	Rn	→ Li	Na	K	Rb	Cs	Fr	→ Be	Mg	Ca	Sr	Ba	Ra	→ Sc	Y	La	Lu	→ Ti	Zr	Hf	Rf	→ V	Nb	Ta	Db	→ Cr	Mo	W	Sg	→ Mn	Tc	Re	Bh	→ Fe	Ru	Os	Hs	→ Co	Rh	Ir	Mt	→ Ni	Pd	Pt	Ds	→ Cu	Ag	Au	Rg	→ Zn	Cd	Hg	→ B	Al	Ga	In	Tl	→ C	Si	Ge	Sn	Pb	→ N	P	As	Sb	Bi	→ O	S	Se	Te	Po	→ F	Cl	Br	I	At
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Table VII Ligand abbreviations

Guidelines for the construction and use of ligand abbreviations are given in Section IR-4.4.4 and their use in the formulae of coordination complexes is described in Section IR-9.2.3.4. Abbreviations are listed in alphabetical order but those beginning with a numeral are listed by the first letter of the abbreviation (e.g. 2,3,2-tet appears under the letter ‘t’).

Structural formulae of selected ligands are shown in Table VIII (numbered according to the present Table).

<i>Number and abbreviation</i>	<i>Systematic name</i>	<i>Other name (from which abbreviation derived)<sup>a</sup></i>
1. 4-abu	4-aminobutanoato	
2. Ac	acetyl	
3. acac	2,4-dioxopentan-3-ido	acetylacetonato
4. acacen	2,2'-[ethane-1,2-diylbis(azanylylidene)]bis(4-oxopentan-3-ido)	bis(acetylacetonato)ethylenediamine
5. ade	9H-purin-6-amine	adenine
6. ado	9-β-D-ribofuranosyl-9H-purin-6-amine	adenosine
7. adp	adenosine 5'-diphosphato(3-)	
8. aet	2-aminoethanethiolato	
9. ala	2-aminopropanoato	alaninato
10. ama	2-aminopropanedioato	aminomalonato
11. amp	adenosine 5'-phosphato(2-)	adenosine monophosphato
12. [9]aneN <sub>3</sub> (also taen)	1,4,7-triazonane	
13. [12]aneN <sub>4</sub> (also cyclen)	1,4,7,10-tetraazacyclododecane	
14. [14]aneN <sub>4</sub> (also cyclam)	1,4,8,11-tetraazacyclotetradecane	
15. [18]aneP <sub>4</sub> O <sub>2</sub>	1,10-dioxo-4,7,13,16-tetraphosphacyclooctadecane	
16. [9]aneS <sub>3</sub>	1,4,7-trithionane	
17. [12]aneS <sub>4</sub>	1,4,7,10-tetrathiaacyclododecane	
18. arg	2-amino-5-carbamimidamidopentanoato	argininato
19. asn	2,4-diamino-4-oxobutanoato	asparaginato
20. asp	2-aminobutanedioato	aspartato
21. atmp	[nitrilotris(methylene)]tris(phosphonato)	aminotris(methylenephosphonato)
22. atp	adenosine 5'-triphosphato(4-)	
23. 2,3-bdta	2,2',2'',2'''-(butane-2,3-diylidinitrilo)tetraacetato	

Table VII Continued

Number and abbreviation	Systematic name	Other name (from which abbreviation derived) <sup>a</sup>
24. benzo-15-crown-5	2,3,5,6,8,9,11,12-octahydro-1,4,7,10,13-benzopentaoxacyclopentadecine	
25. big	bis(carbamimidoyl)azanido	biguanid-3-ido
26. biim	2,2'-bi(1 <i>H</i> -imidazole)-1,1'-diido	2,2'-biimidazolato
27. binap	1,1'-binaphthalene-2,2'-diylbis(diphenylphosphane)	
28. bn	butane-2,3-diamine	
29. bpy	2,2'-bipyridine	
30. 4,4'-bpy	4,4'-bipyridine	
31. Bu	butyl	
32. bzac	1,3-dioxo-1-phenylbutan-2-ido	benzoylacetonoato
33. bzim	1 <i>H</i> -benzimidazol-1-ido	
34. Bz <sup>b</sup>	benzyl	
35. bztz	1,3-benzothiazole	
36. cat	benzene-1,2-diolato	catecholato
37. cbdea	cyclobutane-1,1-dicarboxylato	
38. cdta	2,2',2'',2'''-(cyclohexane-1,2-diylidinitrilo)tetraacetato	
39. C <sub>5</sub> H <sub>4</sub> Me	methylcyclopentadienyl	
40. chxn (also dach)	cyclohexane-1,2-diamine	
41. cit	2-hydroxypropane-1,2,3-tricarboxylato	cittrato
42. C <sub>5</sub> Me <sub>5</sub> <sup>c</sup>	pentamethylcyclopentadienyl	
43. cod	cycloocta-1,5-diene	
44. cot	cycloocta-1,3,5,7-tetraene	
45. Cp	cyclopentadienyl	
46. cptn	cyclopentane-1,2-diamine	
47. 18-crown-6	1,4,7,10,13,16-hexaoxacyclooctadecane	
48. crypt-211	4,7,13,18-tetraoxa-1,10-diazabicyclo[8.5.5]icosane	cryptand 211
49. crypt-222	4,7,13,16,21,24-hexaoxa-1,10-diazabicyclo[8.8.8]hexacosane	cryptand 222
50. Cy	cyclohexyl	

cyclam (see [14]aneN <sub>4</sub> , No. 14)		
cyclen (see [12]aneN <sub>4</sub> , No. 13)		
51. cys	2-amino-3-sulfanypropanoato	cysteinato
52. cyt	4-aminopyrimidin-2(1 <i>H</i> )-one	cytosine
53. dabco	1,4-diazabicyclo[2.2.2]octane	
dach (see chxn, No. 40)		
54. dbm	1,3-dioxo-1,3-diphenylpropan-2-ido	diaminocyclohexane
55. dea	2,2'-azanediyl[di(ethan-1-olato)]	dibenzoylmethanato
56. depe	ethane-1,2-diylbis(diethylphosphane)	diethanolaminato
57. diars	benzene-1,2-diylbis(dimethylarsane)	1,2-bis(diethylphosphino)ethane
58. dien	<i>N</i> -(2-aminoethyl)ethane-1,2-diamine	diethylenetriamine
59. [14]1,3-dieneN <sub>4</sub>	1,4,8,11-tetraazacyclotetradeca-1,3-diene	
60. diop	[(2,2-dimethyl-1,3-dioxolane-4,5-diyl)bis(methylene)]bis(diphenylphosphane)	
61. diox	1,4-dioxane	
62. dipamp	ethane-1,2-diylbis[(2-methoxyphenyl)phenylphosphane]	'dimer of phenylanisylmethylphosphine'
63. dma	<i>N,N</i> -dimethylacetamide	dimethylacetamide
64. dme	1,2-dimethoxyethane	
65. dmf	<i>N,N</i> -dimethylformamide	
66. dmng	butane-2,3-diylidenebis(azanolato)	dimethylglyoximate
67. dmpe	ethane-1,2-diylbis(dimethylphosphane)	1,2-bis(dimethylphosphino)ethane
68. dmpm	methylenebis(dimethylphosphane)	bis(dimethylphosphino)methane
69. dmso	(methanesulfinyl)methane	dimethyl sulfoxide
70. dpm	2,2,6,6-tetramethyl-3,5-dioxoheptan-4-ido	dipivaloylmethanato
71. dppe	ethane-1,2-diylbis(diphenylphosphane)	1,2-bis(diphenylphosphino)ethane
72. dppl	1,1'-bis(diphenylphosphanyl)ferrocene	
73. dppm	methylenebis(diphenylphosphane)	bis(diphenylphosphino)methane
74. dppp	propane-1,3-diylbis(diphenylphosphane)	1,3-bis(diphenylphosphino)propane
75. dtmpe	(phosphonomethyl)azanediylbis[ethane-2,1-diyl]nitrilobis(methylene)]tetrakis(phosphonato)	diethylenetriaminepentakis- $\text{C}$ (methylene)phosphonato) <sup>d</sup>
76. dtpe	2,2',2''/2'''-(carboxylatomethyl)azanediylbis[ethane-2,1-diyl]nitrilol]tetracetato	diethylenetriaminepentaacetato
77. ea	2-amino(ethan-1-olato)	ethanolaminato

Table VII Continued

Number and abbreviation	Systematic name	Other name (from which abbreviation derived) <sup>a</sup>
78. edda	2,2'-(ethane-1,2-diylbis(azanediyl))diacetato	ethylenediaminediacetato
79. edta	2,2',2'',2'''-(ethane-1,2-diyl(dinitrilo)tetraacetato	ethylenediaminetetraacetato
80. edtmpa	ethane-1,2-diylbis[nitrilobis(methyle)]tetrakis(phosphonato)	ethylenediaminetetrakis(methylenephosphonato) <sup>d</sup>
81. egta	2,2',2'',2'''-(ethane-1,2-diylbis(oxyethane-2,1-diyl(nitrilo))tetraacetato	ethylene glycol-bis(2-aminoethyl)- <i>N,N,N',N'</i> -tetraacetic acid
82. en	ethane-1,2-diamine	
83. Et	ethyl	
84. Et <sub>2</sub> dic	<i>N,N</i> -diethylcarbomodithioato	<i>N,N</i> -diethyldithiocarbamato
85. fod	6,6,7,7,8,8,8-heptafluoro-2,2-dimethyl-3,5-dioxooctan-4-ido	
86. fta	1,1,1-trifluoro-2,4-dioxopentan-3-ido	trifluoroacetylacetonato
87. gln	2,5-diamino-5-oxopentanoato	glutaminato
88. glu	2-aminopentanedioato	glutamato
89. gly	aminoacetato	glycinato
90. gua	2-amino-9 <i>H</i> -purin-6(1 <i>H</i> )-one	guanine
91. guo	2-amino-9-β-D-ribofuranosyl-9 <i>H</i> -purin-6(1 <i>H</i> )-one	guanosine
92. hdtmpa	hexane-1,6-diylbis[nitrilobis(methyle)]tetrakis(phosphonato)	hexamethylenediaminetetrakis(methylenephosphonato) <sup>d</sup>
93. hedp	1-hydroxyethane-1,1-diylbis(phosphonato)	1-hydroxyethane-1,1-diphosphonato
94. hfa	1,1,1,5,5,5-hexafluoropentane-2,4-dioxopentan-3-ido	hexafluoroacetylacetonato
95. his	2-amino-3-(imidazol-4-yl)propanoato	histidinato
96. hmpa	hexamethylphosphoric triamide	
97. hmta	1,3,5,7-tetraazatricyclo[3.3.1.1 <sup>3,7</sup> ]decane	hexamethylenetetramine
98. ida	2,2'-azanediylidiacetato	iminodiacetato
99. ile	2-amino-3-methylpentanoato	isoleucinato
100. im	1 <i>H</i> -imidazol-1-ido	
101. isn	pyridine-4-carboxamide	isonicotinamide

102. leu	2-amino-4-methylpentanoato	leucinato
103. lut	2,6-dimethylpyridine	lutidine
104. lys	2,6-diaminohexanoato	lysinato
105. mal	2-hydroxybutanedioato	malato
106. male	(Z)-butenedioato	maleato
107. malo	propanedioato	malonato
108. Me	methyl	
109. 2-Mepy	2-methylpyridine	
110. met	2-amino-4-(methylsulfonyl)butanoato	methioninato
111. mnt	1,2-dicyanoethene-1,2-dithiolato	maleonitriledithiolato
112. napy	1,8-naphthyridine	
113. nbd	bicyclo[2.2.1]hepta-2,5-diene	norbornadiene
114. nia	pyridine-3-carboxamide	nicotinamide
115. nmp	N-methylpyrrolidine	
116. nta	2,2',2''-nitrioltriacetato	
117. oep	2,3,7,8,12,13,17,18-octaethylporphyrin-21,23-diido	
118. ox	ethanedioato	oxalato
119. pc	phthalocyanine-29,31-diido	
120. 1,2-pdta	2,2',2'',2'''-(propane-1,2-diyldinitrilo)tetraacetato	1,2-propylenediaminetetraacetato
121. 1,3-pdta	2,2',2'',2'''-(propane-1,3-diyldinitrilo)tetraacetato	1,3-propylenediaminetetraacetato
122. Ph	phenyl	
123. phe	2-amino-3-phenylpropanoato	phenylalaninato
124. phen	1,10-phenanthroline	
125. pip	piperidine	
126. pmdien	2,2'-(methylazanediyl)bis(N,N-dimethylethan-1-amine)	N,N,N',N'',N'''-pentamethyl- $\text{C}$ -diethylenetriamine <sup>d</sup>
127. pn	propane-1,2-diamine	
128. pplX	2,18-bis(2-carboxyethyl)-3,7,12,17-tetramethyl-8,13-divinylporphyrin-21,23-diido	protoporphyrinato IX
129. pro	pyrrolidine-2-carboxylato	prolinato
130. ptn	pentane-2,4-diamine	
131. py	pyridine	



Table VII Continued

Number and abbreviation	Systematic name	Other name (from which abbreviation derived) <sup>a</sup>
132. pyz	pyrazine	
133. pz	1 <i>H</i> -pyrazol-1-ido	
134. qdt	quinoxaline-2,3-dithiolato	
135. quin	quinolin-8-olato	
136. sal	2-hydroxybenzoato	salicylato
137. salan	2-[(phenylimino)methyl]phenolato	salicylideneanilinato
138. saldien	2,2'-[azanediy]bis(ethane-2,1-diylazanylylidenemethanylylidene)]diphenolato	bis(salicylidene)diethylenetriaminato
139. salen	2,2'-[ethane-1,2-diylbis(azanylylidenemethanylylidene)]diphenolato	bis(salicylidene)ethylenediaminato
140. salgly	<i>N</i> -(2-oxidobenzylidene)glycinato	salicylideneglycinato
141. salpn	2,2'-[propane-1,2-diylbis(azanylylidenemethanylylidene)]diphenolato	bis(salicylidene)propylenediaminato
142. saltn	2,2'-[propane-1,3-diylbis(azanylylidenemethanylylidene)]diphenolato	bis(salicylidene)trimethylenediaminato
143. sdta <sup>e</sup>	2,2',2'',2'''-[(1,2-diphenylethane-1,2-diyl)dinitrilo]tetraacetato	stilbenediaminetetraacetato
144. sepf <sup>f</sup>	1,3,6,8,10,13,16,19-octaazabicyclo[6.6.6]icosane	
145. ser	2-amino-3-hydroxypropanoato	serinato
146. stien <sup>e</sup>	1,2-diphenylethane-1,2-diamine	stilbenediamine
tacn (see [9]aneN <sub>3</sub> , No. 12)		1,4,7-triazacyclononane
147. tap	propane-1,2,3-triamine	1,2,3-triaminopropane
148. tart	2,3-dihydroxybutanedioato	tartrato
149. tcne	ethenetetracarbonitrile	tetracyanoethylene
150. tenq	2,2'-(cyclohexa-2,5-diene-1,4-diylidene)di(propanedinitrile)	tetracyanoquinodimethane
151. tdt	4-methylbenzene-1,2-dithiolato	
152. tea	2,2',2''-nitrioltri(ethan-1-olato)	triethanolaminato
153. terpy	2,2':6':2''-terpyridine	terpyridine
154. 2,3,2-tet	<i>N,N'</i> -bis(2-aminoethyl)propane-1,3-diamine	1,4,8,11-tetrazaundecane
155. 3,3,3-tet	<i>N,N'</i> -bis(3-aminopropyl)propane-1,3-diamine	1,5,9,13-tetrazaundecane
156. tetren	<i>N,N'</i> -(azanediy)diethane-2,1-diyl)di(ethane-1,2-diamine)	tetraethylenepentamine

157. tfa	trifluoroacetato	
158. thf	oxolane	tetrahydrofuran
159. thiox	1,4-oxathiane	thioxane
160. thr	2-amino-3-hydroxybutanoato	threoninato
161. tht	thiolane	tetrahydrothiophene
162. thy	5-methylpyrimidine-2,4(1 <i>H</i> ,3 <i>H</i> )-dione	thymine
163. tmen	<i>N,N,N',N'</i> -tetramethylethane-1,2-diamine	
164. tmp	5,10,15,20-tetrakis(2,4,6-trimethylphenyl)porphyrin-21,23-diido	5,10,15,20-tetramesitylporphyrin-21,23-diido
165. tn	propane-1,3-diamine	trimethylenediamine
166. Tol ( <i>o</i> -, <i>m</i> - or <i>p</i> -)	2-, 3- or 4-methylphenyl	tolyl ( <i>o</i> -, <i>m</i> - or <i>p</i> -)
167. Tp	hydridotris(pyrazolido- <i>N</i> )borato(1-), or tris(1 <i>H</i> -pyrazol-1-yl)boranuido	hydrotris(pyrazolyl)borato
168. Tp <sup>g</sup>	tris(3,5-dimethylpyrazolido- <i>N</i> )hydridoborato(1-)	hydrotris(3,5-dimethylpyrazolyl)borato
169. tpp	5,10,15,20-tetraphenylporphyrin-21,23-diido	
170. tren	<i>N,N</i> -bis(2-aminoethyl)ethane-1,2-diamine	tris(2-aminoethyl)amine
171. trien	<i>N,N'</i> -bis(2-aminoethyl)ethane-1,2-diamine	triethylenetetramine
172. triphos <sup>h</sup>	[(phenylphosphanediy)bis(ethane-2,1-diyl)]bis(diphenylphosphane)	
173. tris	2-amino-2-(hydroxymethyl)propane-1,3-diol	
174. ttp	2-amino-3-(1 <i>H</i> -indol-3-yl)propanoato	tris(hydroxymethyl)aminomethane
175. tsalen	2,2'-[ethane-1,2-diyl]bis(azanylylidenemethanylylidene)]dibenzeneethiolato	tryptophanato
176. tffa	4,4,4-trifluoro-1,3-dioxo-1-(2-thienyl)butan-2-ido	bis(thiosalicylidene)ethylenediaminato
177. ttha	2,2',2'',2'''-(ethane-1,2-diyl)bis{[(carboxylatomethyl)azanediy]ethane-2,1-diylinitrilo}tetraacetato	thenoyltrifluoroacetato
178. ttp	5,10,15,20-tetrakis(4-methylphenyl)porphyrin-21,23-diido	triethylenetetraminehexaacetato
179. tu	thiourea	5,10,15,20-tetra- <i>p</i> -tolylporphyrin-21,23-diido
180. tyr	2-amino-3-(4-hydroxyphenyl)propanoato	tyrosinato
181. tz	1,3-thiazole	thiazole
182. ura	pyrimidine-2,4(1 <i>H</i> ,3 <i>H</i> )-dione	uracil
183. val	2-amino-3-methylbutanoato	valinato

<sup>a</sup> Many of these names are no longer acceptable.

<sup>b</sup> The abbreviation Bz has often been used previously for 'benzoyl', and Bzl has been used for 'benzyl'. Use of the alternatives, PhCO and PhCH<sub>2</sub>, is therefore preferable.

<sup>c</sup> The use of the abbreviation Cp\* for pentamethylcyclopentadienyl is discouraged. It can lead to confusion because the asterisk, \*, is also used to represent an excited state, an optically active substance, *etc.*

- <sup>d</sup> The symbol ‘ $\frown$ ’ is used to divide the name, necessitated by the line break. In the absence of the line break this symbol is omitted. Note that all *hyphens* are true parts of the name.
- <sup>e</sup> The abbreviation derives from the non-systematic name stilbenediamine which incorrectly implies the presence of a C=C double bond in the ligand.
- <sup>f</sup> The abbreviation derives from the non-systematic name sepulchrate which incorrectly implies that the ligand is anionic.
- <sup>g</sup> The use of Tp’ is preferred to Tp\* for the reasons given in footnote c. A general procedure for abbreviating substituted hydridotris(pyrazolido-*N*)borate ligands has been proposed [see S. Trofimenko, *Chem. Rev.*, **93**, 943–980 (1993)]. For example, Tp’ becomes Tp<sup>Me<sub>2</sub></sup>, the superscript denoting the methyl groups at the 3- and 5-positions of the pyrazole rings.
- <sup>h</sup> The abbreviation triphos should not be used for the four-phosphorus ligand PhP(CH<sub>2</sub>PPh<sub>2</sub>)<sub>3</sub>.

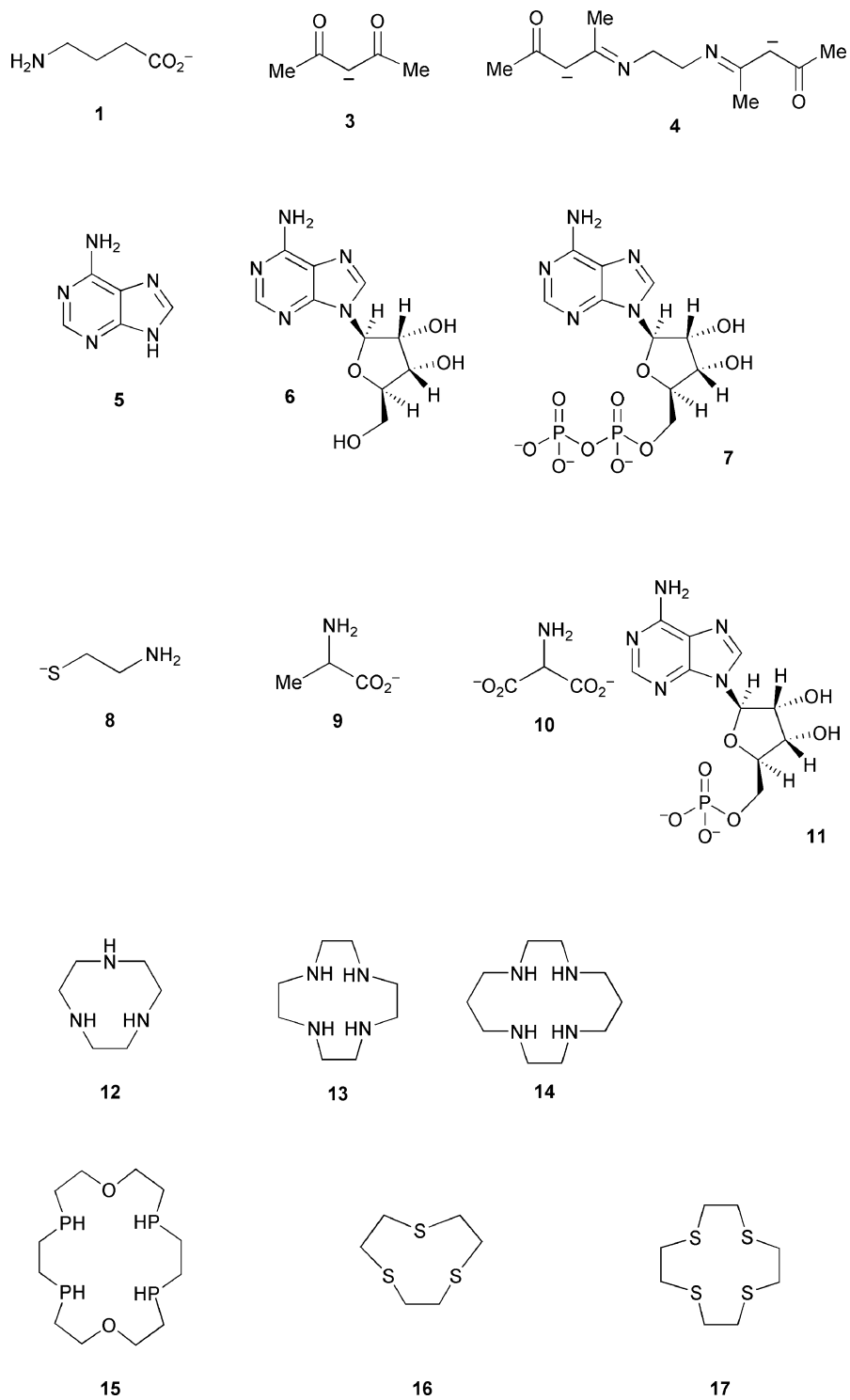
**Table VIII** Structural formulae of selected ligands (numbered according to Table VII)

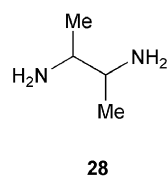
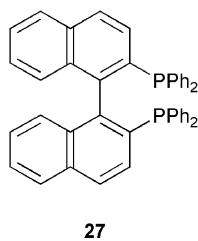
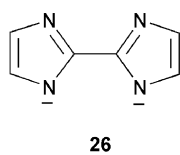
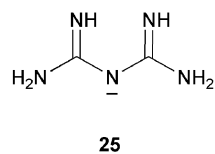
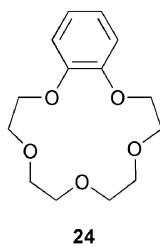
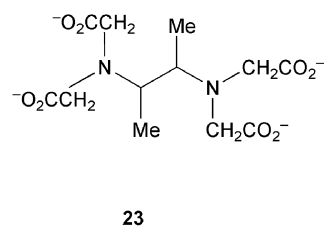
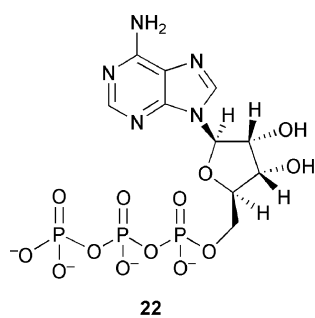
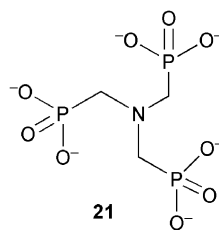
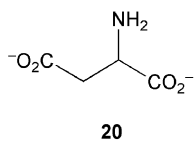
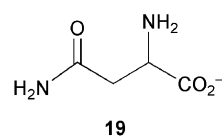
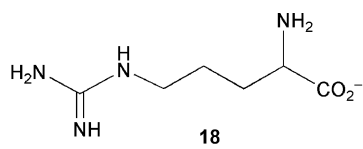
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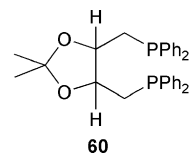
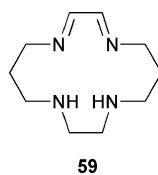
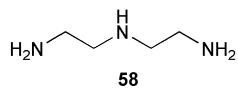
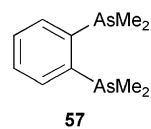
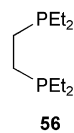
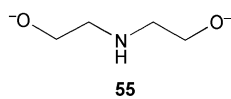
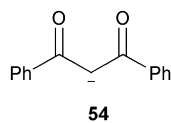
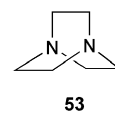
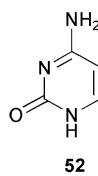
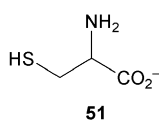
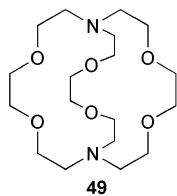
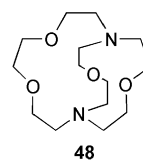
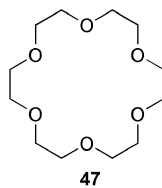
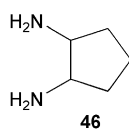
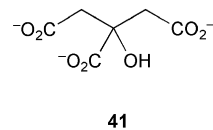
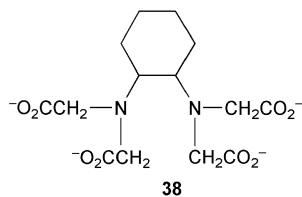
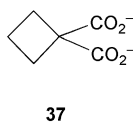
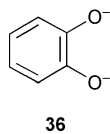
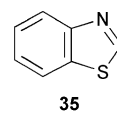
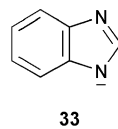
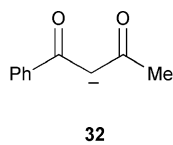
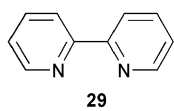
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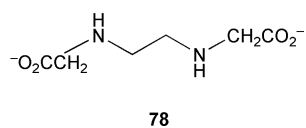
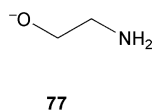
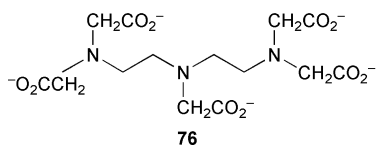
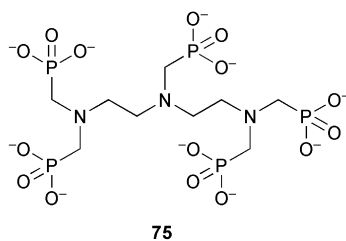
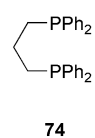
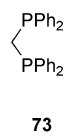
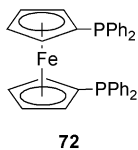
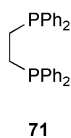
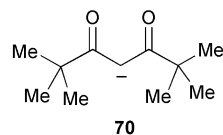
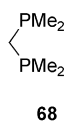
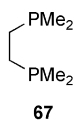
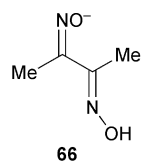
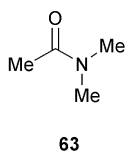
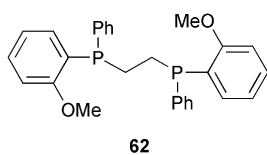
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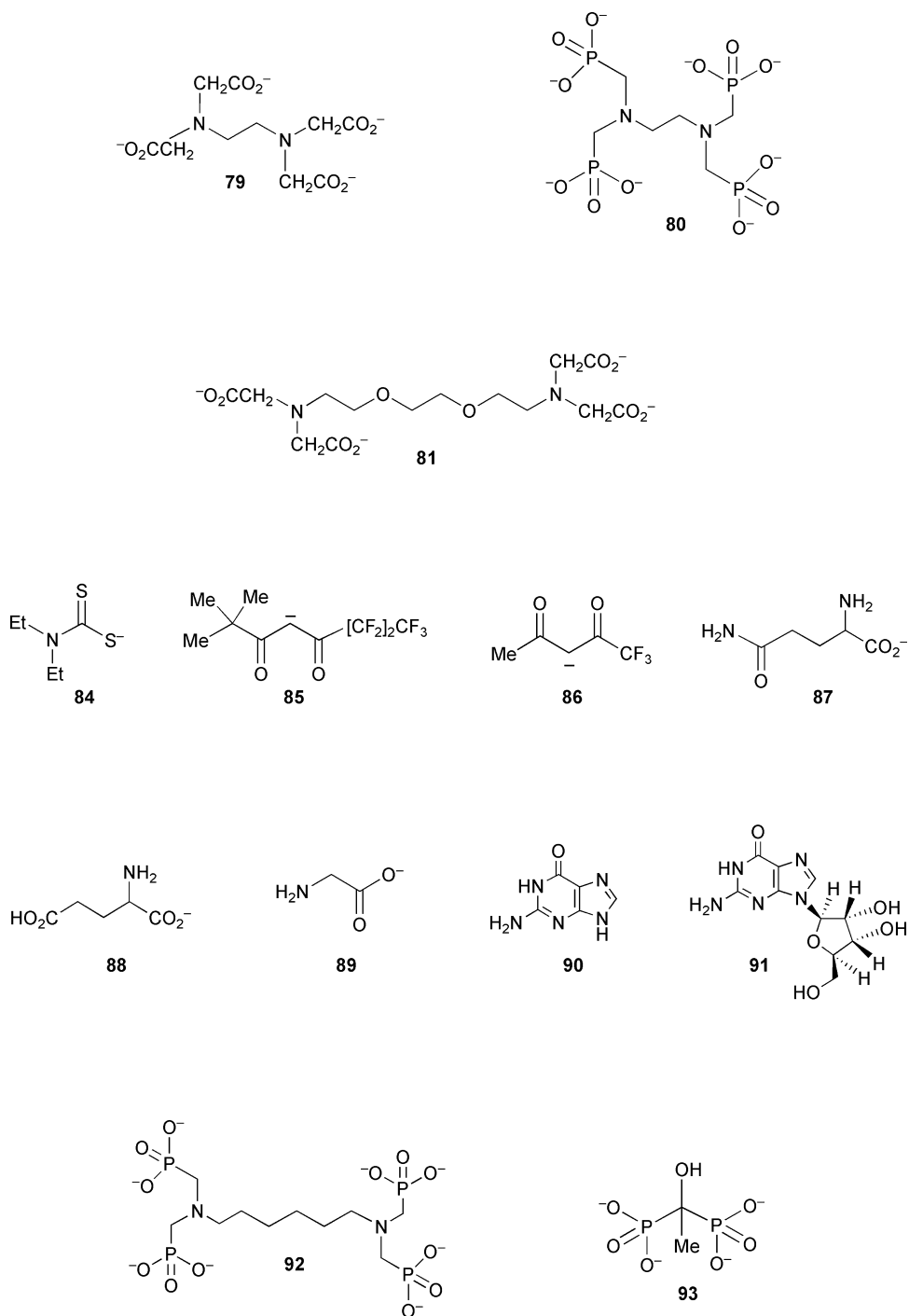
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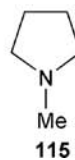
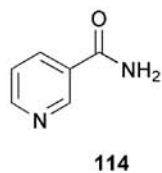
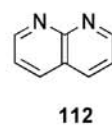
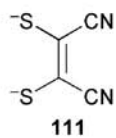
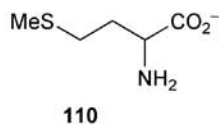
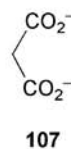
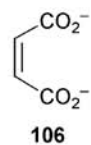
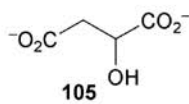
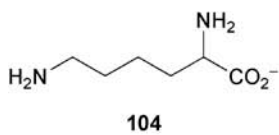
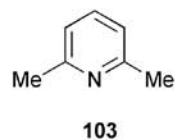
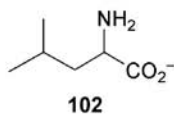
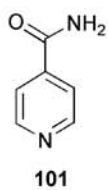
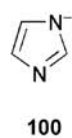
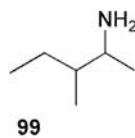
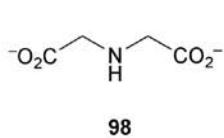
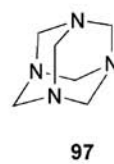
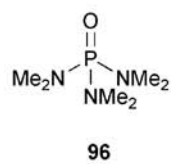
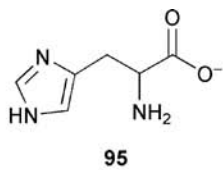
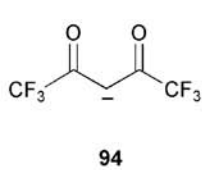


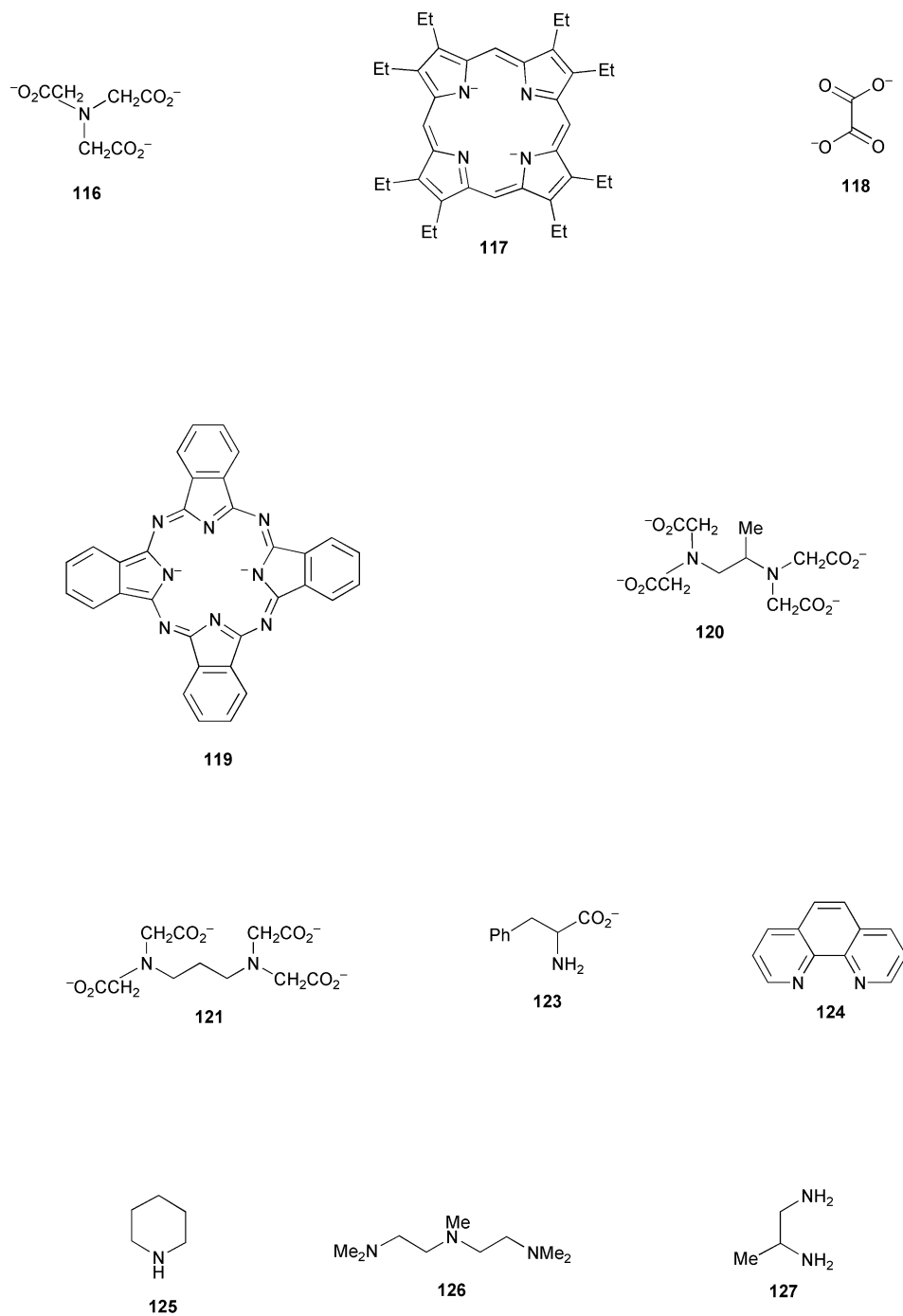
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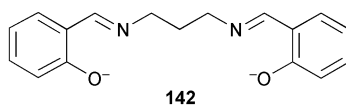
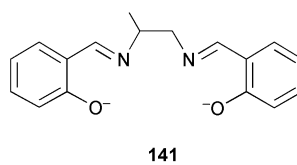
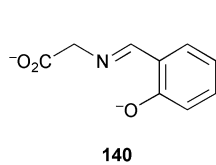
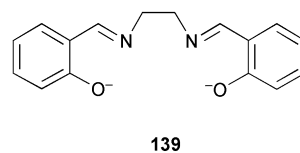
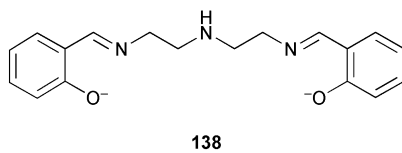
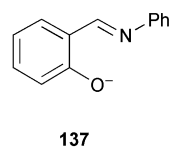
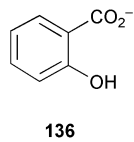
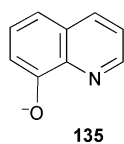
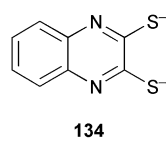
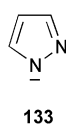
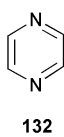
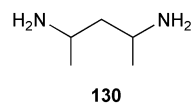
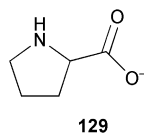
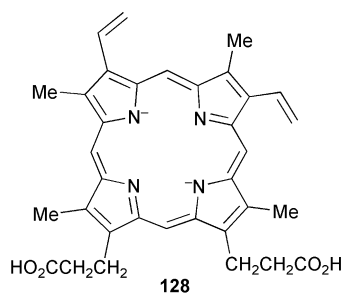
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Table VIII Continued

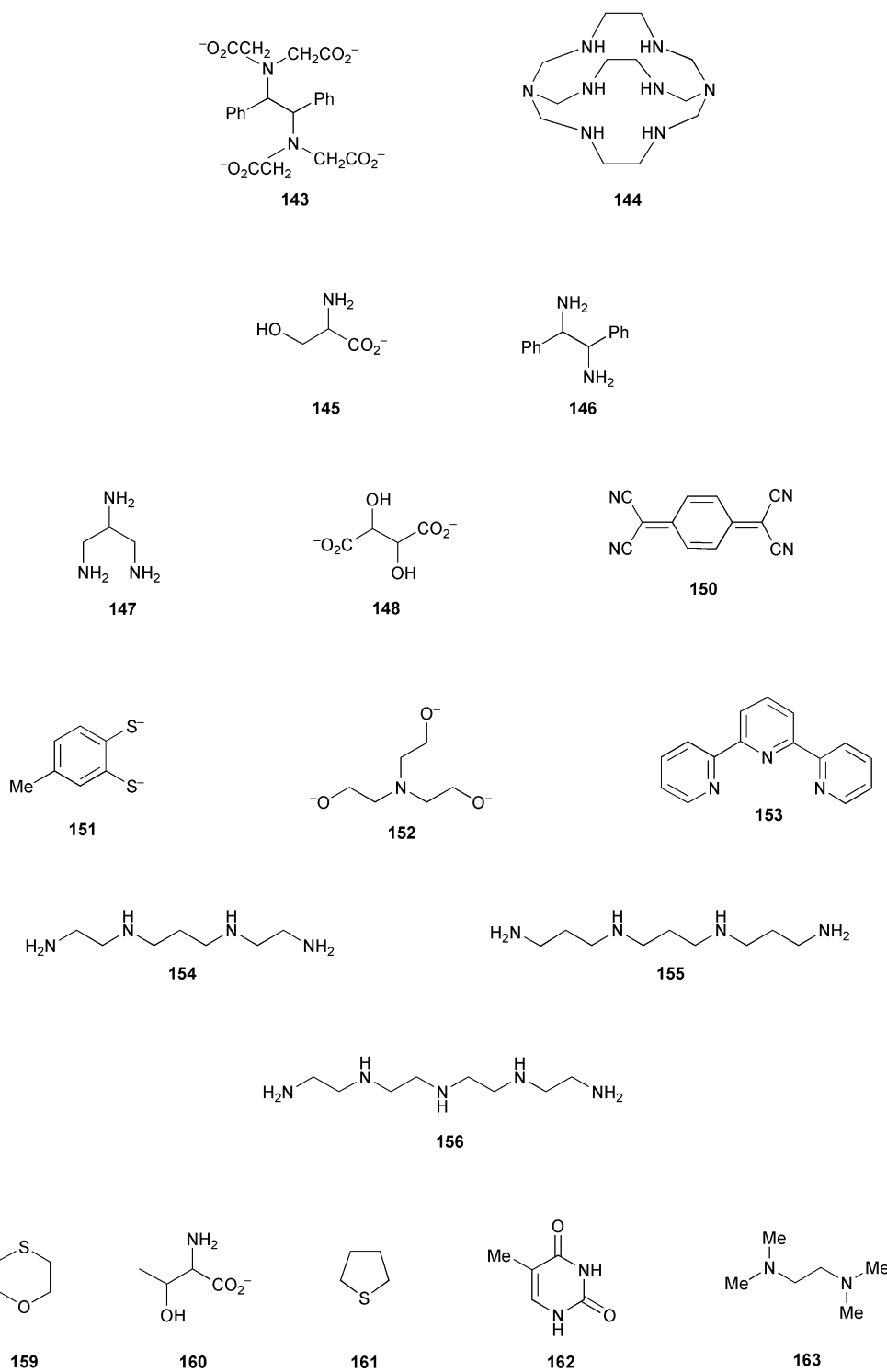


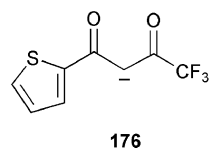
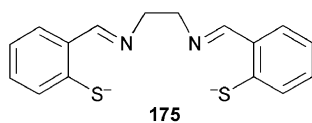
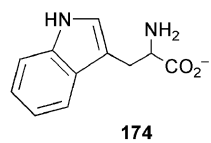
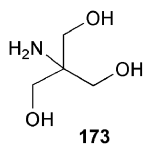
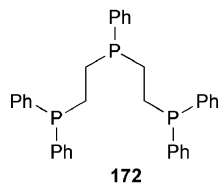
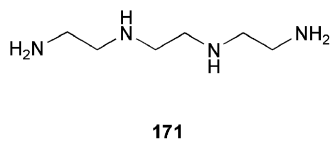
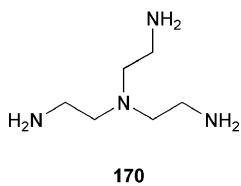
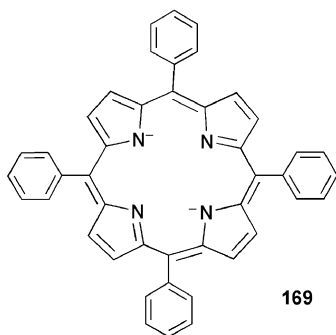
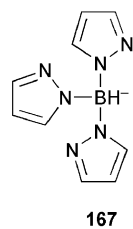
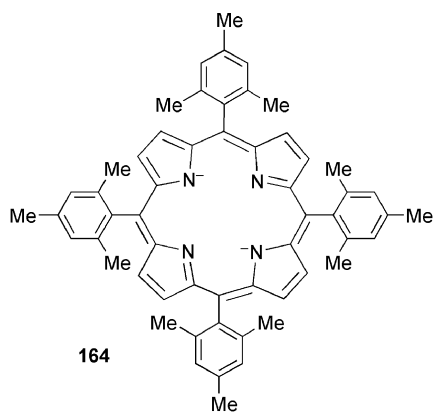
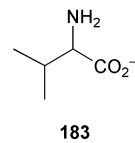
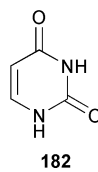
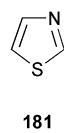
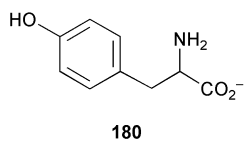
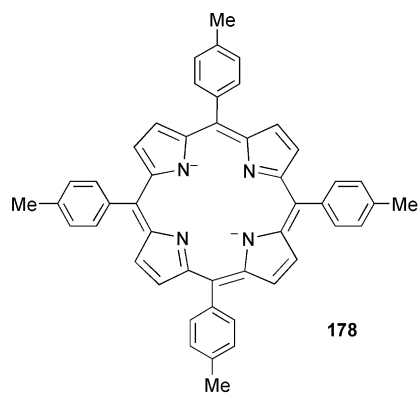
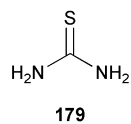
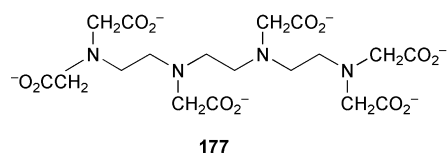
Table VIII *Continued*

Table VIII *Continued*

**Table IX** Names of homoatomic, binary and certain other simple molecules, ions, compounds, radicals and substituent groups

This Table names a large number of homoatomic and binary compounds and species, and some heteropolynuclear entities, and thus may be used as a reference for names of simple compounds and a source of examples to guide in the naming of further compounds. It may be necessary to browse the Table to find (families of) compounds that match those of interest. For example, all the oxides of potassium are named; corresponding compounds of the other alkali metals, not included here, are named analogously. Several silicon and germanium hydride species are named; names for corresponding tin and lead species are not necessarily included.

Some inorganic acids and their corresponding bases are included in this Table, but more acid names are given in Tables IR-8.1 and IR-8.2. Only a few simple carbon-containing compounds and substituent groups are included. In particular, organic ligands belonging to the general classes alcohols, thiolates, phenolates, carboxylates, amines, phosphanes and arsanes as well as (partially) dehydrated amines, phosphanes and arsanes are generally *not* included. Their naming is described and exemplified in Section IR-9.2.2.3.

Entries in the first column are ordered alphabetically according to the formulae as they appear here. Formulae for *binary* species are written in this column according to the position of the two elements in Table VI (Section IR-4.4), *e.g.* ammonia is found under 'NH<sub>3</sub>', but selane under 'H<sub>2</sub>Se' and AlLi under 'LiAl'. In case of doubt, cross references should aid in finding the correct entry in the Table. However, in the first column, formulae of *ternary* and *quaternary* compounds are written strictly alphabetically, *e.g.* 'ClSCN<sup>•-</sup>' is found under the entry 'CClNS', and 'HPO<sub>4</sub><sup>-</sup>' under 'HO<sub>4</sub>P', and these formulae are ordered as described in Section IR-4.4.2.2. In the columns to the right of the first column, special formats may be used for formulae in order to stress a particular structure, *e.g.* under the entry 'BrHO<sub>3</sub>' one finds 'HOBrO<sub>2</sub>' rather than 'HBrO<sub>3</sub>' or '[BrO<sub>2</sub>(OH)]', the two formats presented in Table IR-8.2.

The symbol '⊂' is used for dividing names when this is made necessary by a line break. When the name is reconstructed from the name given in the Table, this symbol should be omitted. Thus, all *hyphens* in the Table are true parts of the names. The symbols '>' and '<' placed next to an element symbol both denote two single bonds connecting the atom in question to two other atoms.

For a given compound, the various systematic names, if applicable, are given in the order: stoichiometric names (Chapter IR-5), substitutive names (Chapter IR-6), additive names (Chapter IR-7) and hydrogen names (Section IR-8.4). Acceptable names which are not entirely systematic (or not formed according to any of the systems mentioned above) are given at the end after a semicolon. No order of preference is implied by the order in which formulae and names are listed, but in practice it may be useful to select particular formulae and names for particular uses. Thus, for sodium chloride the formula [NaCl] and the additive name 'chloridosodium' may be used specifically for the molecular compound, which can be regarded as a coordination compound, whereas 'sodium chloride' may be used, and traditionally *is* used, for the compound in general and for the solid with the composition NaCl. Corresponding remarks apply to a number of hydrides for which a stoichiometric name may be applied to the compound with the stoichiometry in question without further structural implications (such as 'aluminium trihydride' for AlH<sub>3</sub> or 'dihydrogen disulfide' for H<sub>2</sub>S<sub>2</sub>), whereas a parent hydride name (needed anyway for naming certain derivatives) or an additive name may be used to denote specifically the molecular compound or entity (such as 'alumane' or 'trihydroaluminium' for the molecular entity [AlH<sub>3</sub>]) and 'disulfane' for HSSH).

Note from the examples above that in order to stress the distinctions discussed, the square brackets are sometimes used in the Table to enclose formulae for molecular entities that are otherwise often written with no enclosing marks. When a formula with square brackets is shown, there will also be a coordination-type additive name.

Formula for uncharged atom or group	Name			
	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
Ac	actinium	actinium	actinide <sup>d</sup>	actinido
Ag	silver	silver	argentide	argentido
Al	aluminium	aluminium (general) Al <sup>+</sup> , aluminium(1+) Al <sup>3+</sup> , aluminium(3+)	aluminide (general) Al <sup>-</sup> , aluminide(1-)	aluminido (general) Al <sup>-</sup> , aluminido(1-)
AlCl	AlCl, aluminium monochloride [AlCl], chloridoaluminium	AlCl <sup>+</sup> , chloridoaluminium(1+)		
AlCl <sub>3</sub> (see also Al <sub>2</sub> Cl <sub>6</sub> )	AlCl <sub>3</sub> , aluminium trichloride [AlCl <sub>3</sub> ], trichloroalumane, trichloridoaluminium			
AlCl <sub>4</sub>			AlCl <sub>4</sub> <sup>-</sup> , tetrachloroalumanuide, tetrachloridoaluminate(1-)	AlCl <sub>4</sub> <sup>-</sup> , tetrachloroalumanuido, tetrachloridoaluminate(1-)
AlH	AlH, aluminium monohydride [AlH], λ <sup>1</sup> -alumane (parent hydride name), hydridoaluminium	AlH <sup>+</sup> , hydridoaluminium(1+)		
AlH <sub>2</sub>	-AlH <sub>2</sub> , alumanyl			
AlH <sub>3</sub>	AlH <sub>3</sub> , aluminium trihydride [AlH <sub>3</sub> ], alumane (parent hydride name), trihydridoaluminium	AlH <sub>3</sub> <sup>•+</sup> , alumaniumyl, trihydridoaluminium(•1+)	AlH <sub>3</sub> <sup>•-</sup> , alumanidyl, trihydridoaluminate(•1-) <sup>e</sup>	
AlH <sub>4</sub>			AlH <sub>4</sub> <sup>-</sup> , alumanuide, tetrahydridoaluminate(1-)	AlH <sub>4</sub> <sup>-</sup> , alumanuido, tetrahydridoaluminate(1-)
AlO	AlO, aluminium mon(o)oxide [AlO], oxidoaluminium	AlO <sup>+</sup> , oxidoaluminium(1+)	AlO <sup>-</sup> , oxidoaluminate(1-)	
AlSi	AlSi, aluminium monosilicide [AlSi], silicidoaluminium			



Table IX Continued

Name				
Formula for uncharged atom or group	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
Al <sub>2</sub>	Al <sub>2</sub> , dialuminium		Al <sub>2</sub> <sup>-</sup> , dialuminide(1-)	
Al <sub>2</sub> Cl <sub>6</sub>	[Cl <sub>2</sub> Al(μ-Cl) <sub>2</sub> AlCl <sub>2</sub> ], di-μ-chlorido-bis(dichlorido- $\text{O}$ aluminium)			
Al <sub>4</sub>			Al <sub>4</sub> <sup>2-</sup> , tetraaluminide(2-)	
Am	americium	americium	americide	americido
Ar	argon	argon (general) Ar <sup>+</sup> , argon(1+)	argonide	argonido
ArBe		ArBe <sup>+</sup> , beryllidoargon(1+)		
ArF	ArF, argon monofluoride [ArF], fluoroargon	ArF <sup>+</sup> , fluoroargon(1+)		
ArHe		ArHe <sup>+</sup> , helidoargon(1+)		
ArLi		ArLi <sup>+</sup> , lithidoargon(1+)		
Ar <sub>2</sub>	Ar <sub>2</sub> , diargon	Ar <sub>2</sub> <sup>+</sup> , diargon(1+)		
As	arsenic >As-, arsanytriyl	arsenic	arsenide (general) As <sup>3-</sup> , arsenide(3-), arsanytriide; arsenide	arsenido (general) As <sup>3-</sup> , arsanytriido; arsenido
AsH	AsH, arsenic monohydride AsH <sup>2•</sup> , arsanylidene, hydridoarsenic(2•) >AsH, arsanydiyl =AsH, arsanylidene	AsH <sup>2+</sup> , arsanebis(ylum), hydridoarsenic(1+)	AsH <sup>2-</sup> , arsanydiide, hydridoarsenate(2-)	AsH <sup>2-</sup> , arsanydiido, hydridoarsenate(2-)

AsHO	>AsH(O), oxo- $\lambda^5$ -arsanedyl; arsonyl = AsH(O), oxo- $\lambda^5$ -arsanylidene; arsonyldiene			
AsHO <sub>2</sub>	>AsO(OH), hydroxy(oxo)- $\lambda^5$ -arsanedyl; hydroxyarsoryl = AsO(OH), hydroxy(oxo)- $\lambda^5$ - arsanylidene; hydroxyarsorylidene	AsHO <sub>2</sub> <sup>2-</sup> , hydridodioxidoarsenate(2-); arsonite	AsHO <sub>2</sub> <sup>2-</sup> , hydridodioxidoarsenate(2-); arsonite	AsHO <sub>2</sub> <sup>2-</sup> , hydridodioxidoarsenate(2-); arsonito
AsHO <sub>3</sub>		AsHO <sub>3</sub> <sup>2-</sup> , hydridotrioxidoarsenate(2-); arsonate	AsHO <sub>3</sub> <sup>2-</sup> , hydridotrioxidoarsenate(2-); arsonate	AsHO <sub>3</sub> <sup>2-</sup> , hydridotrioxidoarsenate(2-); arsonato
AsH <sub>2</sub>	AsH <sub>2</sub> , arsenic dihydride AsH <sub>2</sub> <sup>•</sup> , arsanyl, dihydridoarsenic(•) -AsH <sub>2</sub> , arsanyl	AsH <sub>2</sub> <sup>+</sup> , arsanylium, dihydridoarsenic(1+)	AsH <sub>2</sub> <sup>+</sup> , arsanylium, dihydridoarsenic(1+)	AsH <sub>2</sub> <sup>+</sup> , arsanylium, dihydridoarsenic(1+)
AsH <sub>2</sub> O	-AsH <sub>2</sub> O, oxo- $\lambda^5$ -arsanyl; arsinoyl	AsH <sub>2</sub> O <sup>-</sup> , dihydridoarsenate(1-); arsinite	AsH <sub>2</sub> O <sup>-</sup> , dihydridoarsenate(1-); arsinite	AsH <sub>2</sub> O <sup>-</sup> , dihydridoarsenate(1-); arsinito
AsH <sub>2</sub> O <sub>2</sub>		AsH <sub>2</sub> O <sub>2</sub> <sup>-</sup> , dihydridodioxidoarsenate(1-); arsinate	AsH <sub>2</sub> O <sub>2</sub> <sup>-</sup> , dihydridodioxidoarsenate(1-); arsinate	AsH <sub>2</sub> O <sub>2</sub> <sup>-</sup> , dihydridodioxidoarsenate(1-); arsinato
AsH <sub>2</sub> O <sub>3</sub>	-As(O)(OH) <sub>2</sub> , dihydroxyoxo- $\lambda^5$ - arsanyl; dihydroxyarsoryl, arsono	AsO(OH) <sub>2</sub> <sup>-</sup> , dihydroxydioxidoarsenate(1-)	AsO(OH) <sub>2</sub> <sup>-</sup> , dihydroxydioxidoarsenate(1-)	AsO(OH) <sub>2</sub> <sup>-</sup> , dihydroxydioxidoarsenate(1-)
AsH <sub>3</sub>	AsH <sub>3</sub> , arsenic trihydride [AsH <sub>3</sub> ], arsane (parent hydride name), trihydridoarsenic	AsH <sub>3</sub> <sup>•+</sup> , arsaniumyl, trihydridoarsenic(•1+) -AsH <sub>3</sub> <sup>+</sup> , arsaniumyl	AsH <sub>3</sub> <sup>•+</sup> , arsaniumyl, trihydridoarsenate(•1+) <sup>e</sup>	
AsH <sub>4</sub>	-AsH <sub>4</sub> , $\lambda^5$ -arsanyl	AsH <sub>4</sub> <sup>+</sup> , arsanium, tetrahydridoarsenic(1+)		
AsH <sub>5</sub>	AsH <sub>5</sub> , arsenic pentahydride [AsH <sub>5</sub> ], $\lambda^5$ -arsane (parent hydride name), pentahydridoarsenic			

Table IX Continued

Name				
Formula for uncharged atom or group	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
AsO	>As(O)–, oxo- $\lambda^5$ -arsanetriyl; arsoryl =As(O)–, oxo- $\lambda^5$ -arsanylidene; arsorylidene $\equiv$ As(O), oxo- $\lambda^5$ -arsanyldiyl; arsoryldiyl			
AsO <sub>3</sub>			AsO <sub>3</sub> <sup>3–</sup> , trioxidoarsenate(3–); arsenite, arsorite –As(=O)(O <sup>–</sup> ) <sub>2</sub> , dioxidooxo- $\lambda^5$ -arsanyl; arsonato	AsO <sub>3</sub> <sup>3–</sup> , trioxidoarsenato(3–); arsenito, arsorito
AsO <sub>4</sub>			AsO <sub>4</sub> <sup>3–</sup> , tetraoxidoarsenate(3–); arsenate, arsorato	AsO <sub>4</sub> <sup>3–</sup> , tetraoxidoarsenato(3–); arsenato, arsorato
AsS <sub>4</sub>			AsS <sub>4</sub> <sup>3–</sup> , tetrasulfidoarsenate(3–)	AsS <sub>4</sub> <sup>3–</sup> , tetrasulfidoarsenato(3–)
As <sub>2</sub> H			HAs=As <sup>–</sup> , diarsenide HAsAs <sup>3–</sup> , diarsanetriide	HAs=As <sup>–</sup> , diarsenido HAsAs <sup>3–</sup> , diarsanetriido
As <sub>2</sub> H <sub>2</sub>	HAs=AsH, diarsene		H <sub>2</sub> AsAs <sup>2–</sup> , diarsane-1,1-diide HAsAsH <sup>2–</sup> , diarsane-1,2-diide	HAs=AsH, diarsene H <sub>2</sub> AsAs <sup>2–</sup> , diarsane-1,1-diido HAsAsH <sup>2–</sup> , diarsane-1,2-diido
As <sub>2</sub> H <sub>4</sub>	H <sub>2</sub> AsAsH <sub>2</sub> , diarsane			H <sub>2</sub> AsAsH <sub>2</sub> , diarsane
As <sub>4</sub>	As <sub>4</sub> , tetraarsenic			As <sub>4</sub> , tetraarsenic
At	astatine (general) At <sup>•</sup> , astatine(•), monoastatine	astatine	At <sup>–</sup> , astatide(1–); astatide	astatido (general) At <sup>–</sup> , astatido(1–); astatido
AtH, see HAt				

At <sub>2</sub>	At <sub>2</sub> , diastatine		auride		aurido
Au	gold	gold (general) Au <sup>+</sup> , gold(1+) Au <sup>3+</sup> , gold(3+)			aurido
B	boron >B-, boranetriyl ≡B, boranylidyne	boron (general) B <sup>+</sup> , boron(1+) B <sup>3+</sup> , boron(3+)	boride (general) B <sup>-</sup> , boride(1-) B <sup>3-</sup> , boride(3-); boride		borido (general) B <sup>-</sup> , borido(1-) B <sup>3-</sup> , borido(3-); borido
BH	>BH, boranediyl =BH, boranylidene	BH <sup>2+</sup> , boranebis(ylium), hydridoboron(2+)	BH <sup>2-</sup> , boranediide, hydridoborate(2-)		BH <sup>2-</sup> , boranediido, hydridoborato(2-)
BHO <sub>3</sub>			BO <sub>2</sub> (OH) <sup>2-</sup> , hydroxidodioxidoborate(2-); hydrogenborate		BO <sub>2</sub> (OH) <sup>2-</sup> , hydroxidodioxidoborato(2-); hydrogenborato
BH <sub>2</sub>	-BH <sub>2</sub> , boranyl	BH <sub>2</sub> <sup>+</sup> , boranylium, dihydridoboron(1+)	BH <sub>2</sub> <sup>-</sup> , boranide, dihydridoborate(2-)		BH <sub>2</sub> <sup>-</sup> , boranido, dihydridoborato(2-)
BH <sub>2</sub> O	-BH(OH), hydroxyboranyl				
BH <sub>2</sub> O <sub>2</sub>	-B(OH) <sub>2</sub> , dihydroxyboranyl; borono				
BH <sub>3</sub>	BH <sub>3</sub> , boron trihydride [BH <sub>3</sub> ], borane (parent hydride name), trihydridoboron	BH <sub>3</sub> <sup>•+</sup> , boraniumyl, trihydridoboron(•1+)	BH <sub>3</sub> <sup>•-</sup> boranuidyl, trihydridoborate(•1-) <sup>e</sup> -BH <sub>3</sub> <sup>-</sup> , boranuidyl		BH <sub>3</sub> <sup>•-</sup> , trihydridoborato(•1-)
BH <sub>4</sub>		BH <sub>4</sub> <sup>+</sup> , boranium, tetrahydridoboron(1+)	BH <sub>4</sub> <sup>-</sup> , boranuide, tetrahydridoborate(1-)		BH <sub>4</sub> <sup>-</sup> , boranuideo, tetrahydridoborato(1-)
BO	BO, boron mon(o)oxide [BO], oxidoboron	BO <sup>+</sup> , oxidoboron(1+)	BO <sup>-</sup> , oxidoborate(1-)		BO <sup>-</sup> , oxidoborato(1-)
BO <sub>2</sub>			(BO <sub>2</sub> <sup>-</sup> ) <sub>n</sub> = (OBO) <sub>n</sub> <sup>n-</sup> , <i>catena</i> -poly[(oxidoborate-μ- oxido)(1-)]; metaborate		
BO <sub>3</sub>			BO <sub>3</sub> <sup>3-</sup> , trioxidoborate(3-); borate		BO <sub>3</sub> <sup>3-</sup> , trioxidoborato(3-); borato
Ba	barium	barium	baride		barido
BaO	barium oxide				

Table IX Continued

Name				
Formula for uncharged atom or group	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
BaO <sub>2</sub>	Ba <sup>2+</sup> O <sub>2</sub> <sup>2-</sup> , barium dioxide(2-); barium peroxide			
Be	beryllium	beryllium (general) Be <sup>+</sup> , beryllium(1+) Be <sup>2+</sup> , beryllium(2+)	beryllide	beryllido
BeH	BeH, beryllium monohydride [BeH], hydridoberyllium	BeH <sup>+</sup> , hydridoberyllium(1+)	BeH <sup>-</sup> , hydridoberyllate(1-)	BeH <sup>-</sup> , hydridoberyllato(1-)
Bh	bohrium	bohrium	bohride	bohrido
Bi	bismuth	bismuth	bismuthide (general) Bi <sup>3-</sup> , bismuthide(3-), bismuthanetriide; bismuthide	bismuthido (general) Bi <sup>3-</sup> , bismuthido(3-), bismuthanetriido; bismuthido
BiH	>BiH, bismuthanediyl =BiH, bismuthanylidene BiH <sup>2•</sup> , bismuthanylidene, hydridobismuth(2•)	BiH <sup>2+</sup> , bismuthanebis(ylum), hydridobismuth(2+)	BiH <sup>2-</sup> , bismuthanediide, hydridobismuthate(2-)	BiH <sup>2-</sup> , bismuthanediido, hydridobismuthato(2-)
BiH <sub>2</sub>	-BiH <sub>2</sub> , bismuthanyl BiH <sub>2</sub> <sup>•</sup> , bismuthanyl, dihydridobismuth(•)	BiH <sub>2</sub> <sup>+</sup> , bismuthanylium, dihydridobismuth(1+)	BiH <sub>2</sub> <sup>-</sup> , bismuthanide, dihydridobismuthate(1-)	BiH <sub>2</sub> <sup>-</sup> , bismuthanido, dihydridobismuthato(1-)
BiH <sub>3</sub>	BiH <sub>3</sub> , bismuth trihydride [BiH <sub>3</sub> ], bismuthane (parent hydride name), trihydridobismuth =BiH <sub>3</sub> , λ <sup>5</sup> -bismuthanylidene	BiH <sub>3</sub> <sup>•+</sup> , bismuthaniumyl, trihydridobismuth(•1+)	BiH <sub>3</sub> <sup>•-</sup> , bismuthanuidyl, trihydridobismuthate(•1-) <sup>e</sup>	

BiH <sub>4</sub>		BiH <sub>4</sub> <sup>+</sup> , bismuthanium, tetrahydridobismuth(1+)		
Bi <sub>5</sub>		Bi <sub>5</sub> <sup>4+</sup> , pentabismuth(4+)		
Bk	berkelium	berkelium	berkelide	berkelido
Br	bromine (general) Br <sup>•</sup> , bromine(•), monobromine -Br, bromo	bromine (general) Br <sup>+</sup> , bromine(1+)	bromide (general) Br <sup>-</sup> , bromide(1-); bromide	bromido (general) Br <sup>-</sup> , bromido(1-); bromido
BrCN	BrCN, cyanobromane, bromidonitridocarbon			
BrH, see HBr				
BrHO	HOBr, bromanol, hydrodibromine <sup>f</sup> ; hypobromous acid			
BrHO <sub>2</sub>	HOBrO, hydroxy-λ <sup>3</sup> -bromanone, hydrodioxidobromine; bromous acid			
BrHO <sub>3</sub>	HOBrO <sub>2</sub> , hydroxy-λ <sup>5</sup> -bromanedione, hydrodioxidobromine; bromic acid			
BrHO <sub>4</sub>	HOBrO <sub>3</sub> , hydroxy-λ <sup>7</sup> -bromanetrione, hydrodioxidobromine; perbromic acid			
Br <sub>2</sub>	Br <sub>2</sub> , dibromine	Br <sub>2</sub> <sup>•+</sup> , dibromine(•1+)	Br <sub>2</sub> <sup>•-</sup> , dibromide(•1-)	Br <sub>2</sub> , dibromine
Br <sub>3</sub>	Br <sub>3</sub> , tribromine		Br <sub>3</sub> <sup>-</sup> , tribromide(1-); tribromide	Br <sub>3</sub> <sup>-</sup> , tribromido(1-); tribromido
C	carbon (general) C, monocarbon >C<, methanetetrayl =C=, methanedilylidene	carbon (general) C <sup>+</sup> , carbon(1+)	carbide (general) C <sup>-</sup> , carbide(1-) C <sup>4-</sup> , carbide(4-), methanetetraide; carbide	carbido (general) C <sup>-</sup> , carbido(1-) C <sup>4-</sup> , carbido(4-), methanetetrayl, methanetetraido
CClNS			ClSCN <sup>•-</sup> , (chloridosulfato)nitrido⇌ carbonate(•1-)	

Table IX Continued

Formula for uncharged atom or group	Name			
	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
CH	CH <sup>•</sup> , hydridocarbon(•) CH <sup>3•</sup> , methylidyne, hydridocarbon(3•), carbyne ≡CH, methyldyne -CH=, methanylylidene -CH<, methanetriyl	CH <sup>+</sup> , λ <sup>2</sup> -methanylium, hydridocarbon(1+)	CH <sup>-</sup> , λ <sup>2</sup> -methanide, hydridocarbonate(1-) CH <sup>3-</sup> , methanetriide, hydridocarbonate(3-)	CH <sup>-</sup> , λ <sup>2</sup> -methanido, hydridocarbonato(1-) CH <sup>3-</sup> , methanetriyl, methanetriido, hydridocarbonato(3-)
CHN	HCN, hydrogen cyanide HCN = [CHN], methanenitrile, hydridonitridocarbon; formonitrile >C=NH, carbonimidoyl =C=NH, iminomethylidene, carbonimidoylidene			
CHNO	HCNO = [N(CH)O], formonitrile oxide, (hydridocarbonato)oxidonitrogen HNCO = [C(NH)O], (hydridonitrato)oxidocarbon; isocyanic acid HOCN = [C(OH)N], hydroxidonitridocarbon; cyanic acid HONC = [NC(OH)], λ <sup>2</sup> -methylidenehydroxylamine, carbidohydroxidonitrogen		HNCO <sup>•-</sup> , (hydridonitrato)oxido⊖ carbonato(•1-) HOCN <sup>•-</sup> , hydroxidonitridocarbonato(•1-)	HNCO <sup>•-</sup> , (hydridonitrato)oxido⊖ carbonato(•1-) HOCN <sup>•-</sup> , hydroxidonitridocarbonato(•1-)

CHNOS			$\text{HONCS}^{\bullet-}$ , (hydroxidonitrato)sulfido $\oslash$ carbonato( $\bullet 1-$ ) $\text{HOSCN}^{\bullet-}$ , (hydroxidosulfato)nitrido $\oslash$ carbonato( $\bullet 1-$ )	$\text{HONCS}^{\bullet-}$ , (hydroxidonitrato)sulfido $\oslash$ carbonato( $\bullet 1-$ ) $\text{HOSCN}^{\bullet-}$ , (hydroxidosulfato)nitrido $\oslash$ carbonato( $\bullet 1-$ )
CHNO <sub>2</sub>			$\text{HOOCN}^{\bullet-}$ , (dioxidanido)nitridocarbonate( $\bullet 1-$ ) $\text{HONCO}^{\bullet-}$ , (hydroxidonitrato)oxido $\oslash$ carbonato( $\bullet 1-$ )	$\text{HOOCN}^{\bullet-}$ , (dioxidanido)nitrido $\oslash$ carbonato( $\bullet 1-$ ) $\text{HONCO}^{\bullet-}$ , (hydroxidonitrato)oxido $\oslash$ carbonato( $\bullet 1-$ )
CHNS	$\text{HCNS} = \text{HC}\equiv\text{N}^+\text{S}^-$ $= [\text{N}(\text{CH})\text{S}]$ , (methyldyneammonium) $\oslash$ sulfanide, (hydridocarbonato)sulfidonitrogen $\text{HNCS} = [\text{C}(\text{NH})\text{S}]$ , (hydridonitrato)sulfidocarbon; isothiocyanic acid $\text{HSCN} = [\text{CN}(\text{SH})]$ , nitridosulfanidocarbon; thiocyanic acid $\text{HSNC} = [\text{NC}(\text{SH})]$ , $\lambda^2$ -methylenethiohydroxylamine, carbidosulfanidonitrogen			



Table IX Continued

Name				
Formula for uncharged atom or group	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
CHNSe	HCNSe = HC≡N <sup>+</sup> Se <sup>-</sup> = [N(CH)Se], (methyldiyneammonium)⊖ selenide, (hydriodocarbonato)selenidonitrogen HNCS <sub>e</sub> = [C(NH)Se], (hydridonitrato)selenidocarbon; isoselenocyanic acid HSeCN = [CN(SeH)], nitridoselanidocarbon; selenocyanic acid HSeNC = [NC(SeH)], λ <sup>2</sup> -methylideneseleno⊖ hydroxylamine, carbidoselanidonitrogen			
CHO	HCO <sup>•</sup> , oxomethyl, hydriooxidocarbon(•) -CH(O), methanoyl, formyl			
CHOS <sub>2</sub>	HOCS <sub>2</sub> <sup>•</sup> , hydroxidodisulfidocarbon(•)			
CHO <sub>2</sub>	HOCO <sup>•</sup> , hydroxidooxidocarbon(•)			

CHO <sub>3</sub>	HOCO <sub>2</sub> <sup>•</sup> , hydroxidodioxidocarbon(•) HOOCO <sup>•</sup> , (dioxidanido)oxidocarbon(•)		HCO <sub>3</sub> <sup>-</sup> , hydroxidodioxidocarbonate(1-); hydrogencarbonate	HCO <sub>3</sub> <sup>-</sup> , hydroxidodioxidocarbonato(1-); hydrogencarbonato
CH <sub>2</sub>	CH <sub>2</sub> , λ <sup>2</sup> -methane CH <sub>2</sub> <sup>2•</sup> , methylenide, dihydridocarbon(2•); carbene >CH <sub>2</sub> , methanediyl, methylene =CH <sub>2</sub> , methylenide		CH <sub>2</sub> <sup>2-</sup> , methanediide, dihydridocarbonate(2-) -CH <sub>2</sub> <sup>-</sup> , methanidyl	>CH <sub>2</sub> , methanediyl, methylene =CH <sub>2</sub> , methylenide CH <sub>2</sub> <sup>2-</sup> , methanediido, dihydridocarbonato(2-)
CH <sub>2</sub> N	H <sub>2</sub> CN <sup>•</sup> , dihydridonitridocarbon(•)			
CH <sub>2</sub> NO	H <sub>2</sub> NCO <sup>•</sup> , (dihydridonitrato)oxidocarbon(•) HNCOH <sup>•</sup> , (hydridonitrato)hydroxido carbon(•)			
CH <sub>3</sub>	CH <sub>3</sub> <sup>•</sup> , methyl -CH <sub>3</sub> <i>or</i> -Me, methyl	CH <sub>3</sub> <sup>+</sup> , methylum, trihydridocarbon(1+)	CH <sub>3</sub> <sup>-</sup> , methanide, trihydridocarbonate(1-)	CH <sub>3</sub> <sup>-</sup> , methyl, methanido, trihydridocarbonato(1-)
CH <sub>4</sub>	CH <sub>4</sub> , methane (parent hydride name), tetrahydridocarbon	CH <sub>4</sub> <sup>•+</sup> , methaniumyl, tetrahydridocarbon(•1+)	CH <sub>4</sub> <sup>•-</sup> , methanuidyl, tetrahydridocarbonate(•1-) <sup>e</sup>	
CH <sub>5</sub>		CH <sub>5</sub> <sup>+</sup> , methanium, pentahydridocarbon(1+)		
CN	CN <sup>•</sup> , nitridocarbon(•); cyanyl -CN, cyano -NC, isocyano	CN <sup>+</sup> , azanylidynemethylum, nitridocarbon(1+)	CN <sup>-</sup> , nitridocarbonate(1-); cyanide	nitridocarbonato (general) CN <sup>-</sup> , nitridocarbonato(1-); cyanido = [nitridocarbonato(1-)-κC]
CN <sub>2</sub>			NCN <sup>2-</sup> , dinitridocarbonate(2-)	NCN <sup>2-</sup> , dinitridocarbonato(2-)
CNO	OCN <sup>•</sup> , nitridooxidocarbon(•) -OCN, cyanato -NCO, isocyanato -ONC, λ <sup>2</sup> -methylenideneazanylideneoxy -CNO, (oxo-λ <sup>2</sup> -azanylidyne)methyl		OCN <sup>-</sup> , nitridooxidocarbonate(1-); cyanate ONC <sup>-</sup> , carbidooxidonitrate(1-); fulminate OCN <sup>•2-</sup> , nitridooxidocarbonate(•2-)	OCN <sup>-</sup> , nitridooxidocarbonato(1-); cyanato ONC <sup>-</sup> , carbidooxidonitrato(1-); fulminato

Table IX Continued

Formula for uncharged atom or group	Name			
	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
CNS	SCN <sup>•</sup> , nitridosulfidocarbon(•) –SCN, thiocyanato –NCS, isothiocyanato –SNC, $\lambda^2$ -methylidene- $\text{C}\equiv$ azanylylidenesulfanediyyl –CNS, (sulfanylidene- $\lambda^5$ - azanylidyne)methyl		SCN <sup>–</sup> , nitridosulfidocarbonato(1–); thiocyanato SNC <sup>–</sup> , carbidosulfidonitrato(1–)	SCN <sup>–</sup> , nitridosulfidocarbonato(1–); thiocyanato SNC <sup>–</sup> , carbidosulfidonitrato(1–)
CNSe	SeCN <sup>•</sup> , nitridoselenidocarbon(•) –SeCN, selenocyanato –NCSe, isoselenocyanato –SeNC, $\lambda^2$ -methylidene- $\text{C}\equiv$ azanylylideneselenanediyyl –CNSe, (selanylidene- $\lambda^5$ - azanylidyne)methyl		SeCN <sup>–</sup> , nitridoselenidocarbonato(1–); selenocyanato SeNC <sup>–</sup> , carbidoselenidonitrato(1–)	SeCN <sup>–</sup> , nitridoselenidocarbonato(1–); selenocyanato SeNC <sup>–</sup> , carbidoselenidonitrato(1–)
CO	CO, carbon mon(o)oxide >C=O, carbonyl =C=O, carbonylidene	CO <sup>•+</sup> , oxidocarbon(•1+) CO <sup>2+</sup> , oxidocarbon(2+)	CO <sup>•–</sup> , oxidocarbonato(•1–)	CO, oxidocarbon, oxidocarbonato (general); carbonyl = oxidocarbon- $\kappa\text{C}$ (general) CO <sup>•+</sup> , oxidocarbon(•1+) CO <sup>•–</sup> , oxidocarbonato(•1–)
COS	C(O)S, carbonyl sulfide, oxidosulfidocarbon			
CO <sub>2</sub>	CO <sub>2</sub> , carbon dioxide, dioxidocarbon		CO <sub>2</sub> <sup>•–</sup> , oxidooxomethyl, dioxidocarbonato(•1–)	CO <sub>2</sub> , dioxidocarbon CO <sub>2</sub> <sup>•–</sup> , oxidooxomethyl, dioxidocarbonato(•1–)

$\text{CO}_3$			$\text{CO}_3^{\bullet-}$ , trioxidocarbonate( $\bullet 1-$ ), $\text{OCO}^{\bullet-}$ , (dioxido)oxidocarbonate( $\bullet 1-$ ), oxidoperoxidocarbonate( $\bullet 1-$ ) $\text{CO}_3^{2-}$ , trioxidocarbonate( $2-$ ); carbonate	$\text{CO}_3^{2-}$ , trioxidocarbonato( $2-$ ); carbonato
CS	carbon monosulfide >C=S, carbonothioyl; thiocarbonyl =C=S, carbonothioylidene	$\text{CS}^{\bullet+}$ , sulfidocarbon( $\bullet 1+$ )	$\text{CS}^{\bullet-}$ , sulfidocarbonate( $\bullet 1-$ )	CS, sulfidocarbon, sulfidocarbonato, thiocarbonyl (general); $\text{CS}^{\bullet+}$ , sulfidocarbon( $\bullet 1+$ ) $\text{CS}^{\bullet-}$ , sulfidocarbonato( $\bullet 1-$ )
$\text{CS}_2$	$\text{CS}_2$ , disulfidocarbon, carbon disulfide		$\text{CS}_2^{\bullet-}$ , sulfidothioxomethyl, disulfidocarbonate( $\bullet 1-$ )	$\text{CS}_2$ , disulfidocarbon $\text{CS}_2^{\bullet-}$ , sulfidothioxomethyl, disulfidocarbonato( $\bullet 1-$ )
$\text{CS}_3$			$\text{CS}_3^{2-}$ , trisulfidocarbonate( $2-$ )	$\text{CS}_3^{2-}$ , trisulfidocarbonato( $2-$ )
$\text{C}_2$	$\text{C}_2$ , dicarbon	$\text{C}_2^+$ , dicarbon( $1+$ )	$\text{C}_2^-$ , dicarbide( $1-$ ) $\text{C}_2^{2-}$ , dicarbide( $2-$ ), ethynediide, acetylenediide; acetylde	dicarbido (general) $\text{C}_2^{2-}$ , dicarbido( $2-$ ), ethynediido, ethyne-1,2-diyl
$\text{C}_2\text{H}$	$\text{HCC}^\bullet$ , ethynyl, hydridodicarbon( $\bullet$ )			
$\text{C}_2\text{N}_2$	$\text{NCCN}$ , ethanedinitrile, bis(nitridocarbon)( $C-C$ ); oxalonitrile		$\text{NCCN}^{\bullet-}$ , bis(nitridocarbonato)( $C-C$ )( $\bullet 1-$ )	
$\text{C}_2\text{N}_2\text{O}_2$	$\text{NCOOCN}$ , dioxidanedicarbonitrile, bis[cyanidooxygen]( $O-O$ )		$\text{NCOOCN}^{\bullet-}$ , bis[cyanidooxygenate]( $O-O$ )( $\bullet 1-$ ) <sup>e</sup> $\text{OCNNCO}^{\bullet-}$ , bis(carbonylnitrate)( $N-N$ )( $\bullet 1-$ ) <sup>e</sup>	$\text{NCOOCN}^{\bullet-}$ , bis[cyanidooxygenate]( $O-O$ )( $\bullet 1-$ ) $\text{OCNNCO}^{\bullet-}$ , bis(carbonylnitrate)( $N-N$ )( $\bullet 1-$ )
$\text{C}_2\text{N}_2\text{S}_2$	$\text{NCSSCN}$ , disulfanedicarbonitrile, bis[cyanidosulfur]( $S-S$ )		$\text{NCSSCN}^{\bullet-}$ , bis[cyanidosulfate]( $S-S$ )( $\bullet 1-$ ) <sup>e</sup>	$\text{NCSSCN}^{\bullet-}$ , bis[cyanidosulfato]( $S-S$ )( $\bullet 1-$ )
$\text{C}_3\text{O}_2$	$\text{C}_3\text{O}_2$ , tricarbon dioxide $\text{O}=\text{C}=\text{C}=\text{C}=\text{O}$ , propa-1,2-diene-1,3-dione			
$\text{C}_{12}\text{O}_9$	$\text{C}_{12}\text{O}_9$ , dodecacarbon nonaoxide			

Table IX Continued

Name				
Formula for uncharged atom or group	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
Ca	calcium	calcium (general) Ca <sup>2+</sup> , calcium(2+)	calcide	calcido
Cd	cadmium	cadmium (general) Cd <sup>2+</sup> , cadmium(2+)	cadmide	cadmido
Ce	cerium	cerium (general) Ce <sup>3+</sup> , cerium(3+) Ce <sup>4+</sup> , cerium(4+)	ceride	cerido
Cf	californium	californium	californide	californido
Cl	chlorine (general) Cl <sup>•</sup> , chlorine(•), monochlorine -Cl, chloro	chlorine (general) Cl <sup>+</sup> , chlorine(1+)	chloride (general) Cl <sup>-</sup> , chloride(1-); chloride	chlorido (general) Cl <sup>-</sup> , chlorido(1-); chlorido
ClF	ClF, fluoridochlorine, chlorine monofluoride	ClF <sup>+</sup> , fluoridochlorine(1+)		
ClF <sub>2</sub>			ClF <sub>2</sub> <sup>-</sup> , difluoridochlorate(1-)	ClF <sub>2</sub> <sup>-</sup> , difluoridochlorato(1-)
ClF <sub>4</sub>		ClF <sub>4</sub> <sup>+</sup> , tetrafluoridochlorine(1+)	ClF <sub>4</sub> <sup>-</sup> , tetrafluoridochlorate(1-)	ClF <sub>4</sub> <sup>-</sup> , tetrafluoridochlorato(1-)
ClH, see HCl				
ClHN			NHCl <sup>-</sup> , chloroazanide, chloridohydridonitrate(1-)	NHCl <sup>-</sup> , chloroazanido, chloridohydridonitrato(1-)
ClHO	HOCl, chloranol, hydroxidochlorine <sup>f</sup> ; hypochlorous acid		HOCl <sup>•-</sup> , hydroxidochlorate(•1-)	
ClHO <sub>2</sub>	HOClO, hydroxy-λ <sup>3</sup> -chloranone, hydroxidooxidochlorine; chlorous acid			

ClHO <sub>3</sub>	HOClO <sub>2</sub> , hydroxy-λ <sup>5</sup> -chloranediene, hydroxidodioxichlorine; chloric acid				
ClHO <sub>4</sub>	HOClO <sub>3</sub> , hydroxy-λ <sup>7</sup> -chloranetrione, hydroxidotrioxichlorine; perchloric acid				
Cl <sub>2</sub>	Cl <sub>2</sub> , dichlorine	Cl <sub>2</sub> <sup>•+</sup> , dichlorine(•1+)	Cl <sub>2</sub> <sup>•-</sup> , dichloride(•1-)	Cl <sub>2</sub> , dichlorine Cl <sub>2</sub> <sup>•-</sup> , dichlorido(•1-)	
Cl <sub>2</sub> OP	-P(Cl <sub>2</sub> (O), dichlorooxo-λ <sup>5</sup> -phosphanyl, phosphorodichloridoyl				
Cl <sub>4</sub>		Cl <sub>4</sub> <sup>+</sup> , tetrachlorine(1+)			
Cm	curium	curium	curide	curido	
Co	cobalt	cobalt (general) Co <sup>2+</sup> , cobalt(2+) Co <sup>3+</sup> , cobalt(3+)	cobaltide	cobaltido	
Cr	chromium	chromium (general) Cr <sup>2+</sup> , chromium(2+) Cr <sup>3+</sup> , chromium(3+)	chromide	chromido	
CrO	CrO, chromium mon(o)oxide, chromium(II) oxide				
CrO <sub>2</sub>	CrO <sub>2</sub> , chromium dioxide, chromium(IV) oxide				
CrO <sub>3</sub>	CrO <sub>3</sub> , chromium trioxide, chromium(VI) oxide				
CrO <sub>4</sub>	[Cr(O <sub>2</sub> ) <sub>2</sub> ], dioxodichromium		CrO <sub>4</sub> <sup>2-</sup> , tetraoxodichromate(2-); chromate	CrO <sub>4</sub> <sup>2-</sup> , tetraoxodichromato(2-); chromato	
			CrO <sub>4</sub> <sup>3-</sup> , tetraoxodichromate(3-)	CrO <sub>4</sub> <sup>3-</sup> , tetraoxodichromato(3-)	
			CrO <sub>4</sub> <sup>4-</sup> , tetraoxodichromate(4-)	CrO <sub>4</sub> <sup>4-</sup> , tetraoxodichromato(4-)	
CrO <sub>5</sub>	[CrO(O <sub>2</sub> ) <sub>2</sub> ], oxidodiperoxidochromium				

Table IX Continued

Name				
Formula for uncharged atom or group	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
CrO <sub>6</sub>			CrO <sub>2</sub> (O <sub>2</sub> ) <sub>2</sub> <sup>2-</sup> , dioxidodiperoxidochromate(2-)	
CrO <sub>8</sub>			Cr(O <sub>2</sub> ) <sub>4</sub> <sup>2-</sup> , tetraperoxidochromate(2-) Cr(O <sub>2</sub> ) <sub>4</sub> <sup>3-</sup> , tetraperoxidochromate(3-)	
Cr <sub>2</sub> O <sub>3</sub>	Cr <sub>2</sub> O <sub>3</sub> , dichromium trioxide, chromium(III) oxide			
Cr <sub>2</sub> O <sub>7</sub>			Cr <sub>2</sub> O <sub>7</sub> <sup>2-</sup> , heptaoxidodichromate(2-) O <sub>3</sub> CrOCrO <sub>3</sub> <sup>2-</sup> , μ-oxido-bis(trioxidochromate)(2-); dichromate	Cr <sub>2</sub> O <sub>7</sub> <sup>2-</sup> , heptaoxidodichromato(2-) O <sub>3</sub> CrOCrO <sub>3</sub> <sup>2-</sup> , μ-oxido-bis(trioxidochromato)(2-); dichromato
Cs	caesium	caesium	caeside	caesido
Cu	copper	copper (general) Cu <sup>+</sup> , copper(1+) Cu <sup>2+</sup> , copper(2+)	cupride	cuprido
D, see H				
D <sub>2</sub> , see H <sub>2</sub>				
D <sub>2</sub> O, see H <sub>2</sub> O				
Db	dubnium	dubnium	dubnide	dubnido
Ds	darmstadtium	darmstadtium	darmstadtide	darmstadtido
Dy	dysprosium	dysprosium	dysproside	dysprosido
Er	erbium	erbium	erbide	erbido

Es	einsteinium	einsteinium	einsteinide	einsteinido
Eu	euprium	euprium	eupride	euprido
F	fluorine F <sup>•</sup> ; fluorine(•), monofluorine -F, fluoro	fluorine (general) F <sup>+</sup> , fluorine(1+)	fluoride (general) F <sup>-</sup> , fluoride(1-); fluoride	F <sup>-</sup> , fluorido(1-); fluorido
FH, see HF				
FHO	HOF, fluoranol, fluoridohydridoxygen			
FNS	NSF, fluoridonitridosulfur			
FN <sub>3</sub>	FNNN, fluorido-1κF-trinitrogen(2 N-N)			
FO, see OF				
F <sub>2</sub>	F <sub>2</sub> , difluorine	F <sub>2</sub> <sup>+</sup> , difluorine(•1+)	F <sub>2</sub> <sup>-</sup> , difluoride(•1-)	F <sub>2</sub> , difluorine
F <sub>2</sub> N <sub>2</sub>	FN=NF, difluorido-1κF,2κF- dinitrogen(N-N), difluorodiazene			
Fe	iron	iron (general) Fe <sup>2+</sup> , iron(2+) Fe <sup>3+</sup> , iron(3+)	ferride	ferrido
Fm	fermium	fermium	fermide	fermido
Fr	francium	francium	francide	francido
Ga	gallium	gallium	gallide	gallido
GaH <sub>2</sub>	-GaH <sub>2</sub> , gallanyl			
GaH <sub>3</sub>	GaH <sub>3</sub> , gallium trihydride [GaH <sub>3</sub> ], gallane (parent hydride name), trihydridogallium			
Gd	gadolinium	gadolinium	gadolinide	gadolinido
Ge	germanium >Ge<, germanetetrayl =Ge=, germanediylidene >GeH-, germanetriyl =GeH-, germanylylidene ≡GeH, germilydine	germanium (general) Ge <sup>2+</sup> , germanium(2+) Ge <sup>4+</sup> , germanium(4+)	germide (general) Ge <sup>4-</sup> , germide(4-); germide	germido (general) Ge <sup>4-</sup> , germido(4-); germido
GeH				



Table IX Continued

Name				
Formula for uncharged atom or group	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
GeH <sub>2</sub>	>GeH <sub>2</sub> , germanediyl =GeH <sub>2</sub> , germalidene			
GeH <sub>3</sub>	–GeH <sub>3</sub> , germyl	GeH <sub>3</sub> <sup>+</sup> , germylum, trihydridogermanium(1+)	GeH <sub>3</sub> <sup>–</sup> , germanide, trihydridogermanate(1–)	GeH <sub>3</sub> <sup>–</sup> , germanido, trihydridogermanato(1–)
GeH <sub>4</sub>	GeH <sub>4</sub> , germane (parent hydride name), tetrahydridogermanium			
Ge <sub>4</sub>				
H	hydrogen H <sup>•</sup> , hydrogen(•), monohydrogen (natural or unspecified isotopic composition) <sup>1</sup> H <sup>•</sup> , protium(•), monoprotrium <sup>2</sup> H <sup>•</sup> = D <sup>•</sup> , deuterium(•), monodeuterium <sup>3</sup> H <sup>•</sup> = T <sup>•</sup> , tritium(•), monotritium	hydrogen (general) H <sup>+</sup> , hydrogen(1+), hydron (natural or unspecified isotopic composition) <sup>1</sup> H <sup>+</sup> , protium(1+), proton <sup>2</sup> H <sup>+</sup> = D <sup>+</sup> , deuterium(1+), deuteron <sup>3</sup> H <sup>+</sup> = T <sup>+</sup> , tritium(1+), triton	Ge <sub>4</sub> <sup>4–</sup> , tetragermide(4–) hydride (general) H <sup>–</sup> , hydride (natural or unspecified isotopic composition) <sup>1</sup> H <sup>–</sup> , protide <sup>2</sup> H <sup>–</sup> = D <sup>–</sup> , deuteride <sup>3</sup> H <sup>–</sup> = T <sup>–</sup> , tritide	hydrido protido deuterido tritido
HAt	HAt, hydrogen astatide [HAt], astatidohydrogen			
HBr	HBr, hydrogen bromide [HBr], bromane (parent hydride name), bromidohydrogen			
HCO, see CHO				

HCl	HCl, hydrogen chloride [HCl], chlorane (parent hydride name), chloridohydrogen	HCl <sup>+</sup> , chloraniumyl, chloridohydrogen(•1+)	
HF	HF, hydrogen fluoride [HF], fluorane (parent hydride name), fluoridohydrogen	HF <sup>+</sup> , fluoraniumyl, fluoridohydrogen(•1+)	
HF <sub>2</sub>			FHF <sup>-</sup> , fluoro fluoranuide, $\mu$ -hydridodifluorate(1-), difluoridohydrogenate(1-)
HI	HI, hydrogen iodide [HI], iodane (parent hydride name), iodidohydrogen		
HIO	HOI, iodanol, hydroxidoiodine <sup>1</sup> ; hypiodous acid		
HIO <sub>2</sub>	HOIO, hydroxy- $\lambda^3$ -iodanone, hydroxidoiodine; iodous acid		
HIO <sub>3</sub>	HOIO <sub>2</sub> , hydroxy- $\lambda^5$ -iodanedione, hydroxidoiodine; iodic acid		HOIO <sub>2</sub> <sup>•-</sup> , hydroxidoiodine(•1-)
HIO <sub>4</sub>	HOIO <sub>3</sub> , hydroxy- $\lambda^7$ -iodanetrione, hydroxidoiodine; periodic acid		
H <sub>n</sub> N <sub>m</sub> , see N <sub>m</sub> H <sub>n</sub>			
HMnO <sub>4</sub>	HMnO <sub>4</sub> = [MnO <sub>3</sub> (OH)], hydroxidotrioxomanganese		HMnO <sub>4</sub> <sup>-</sup> = [MnO <sub>3</sub> (OH)] <sup>-</sup> , hydroxidotrioxomanganate(1-)

Table IX Continued

Formula for uncharged atom or group	Name			
	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
HNO	HNO = [NH(O)], azanone, hydridoxygenitrogen HON <sup>2•</sup> , hydroxidonitrogen(2•) >NH(O), oxo-λ <sup>5</sup> -azanedyl; azonoyl =NH(O), oxo-λ <sup>5</sup> -azanylidene; azonoylidene >N-OH, hydroxyazanediyl =N-OH, hydroxyazanylidene; hydroxyimino	HNO <sup>•+</sup> = [NH(O)] <sup>•+</sup> , hydridoxygenitrogen(•1+)	HON <sup>2-</sup> , hydroxidonitrate(2-)	HON <sup>2-</sup> , hydroxidonitrate(2-)
HNO <sub>2</sub>	HNO <sub>2</sub> = [NO(OH)], hydrodioxidonitrogen; nitrous acid >N(O)(OH), hydroxyoxo-λ <sup>5</sup> -azanedyl; hydroxyazoryl =N(O)(OH), hydroxyoxo-λ <sup>5</sup> -azanylidene; hydroxyazorylidene			
HNO <sub>3</sub>	HNO <sub>3</sub> = [NO <sub>2</sub> (OH)], hydrodioxididonitrogen; nitric acid HNO(O <sub>2</sub> ) = [NO(OOH)], dioxidanidooxygenitrogen, peroxynitrous acid			

HNO <sub>4</sub>	HNO <sub>4</sub> = [NO <sub>2</sub> (OOH)], (dioxidanido)dioxidonitrogen; peroxynitric acid			
HNS	>S(=NH), imino-λ <sup>4</sup> -sulfanediyl; sulfiminidoyl			
HN <sub>2</sub> O <sub>2</sub>	–NHNO <sub>2</sub> , nitrozazanyl, nitroamino		[HON=NO] <sup>–</sup> , 2-hydroxydiazen-1-olate, hydroxido-1κO-oxido-2κO- dinitrate(N–N)(1–)	
HN <sub>2</sub> O <sub>3</sub>			HN <sub>2</sub> O <sub>3</sub> <sup>–</sup> = N(H)(O)NO <sub>2</sub> <sup>–</sup> , hydrido-1κH-trioxido- 1κO,2κ <sup>2</sup> O-dinitrate(N–N)(1–)	
HN <sub>3</sub> O			HON <sub>3</sub> <sup>•–</sup> , hydroxido-1κO- trinitrate(2 N–N)(•1–)	
HO	HO <sup>•</sup> , oxidanyl, hydridoxygen(•); hydroxyl –OH, oxidanyl; hydroxy	HO <sup>+</sup> , oxidanylium, hydridoxygen(1+); hydroxylum	HO <sup>–</sup> , oxidanide, hydridoxygenate(1–); hydroxide	HO <sup>–</sup> , oxidanido; hydroxido
HOP	HPO = [P(H)O], phosphanone, hydridoxygenphosphorus >PH(O), oxo-λ <sup>5</sup> -phosphanediyl; phosphonoyl = PH(O), oxo-λ <sup>5</sup> -phosphanylidene; phosphonoylidene = P–OH, hydroxyphosphanylidene			
HOS	–SH(O), oxo-λ <sup>4</sup> -sulfanyl –SOH, hydroxysulfanyl –OSH, sulfanyloxy		HSO <sup>–</sup> , sulfanolate, hydridoxygenate(1–)	HSO <sup>–</sup> , sulfanolato, hydridoxygenate(1–)
HOSe	–SeH(O), oxo-λ <sup>4</sup> -selanyl –SeOH, hydroxyselanyl –OSeH, selanyloxy			

Table IX Continued

Formula for uncharged atom or group	Name			
	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
HO <sub>2</sub>	HO <sub>2</sub> <sup>•</sup> , dioxidanyl, hydridodioxygen(•) -OOH, dioxidanyl; hydroperoxy	HO <sub>2</sub> <sup>+</sup> , dioxidanylium, hydridodioxygen(1+)	HO <sub>2</sub> <sup>-</sup> , dioxidanide, hydrogen(peroxide)(1-)	HO <sub>2</sub> <sup>-</sup> , dioxidanido, hydrogen(peroxido)(1-)
HO <sub>2</sub> P	P(O)(OH), hydroxyphosphanone, hydroxidooxidophosphorus >P(O)(OH), hydroxyoxo-λ <sup>5</sup> -phosphanedyl; hydroxyphosphoryl =P(O)(OH), hydroxyoxo-λ <sup>5</sup> -phosphanylidene; hydroxyphosphorylidene		HOPO <sup>•-</sup> , hydroxidooxidophosphate(•1-) HPO <sub>2</sub> <sup>2-</sup> , hydridodioxidophosphate(2-)	HOPO <sup>•-</sup> , hydroxidooxidophosphato(•1-) HPO <sub>2</sub> <sup>2-</sup> , hydridodioxidophosphato(2-)
HO <sub>2</sub> S	HOOS <sup>•</sup> , hydrido-1κH-sulido-2κS-dioxygen(•) HOSO <sup>•</sup> , hydroxidooxidofur(•) HSOO <sup>•</sup> , (hydridosulfato)dioxygen(•) -S(O)(OH), hydroxyoxo-λ <sup>4</sup> -sulfanyl; hydroxysulfinyl, sulfinio -S(O) <sub>2</sub> H, dioxo-λ <sup>6</sup> -sulfanyl		HOSO <sup>-</sup> , hydroxysulfanolate, hydroxidooxidosulfate(1-)	HOSO <sup>-</sup> , hydroxysulfanolato, hydroxidooxidosulfato(1-)

HO <sub>2</sub> Se	–Se(O)(OH), hydroxyoxo-λ <sup>4</sup> -selenyl; hydroxyseleninyl, selenino –Se(O) <sub>2</sub> H, dioxo-λ <sup>6</sup> -selenyl			
HO <sub>3</sub>	HO <sub>3</sub> <sup>•</sup> , hydriotrioxigen(•) HO <sub>3</sub> <sup>•</sup> , trioxidanyl, hydrido- 1κH-trioxygen(2 O–O)(•) –OOOH, trioxidanyl			
HO <sub>3</sub> P	P(O) <sub>2</sub> (OH), hydroxy-λ <sup>5</sup> -phosphanedione, hydroxidodioxidophosphorus	HOPO <sub>2</sub> <sup>•–</sup> , hydroxidodioxidophosphate(•1–) PHO <sub>3</sub> <sup>2–</sup> , hydriotrioxidophosphate(2–); phosphonate HPO <sub>3</sub> <sup>2–</sup> = PO <sub>2</sub> (OH) <sup>2–</sup> , hydroxidodioxidophosphate(2–); hydrogenphosphite	HOPO <sub>2</sub> <sup>•–</sup> , hydroxidodioxidophosphato(•1–) PHO <sub>3</sub> <sup>2–</sup> , hydriotrioxidophosphato(2–); phosphonate HPO <sub>3</sub> <sup>2–</sup> = PO <sub>2</sub> (OH) <sup>2–</sup> , hydroxidodioxidophosphato(2–); hydrogenphosphito	
HO <sub>3</sub> S	–S(O) <sub>2</sub> (OH), hydroxydioxo-λ <sup>6</sup> -sulfanyl, hydroxysulfonyl; sulfo		HSO <sub>3</sub> <sup>–</sup> , hydroxidodioxidosulfate(1–), hydrogensulfite	HSO <sub>3</sub> <sup>–</sup> , hydroxidodioxidosulfato(1–), hydrogensulfito
HO <sub>3</sub> Se	HOSeO <sub>2</sub> <sup>•</sup> , hydroxidodioxidoselenium(•) –Se(O) <sub>2</sub> (OH), hydroxydioxo-λ <sup>6</sup> -selenyl, hydroxyselenonyl; selenono		HSO <sub>3</sub> <sup>–</sup> , hydroxidodioxidoselenate(1–)	HSO <sub>3</sub> <sup>–</sup> , hydroxidodioxidoselenato(1–)
HO <sub>4</sub> P			HOPO <sub>3</sub> <sup>•–</sup> = PO <sub>3</sub> (OH) <sup>•–</sup> , hydroxidotrioxidophosphate(•1–) HPO <sub>4</sub> <sup>2–</sup> = PO <sub>3</sub> (OH) <sup>2–</sup> , hydroxidotrioxidophosphate(2–); hydrogenphosphate	HOPO <sub>3</sub> <sup>•–</sup> = PO <sub>3</sub> (OH) <sup>•–</sup> , hydroxidotrioxidophosphato(•1–) HPO <sub>4</sub> <sup>2–</sup> , hydroxidotrioxidophosphato(2–); hydrogenphosphato
HO <sub>4</sub> S	HOSeO <sub>3</sub> <sup>•</sup> , hydro- xidotrioxidosulfur(•) –OS(O) <sub>2</sub> (OH), hydroxysulfonyloxy; sulfooxy		HSO <sub>4</sub> <sup>–</sup> , hydroxidotrioxidosulfate(1–); hydrogensulfate	HSO <sub>4</sub> <sup>–</sup> , hydroxidotrioxidosulfato(1–); hydrogensulfato

Table IX Continued

Formula for uncharged atom or group		Name		
	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
HO <sub>4</sub> Se			HSeO <sub>4</sub> <sup>−</sup> , hydroxidotrioxoselenate(1−)	HSeO <sub>4</sub> <sup>−</sup> , hydroxidotrioxoselenato(1−)
HO <sub>5</sub> P			HOPO <sub>4</sub> <sup>•−</sup> = PO <sub>2</sub> (OH)(OO) <sup>•−</sup> , (dioxido)hydroxidodioxido phosphate(•1−)	PO <sub>2</sub> (OH)(OO) <sup>•−</sup> , (dioxido)hydroxidodioxido phosphato(•1−)
HO <sub>5</sub> S	HOSO <sub>4</sub> <sup>•</sup> = [SO <sub>2</sub> (OH)(OO)] <sup>•</sup> , (dioxido)hydroxidodioxidosulfur(•)			
HS	−SH, sulfanyl	HS <sup>+</sup> , sulfanylium, hydridosulfur(1+)	HS <sup>−</sup> , sulfanide, hydrogen(sulfide)(1−)	HS <sup>−</sup> , sulfanido, hydrogen(sulfido)(1−)
HS <sub>2</sub>	HS <sup>•</sup> , sulfanyl, hydridosulfur(•)		HSS <sup>−</sup> , disulfanide	HSS <sup>−</sup> , disulfanido
HS <sub>3</sub>	−SSH, disulfanyl		HSSS <sup>−</sup> , trisulfanide	HSSS <sup>−</sup> , trisulfanido
HS <sub>4</sub>	−SSSH, trisulfanyl		HSSSS <sup>−</sup> , tetrasulfanide	HSSSS <sup>−</sup> , tetrasulfanido
HS <sub>5</sub>	−SSSSH, pentasulfanyl		HSSSSS <sup>−</sup> , pentasulfanide	HSSSSS <sup>−</sup> , pentasulfanido
HSe	HSe <sup>•</sup> , selanyl, hydridoselenium(•)	HSe <sup>+</sup> , selanylium, hydridoselenium(1+)	HSe <sup>−</sup> , selanide, hydrogen(selenide)(1−)	HSe <sup>−</sup> , selanido, hydrogen(selenido)(1−)
−SeH, selanyl			HSeSe <sup>−</sup> , diselanide	HSeSe <sup>−</sup> , diselanido
HSe <sub>2</sub>	−SeSeH, diselanyl		HTe <sup>−</sup> , tellanide, hydrogen(tellanide)(1−)	
HTe	HTe <sup>•</sup> , tellanyl, hydridotellurium(•)	HTe <sup>+</sup> , tellanylium, hydridotellurium(1+)		
−TeH, tellanyl				
HTe <sub>2</sub>	−TeTeH, ditellanyl		HTeTe <sup>−</sup> , ditellanide	HTeTe <sup>−</sup> , ditellanido
H <sub>2</sub>	H <sub>2</sub> , dihydrogen	H <sub>2</sub> <sup>•+</sup> , dihydrogen(•1+)		
D <sub>2</sub> , dideuterium		<sup>1</sup> H <sub>2</sub> <sup>•+</sup> , diprotium(•1+)		
T <sub>2</sub> , ditritium		D <sub>2</sub> <sup>•+</sup> , dideuterium(•1+)		
		T <sub>2</sub> <sup>•+</sup> , ditritium(•1+)		

$H_2Br$	$H_2Br^\bullet$ , $\lambda^3$ -bromanyl, dihydrdobromine( $\bullet$ )	$H_2Br^+$ , bromanium, dihydrdobromine( $1+$ )		
$H_2Cl$	$H_2Cl^\bullet$ , $\lambda^3$ -chloranyl, dihydrdochlorine( $\bullet$ )	$H_2Cl^+$ , chloranium, dihydrdochlorine( $1+$ )		
$H_2F$	$H_2F^\bullet$ , $\lambda^3$ -fluoranyl, dihydrdofluorine( $\bullet$ )	$H_2F^+$ , fluoranium, dihydrdofluorine( $1+$ )		
$H_2I$	$H_2I^\bullet$ , $\lambda^3$ -iodanyl, dihydrdoiodine( $\bullet$ )	$H_2I^+$ , iodanium, dihydrdoiodine( $1+$ )		
$H_2IO_2$	$-I(OH)_2$ , dihydroxy- $\lambda^3$ -iodanyl			
$H_2MnO_4$	$H_2MnO_4 = [MnO_2(OH)_2]$ , dihydroxidodioxidomanganese			
$H_2N_m$ , see $N_mH_2$				
$H_2NO$	$H_2NO^\bullet$ , aminooxidanyl, dihydrdooxidonitrogen( $\bullet$ ); aminoxyl $HONH^\bullet$ , hydroxyazanyl, hydridohydroxididonitrogen( $\bullet$ ) $-NH(OH)$ , hydroxyazanyl, hydroxyamino $-ONH_2$ , aminooxy $-NH_2(O)$ , oxo- $\lambda^5$ -azanyl; azinoyl	$HONH^-$ , hydroxyazanide, hydridohydroxididonitrate( $1-$ ) $H_2NO^-$ , azanolate, aminooxidamide, dihydrdooxidonitrate( $1-$ )	$NHOH^-$ , hydroxyazanido, hydridohydroxididonitrate( $1-$ ) $H_2NO^-$ , azanolate, aminooxidamide, dihydrdooxidonitrate( $1-$ )	
$H_2NOS$	$-S(O)NH_2$ , azanyloxo- $\lambda^4$ -sulfanyl; aminosulfanyl			
$H_2NO_2S$	$-S(O)_2NH_2$ , azanyldioxo- $\lambda^6$ -sulfanyl; aminosulfonyl; sulfamoyl			
$H_2NO_3$		$[NO(OH)_2]^+$ , dihydroxidooxididonitrogen( $1+$ )		
$H_2NS$	$-SNH_2$ , azanylsulfanyl; aminosulfanyl $-NH_2(S)$ , sulfanylidene- $\lambda^5$ -azanyl; azinothioyl			



Table IX Continued

Name				
Formula for uncharged atom or group	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
$\text{H}_2\text{N}_m$ , see $\text{N}_m\text{H}_2$				
$\text{H}_2\text{O}$	$\text{H}_2\text{O}$ , dihydrogen oxide; water $\text{H}_2\text{O} = [\text{OH}_2]$ , oxidane (parent hydride name), dihydrodooxygen $^1\text{H}_2\text{O}$ , diprotium oxide; ( $^1\text{H}_2$ )water $\text{D}_2\text{O} = ^2\text{H}_2\text{O}$ , dideuterium oxide; ( $^2\text{H}_2$ )water $\text{T}_2\text{O} = ^3\text{H}_2\text{O}$ , ditritium oxide; ( $^3\text{H}_2$ )water			$\text{H}_2\text{O}$ , aqua
$\text{H}_2\text{OP}$	$-\text{PH}_2\text{O}$ , oxo- $\lambda^5$ -phosphanyl; phosphinoyl		$\text{PH}_2\text{O}^-$ , dihydrodooxidophosphate(1-); phosphinite	$\text{PH}_2\text{O}^-$ , dihydrodooxidophosphato(1-); phosphinito
$\text{H}_2\text{OSb}$	$-\text{SbH}_2\text{O}$ , oxo- $\lambda^5$ -stibanyl, stibinoyl			
$\text{H}_2\text{O}_2$	$\text{H}_2\text{O}_2$ , dihydrogen peroxide; hydrogen peroxide $\text{HOOH}$ , dioxidane (parent hydride name), bis(hydrodooxygen)( $\text{O}-\text{O}$ )	$\text{HOOH}^{\bullet+}$ , dioxidaniumyl, bis(hydrodooxygen)( $\text{O}-\text{O}$ )( $\bullet 1^+$ )		$\text{HOOH}$ , dioxidane
$\text{H}_2\text{O}_2\text{P}$	$-\text{P}(\text{OH})_2$ , dihydroxyphosphanyl $-\text{PH}(\text{O})(\text{OH})$ , hydroxyoxo- $\lambda^5$ -phosphanyl		$\text{PH}_2\text{O}_2^-$ , dihydrodooxidophosphate(1-); phosphinate	$\text{PH}_2\text{O}_2^-$ , dihydrodooxidophosphato(1-); phosphinato

$H_2O_3B$				$H_2BO_3^- = [BO(OH)_2]^-$ , dihydroxidooxidoborate(1-); dihydrogenborate	$H_2BO_3^- = [BO(OH)_2]^-$ , dihydroxidooxidoborate(1-); dihydrogenborato
$H_2O_3P$	$-P(O)(OH)_2$ , dihydroxyoxo- $\lambda^5$ -phosphanyl; dihydroxyphosphoryl, phosphono			$[PHO_2(OH)]^-$ , hydrihydroxidodioxido- phosphate(1-); hydrogenphosphonate $[PO(OH)_2]^-$ , dihydroxidooxidophosphate(1-); dihydrogenphosphite	$[PHO_2(OH)]^-$ , hydrihydroxidodioxido- phosphato(1-); hydrogenphosphonato $[PO(OH)_2]^-$ , dihydroxidooxidophosphato(1-); dihydrogenphosphito
$H_2O_4P$	$(HO)_2PO_2^\bullet$ , (dihydroxido)dioxidophosphorus( $\bullet$ )			$H_2PO_4^-$ , dihydroxidodioxidophosphate(1-); dihydrogenphosphate	$H_2PO_4^-$ , dihydroxidodioxidophosphato(1-); dihydrogenphosphato
$H_2O_5P_2$				$P_2H_2O_5^{2-} = [PH(O)_2OPH(O)_2]^{2-}$ , $\mu$ -oxido- bis(hydriodioxidophosphate)(2-); diphosphonate	$P_2H_2O_5^{2-} = [PH(O)_2OPH(O)_2]^{2-}$ , $\mu$ -oxido- bis(hydriodioxidophosphato)(2-); diphosphonato
$H_2PS$	$-PH_2(S)$ , sulfanylidene- $\lambda^5$ -phosphanyl; phosphinothioyl				
$H_2Po$	$H_2Po$ , dihydrogen polonide $H_2Po = [PoH_2]$ , polane (parent hydride name), dihydriodopolonium				
$H_2S$	$H_2S$ , dihydrogen sulfide; hydrogen sulfide $H_2S = [SH_2]$ , sulfane (parent hydride name), dihydridosulfur	$H_2S^{\bullet+}$ , sulfaniumyl, dihydridosulfur( $\bullet 1+$ ) $-SH_2^+$ , sulfaniumyl		$H_2S^{\bullet-}$ , sulfaniumyl, dihydridosulfate( $\bullet 1-$ ) <sup>e</sup>	$H_2S$ , sulfane
$H_2S_2$	$H_2S_2$ , dihydrogen disulfide HSSH, disulfane (parent hydride name), bis(hydridosulfur)( $S-S$ )	$HSSH^{\bullet+}$ , disulfaniumyl, bis(hydridosulfur)( $S-S$ )( $\bullet 1+$ )		$HSSH^{\bullet-}$ , disulfaniumyl, bis(hydridosulfate)( $S-S$ )( $\bullet 1-$ ) <sup>e</sup>	HSSH, disulfane
$H_2S_3$	$H_2S_3$ , dihydrogen trisulfide HSSSH, trisulfane (parent hydride name)				HSSSH, trisulfane

Table IX Continued

Name				
Formula for uncharged atom or group	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
H <sub>2</sub> S <sub>4</sub>	H <sub>2</sub> S <sub>4</sub> , dihydrogen tetrasulfide HSSSSH, tetrasulfane (parent hydride name)			HSSSSH, tetrasulfane
H <sub>2</sub> S <sub>5</sub>	H <sub>2</sub> S <sub>5</sub> , dihydrogen pentasulfide HSSSSSH, pentasulfane (parent hydride name)			HSSSSSH, pentasulfane
H <sub>2</sub> Se	H <sub>2</sub> Se, dihydrogen selenide; hydrogen selenide H <sub>2</sub> Se = [SeH <sub>2</sub> ], selane (parent hydride name), dihydridoselenium	H <sub>2</sub> Se <sup>•+</sup> , seleniumyl, dihydridoselenium(•1+) -SeH <sub>2</sub> <sup>+</sup> , seleniumyl	H <sub>2</sub> Se <sup>•-</sup> , selenuidyl, dihydridoselenate(•1-) <sup>e</sup>	H <sub>2</sub> Se, selane
H <sub>2</sub> Se <sub>2</sub>	H <sub>2</sub> Se <sub>2</sub> , dihydrogen diselenide HSeSeH, diselane (parent hydride name), bis(hydridoselenium)(Se-Se)	HSeSeH <sup>•+</sup> , diselaniumyl, bis(hydridoselenium)(Se-Se)(•1+)	HSeSeH <sup>•-</sup> , diselanuidyl, bis(hydridoselenate)(Se-Se)(•1-) <sup>e</sup>	HSeSeH, diselane
H <sub>2</sub> Te	H <sub>2</sub> Te, dihydrogen tellanide; hydrogen tellanide H <sub>2</sub> Te = [TeH <sub>2</sub> ], tellane (parent hydride name), dihydridotellurium	H <sub>2</sub> Te <sup>•+</sup> , tellaniumyl, dihydridotellurium(•1+) -TeH <sub>2</sub> <sup>+</sup> , tellaniumyl	H <sub>2</sub> Te <sup>•-</sup> , tellanuidyl, dihydridotellurate(•1-) <sup>e</sup>	H <sub>2</sub> Te, tellane
H <sub>3</sub>		H <sub>3</sub> <sup>+</sup> , trihydrogen(1+)		
H <sub>3</sub> N <sub>m</sub> , see N <sub>m</sub> H <sub>3</sub>				

$\text{H}_3\text{NO}$	$\text{HONH}_2$ , azanol, dihydrodihydroxidodinitrogen; hydroxylamine (parent name for organic derivatives)	$\text{HONH}_2^{\bullet+}$ , hydroxyazanumyl, dihydrodihydroxidodinitrogen( $\bullet 1+$ )		$\text{HONH}_2$ , azanol, dihydrodihydroxidodinitrogen; hydroxylamine
$\text{H}_3\text{NP}$	$-\text{PH}_2(=\text{NH})$ , imino- $\lambda^5$ -phosphanyl; phosphinimidoyl			
$\text{H}_3\text{O}$		$\text{H}_3\text{O}^+$ , oxidanium, trihydrodooxygen( $1+$ ), aquahydrogen( $1+$ ); oxonium ( <i>not</i> hydronium)		
$\text{H}_3\text{OS}$	$\text{H}_3\text{OS}^+ = [\text{SH}_3(\text{O})]^+$ , oxo- $\lambda^5$ -sulfanylium, trihydrodooxidodisulfur( $1+$ )			
$\text{H}_3\text{OSi}$	$-\text{OSiH}_3$ , silyloxy			
$\text{H}_3\text{O}_4\text{S}$		$[\text{SO}(\text{OH})_3]^+ = \text{H}_3\text{SO}_4^+$ , trihydrodooxidodisulfur( $1+$ ), trihydrogen(tetraoxidodisulfate)( $1+$ )		
$\text{H}_3\text{O}_5\text{P}$	$[\text{PO}(\text{OH})_2(\text{OOH})]$ , (dioxidanido)dihydroxido $\ominus$ oxidophosphorus; peroxyphosphoric acid, phosphoroperoxoic acid			
$\text{H}_3\text{S}$	$\text{H}_3\text{S}^\bullet$ , $\lambda^4$ -sulfanyl, trihydrodisulfur( $\bullet$ )	$\text{H}_3\text{S}^+$ , sulfanium, trihydrodisulfur( $1+$ )	$\text{H}_3\text{S}^-$ , sulfanuide, trihydrodisulfate( $1-$ )	
$\text{H}_3\text{Se}$	$\text{H}_3\text{Se}^\bullet$ , $\lambda^4$ -selanyl, trihydrodiselenium( $\bullet$ )	$\text{H}_3\text{Se}^+$ , selanium, trihydrodiselenium( $1+$ )	$\text{H}_3\text{Se}^-$ , selanuide, trihydrodiselenate( $1-$ )	
$\text{H}_3\text{Te}$	$\text{H}_3\text{Te}^\bullet$ , $\lambda^4$ -tellanyl, trihydrodote tellurium( $\bullet$ )	$\text{H}_3\text{Te}^+$ , tellanium, trihydrodote tellurium( $1+$ )	$\text{H}_3\text{Te}^-$ , tellanuide, trihydrodote tellurate( $1-$ )	
$\text{H}_4\text{N}_m$ , see $\text{N}_m\text{H}_4$				
$\text{H}_4\text{NO}$		$\text{NH}_2\text{OH}_2^+$ , aminooxidanium, aquadihydroxidodinitrogen( $1+$ ) $\text{NH}_3\text{OH}^+$ , hydroxyazanum, trihydrodihydroxidodinitrogen( $1+$ ); hydroxyammonium		

Table IX Continued

Name				
Formula for uncharged atom or group	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
H <sub>4</sub> O		H <sub>4</sub> O <sup>2+</sup> , oxidanadium, tetrahydridoxygen(2+)		
H <sub>5</sub> IO <sub>6</sub>	IO(OH) <sub>5</sub> , pentahydroxy-λ <sup>7</sup> -iodanone, pentahydroxidoiodine; orthoperiodic acid			
H <sub>5</sub> N <sub>2</sub> , see N <sub>2</sub> H <sub>5</sub>				
H <sub>5</sub> O <sub>2</sub>		[H(H <sub>2</sub> O) <sub>2</sub> ] <sup>+</sup> , μ-hydrido- bis(dihydrodooxygen)(1+), diaquahydrogen(1+)		
H <sub>6</sub> N <sub>2</sub> , see N <sub>2</sub> H <sub>6</sub>				
H <sub>n</sub> N <sub>m</sub> , see N <sub>m</sub> H <sub>n</sub>				
He	helium	helium (general) He <sup>•+</sup> , helium(•1+)	helide	helido
HeH		HeH <sup>+</sup> , hydridohelium(1+)		
He <sub>2</sub>		He <sub>2</sub> <sup>+</sup> , dihelium(1+) He <sub>2</sub> <sup>2+</sup> , dihelium(2+)		
Hf	hafnium	hafnium	hafnide	hafnido
Hg	mercury	mercury (general) Hg <sup>2+</sup> , mercury(2+)	mercuride	mercurido
Hg <sub>2</sub>		Hg <sub>2</sub> <sup>2+</sup> , dimercury(2+)		
Ho	holmium	holmium	holmide	holmido

Hs	hassium	hassium	hassium	hassido
I	iodine (general) $I^\bullet$ , iodine( $\bullet$ ), moniodine -I, iodo	iodine (general) $I^{+}$ , iodine( $1+$ )	iodide (general) $I^-$ , iodide( $1^-$ ); iodide	$I^-$ , iodido( $1-$ ); iodido
ICl <sub>2</sub>	ICl <sub>2</sub> $^\bullet$ , dichloriodiodine( $\bullet$ ) -ICl <sub>2</sub> , dichloro- $\lambda^3$ -iodanyl	ICl <sub>2</sub> $^{+}$ , dichloriodanium, dichloriodiodine( $1+$ )		
IF	IF, iodine fluoride [IF], fluoriodiodine			
IF <sub>4</sub>		IF <sub>4</sub> $^{+}$ , tetrafluoro- $\lambda^3$ -iodanium, tetrafluoriodiodine( $1+$ )	IF <sub>4</sub> $^-$ , tetrafluoro- $\lambda^3$ -iodanuide, tetrafluoriodiodate( $1-$ )	IF <sub>4</sub> $^-$ , tetrafluoro- $\lambda^3$ -iodanuïdo, tetrafluoriodiodato( $1-$ )
IF <sub>6</sub>			IF <sub>6</sub> $^-$ , hexafluoro- $\lambda^5$ -iodanuide, hexafluoriodiodate( $1-$ )	IF <sub>6</sub> $^-$ , hexafluoro- $\lambda^5$ -iodanuïdo, hexafluoriodiodato( $1-$ )
IH, see HI				
I <sub>2</sub>	I <sub>2</sub> , diiodine	I <sub>2</sub> $^{\bullet+}$ , diiodine( $\bullet 1+$ )	I <sub>2</sub> $^{\bullet-}$ , diiodide( $\bullet 1-$ )	I <sub>2</sub> , diiodine
I <sub>3</sub>	I <sub>3</sub> , triiodine		I <sub>3</sub> $^-$ , triiodide( $1-$ ); triiodide	I <sub>3</sub> $^-$ , triiodido( $1-$ ); triiodido
In	indium	indium	indide	indido
InH <sub>2</sub>	-InH <sub>2</sub> , indiganyl			
InH <sub>3</sub>	InH <sub>3</sub> , indium trihydride [InH <sub>3</sub> ], indigane (parent hydride name), trihydridoindium			
Ir	iridium	iridium	iridide	iridido
K	potassium	potassium	potasside	potassido
KO <sub>2</sub>	KO <sub>2</sub> , potassium dioxide( $1-$ ); potassium superoxide			
KO <sub>3</sub>	KO <sub>3</sub> , potassium trioxide( $1-$ ); potassium ozonide			
K <sub>2</sub> O	K <sub>2</sub> O, dipotassium oxide			
K <sub>2</sub> O <sub>2</sub>	K <sub>2</sub> O <sub>2</sub> , dipotassium dioxide( $2-$ ); potassium peroxide			
Kr	krypton	krypton	kryptonide	kryptonido
La	lanthanum	lanthanum	lanthanide <sup>d</sup>	lanthanido
Li	lithium	lithium (general) Li $^{+}$ , lithium( $1+$ )	lithide (general) Li $^-$ , lithide( $1-$ ); lithide	lithido Li $^-$ , lithido( $1-$ ); lithido

Table IX Continued

Formula for uncharged atom or group	Name			
	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
LiAl	[LiAl], aluminidolithium			
LiBe	[LiBe], beryllidolithium			
LiCl	LiCl, lithium chloride [LiCl], chloridolithium	LiCl <sup>+</sup> , chloridolithium(1+)	LiCl <sup>-</sup> , chloridolithate(1-)	LiCl <sup>-</sup> , chloridolithato(1-)
LiH	LiH, lithium hydride [LiH], hydridolithium	LiH <sup>+</sup> , hydridolithium(1+)	LiH <sup>-</sup> , hydridolithate(1-)	LiH <sup>-</sup> , hydridolithato(1-)
LiMg	LiMg, lithium monomagneside	LiMg <sup>+</sup> , magnesidolithium(1+)		
Li <sub>2</sub>	Li <sub>2</sub> , dilithium	Li <sub>2</sub> <sup>+</sup> , dilithium(•1+)	Li <sub>2</sub> <sup>-</sup> , dilithide(•1-)	Li <sub>2</sub> <sup>-</sup> , dilithido(•1-)
Lr	lawrencium	lawrencium	lawrencide	lawrencido
Lu	lutetium	lutetium	lutetide	lutetido
Md	mendelevium	mendelevium	mendelevide	mendelevido
Mg	magnesium	magnesium (general) Mg <sup>+</sup> , magnesium(1+) Mg <sup>2+</sup> , magnesium(2+)	magneside (general) Mg <sup>-</sup> , magneside(1-)	magnesido Mg <sup>-</sup> , magnesido(1-)
Mn	manganese	manganese (general) Mn <sup>2+</sup> , manganese(2+) Mn <sup>3+</sup> , manganese(3+)	manganide	manganido
MnO	MnO, manganese mon(o)oxide, manganese(II) oxide			
MnO <sub>2</sub>	MnO <sub>2</sub> , manganese dioxide, manganese(IV) oxide			
MnO <sub>3</sub>		MnO <sub>3</sub> <sup>+</sup> , trioxidomanganese(1+)		

MnO <sub>4</sub>			MnO <sub>4</sub> <sup>-</sup> , tetraoxidomanganate(1-), permanganate MnO <sub>4</sub> <sup>2-</sup> , tetraoxidomanganate(2-), manganate(VI) MnO <sub>4</sub> <sup>3-</sup> , tetraoxidomanganate(3-), manganate(V)	MnO <sub>4</sub> <sup>-</sup> , tetraoxidomanganato(1-), permanganato MnO <sub>4</sub> <sup>2-</sup> , tetraoxidomanganato(2-), manganato(VI) MnO <sub>4</sub> <sup>3-</sup> , tetraoxidomanganato(3-), manganato(V)
Mn <sub>2</sub> O <sub>3</sub>	Mn <sub>2</sub> O <sub>3</sub> , dimanganese trioxide, manganese(III) oxide			
Mn <sub>2</sub> O <sub>7</sub>	Mn <sub>2</sub> O <sub>7</sub> , dimanganese heptaoxide, manganese(VII) oxide [O <sub>3</sub> MnOMnO <sub>3</sub> ], μ-oxido-bis(trioxidomanganese)			
Mn <sub>3</sub> O <sub>4</sub>	Mn <sub>3</sub> O <sub>4</sub> , trimanganese tetraoxide Mn <sup>II</sup> Mn <sup>III</sup> <sub>2</sub> O <sub>4</sub> , manganese(II,III) tetraoxide			
Mo	molybdenum	molybdenum	molybdenide	molybdenido
Mt	meitnerium	meitnerium	meitneride	meitnerido
Mu	Mu <sup>•</sup> = μ <sup>+</sup> e <sup>-</sup> , muonium	Mu <sup>+</sup> = μ <sup>+</sup> , muon	Mu <sup>-</sup> = μ <sup>+</sup> (e <sup>-</sup> ) <sup>2</sup> , muonide	
N	nitrogen N <sup>•</sup> , nitrogen(•), mononitrogen -N<, azanetriyl; nitrilo -N=, azanylylidene ≡N, azanylidyne	nitrogen (general) N <sup>+</sup> , nitrogen(1+)	nitride (general) N <sup>3-</sup> , nitride(3-), azanetriide; nitride =N-, azanidylydene; amidylidene -N <sup>2-</sup> , azanediidyl	N <sup>3-</sup> , nitrido(3-), azanetriido
NCO, see CNO				
NCS, see CNS				
NCl <sub>2</sub>			NCl <sub>2</sub> <sup>-</sup> , dichloroazanide, dichloridonitrate(1-)	NCl <sub>2</sub> <sup>-</sup> , dichloroazanido, dichloridonitrato(1-)
NF			NF <sup>2-</sup> , fluoroazanediide, fluoridonitrate(2-)	NF <sup>2-</sup> , fluoroazanediido, fluoridonitrato(2-)



Table IX Continued

Name				
Formula for uncharged atom or group	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
NF <sub>3</sub>	NF <sub>3</sub> , nitrogen trifluoride [NF <sub>3</sub> ], trifluoroazane, trifluoridonitrogen			NF <sub>3</sub> , trifluoroazane, trifluoridonitrogen
NF <sub>4</sub>		NF <sub>4</sub> <sup>+</sup> , tetrafluoroammonium, tetrafluoroazanium, tetrafluoridonitrogen(1+)		
NH	NH <sup>2•</sup> , azanylidene, hydridonitrogen(2•); nitrene >NH, azanediyl =NH, azanylidene; imino	NH <sup>+</sup> , azanyliumdiyl, hydridonitrogen(1+) NH <sup>2+</sup> , azanebis(ylium), hydridonitrogen(2+)	NH <sup>-</sup> , azanidyl, hydridonitrate(1-) NH <sup>2-</sup> , azanediide, hydridonitrate(2-); imide -NH <sup>-</sup> , azanidyl; amidyl	NH <sup>2-</sup> , azanediido, hydridonitrate(2-); imido
NH <sub>2</sub>	NH <sub>2</sub> <sup>•</sup> , azanyl, dihydridonitrogen(•); aminyl -NH <sub>2</sub> , azanyl; amino	NH <sub>2</sub> <sup>+</sup> , azanylium, dihydridonitrogen(1+)	NH <sub>2</sub> <sup>-</sup> , azanide, dihydridonitrate(1-); amide	NH <sub>2</sub> <sup>-</sup> , azanido, dihydridonitrate(1-), amido
NH <sub>3</sub>	NH <sub>3</sub> , azane (parent hydride name), amine (parent name for certain organic derivatives), trihydridonitrogen; ammonia	NH <sub>3</sub> <sup>•+</sup> , azaniumyl, trihydridonitrogen(•1+) -NH <sub>3</sub> <sup>+</sup> , azaniumyl; ammonio	NH <sub>3</sub> <sup>•-</sup> , azanuidyl, trihydridonitrate(•1-) <sup>e</sup>	NH <sub>3</sub> , ammine
NH <sub>4</sub>	NH <sub>4</sub> <sup>•</sup> , λ <sup>5</sup> -azanyl, tetrahydridonitrogen(•)	NH <sub>4</sub> <sup>+</sup> , azanium; ammonium		

NO	NO, nitrogen mon(o)oxide ( <i>not</i> nitric oxide) NO <sup>•</sup> , oxoazanyl, oxidonitrogen(•); nitrosyl -N=O, oxoazanyl; nitroso >N(O)-, oxo- $\lambda^3$ -azanetriyl; azoryl =N(O)-, oxo- $\lambda^5$ -azanylidene; azorylidene $\equiv$ N(O), oxo- $\lambda^5$ -azanylidyne; azorylidyne -O <sup>+</sup> =N <sup>-</sup> , azanidyldeneoxoazaniumyl	NO <sup>+</sup> , oxidonitrogen(1+) ( <i>not</i> nitrosyl) NO <sup>•2+</sup> , oxidonitrogen(•2+)	NO <sup>-</sup> , oxidonitrate(1-) NO <sup>(2•-)</sup> , oxidonitrate(•2-1-)	NO, oxidonitrogen (general); nitrosyl = oxidonitrogen-κN (general) NO <sup>+</sup> , oxidonitrogen(1+) NO <sup>-</sup> , oxidonitrate(1-)
NO <sub>2</sub>	NO <sub>2</sub> , nitrogen dioxide NO <sub>2</sub> <sup>•</sup> = ONO <sup>•</sup> , nitrosooxidanyl, dioxidonitrogen(•); nitryl -NO <sub>2</sub> , nitro -ONO, nitrosoxy	NO <sub>2</sub> <sup>+</sup> , dioxidonitrogen(1+) ( <i>not</i> nitryl)	NO <sub>2</sub> <sup>-</sup> , dioxidonitrate(1-); nitrite NO <sub>2</sub> <sup>•2-</sup> , dioxidonitrate(•2-)	NO <sub>2</sub> <sup>-</sup> , dioxidonitrate(1-); nitrite NO <sub>2</sub> <sup>•2-</sup> , dioxidonitrate(•2-)
NO <sub>3</sub>	NO <sub>3</sub> , nitrogen trioxide NO <sub>3</sub> <sup>•</sup> = O <sub>2</sub> NO <sup>•</sup> , nitrooxidanyl, trioxidonitrogen(•) ONOO <sup>•</sup> , nitrosodioxidanyl, oxidoperoxidonitrogen(•) -ONO <sub>2</sub> , nitrooxy		NO <sub>3</sub> <sup>-</sup> , trioxidonitrate(1-); nitrate NO <sub>3</sub> <sup>•2-</sup> , trioxidonitrate(•2-) [NO(OO)] <sup>-</sup> , oxidoperoxidonitrate(1-); peroxynitrite	NO <sub>3</sub> <sup>-</sup> , trioxidonitrate(1-); nitrate NO <sub>3</sub> <sup>•2-</sup> , trioxidonitrate(•2-) [NO(OO)] <sup>-</sup> , oxidoperoxidonitrate(1-); peroxynitrite
NO <sub>4</sub>			NO <sub>2</sub> (O <sub>2</sub> ) <sup>-</sup> , dioxidoperoxidonitrate(1-); peroxynitrate	NO <sub>2</sub> (O <sub>2</sub> ) <sup>-</sup> , dioxidoperoxidonitrate(1-); peroxynitrate
NS	NS, nitrogen monosulfide NS <sup>•</sup> , sulfidonitrogen(•) -N=S, sulfanylideneazanyl; thionitroso	NS <sup>+</sup> , sulfidonitrogen(1+) ( <i>not</i> thionitrosyl)	NS <sup>-</sup> , sulfidonitrate(1-)	NS, sulfidonitrogen, sulfidonitrate, thionitrosyl (general) NS <sup>+</sup> , sulfidonitrogen(1+) NS <sup>-</sup> , sulfidonitrate(1-)

Table IX Continued

Name				
Formula for uncharged atom or group	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
N <sub>2</sub>	N <sub>2</sub> , dinitrogen =N <sup>+</sup> =N <sup>-</sup> , (azanidylidene)azanumylidene; diazo =NN=, diazene-1,2-diylidene; hydrazinediylidene -N=N-, diazene-1,2-diyl; azo	N <sub>2</sub> <sup>•+</sup> , dinitrogen(•1+) N <sub>2</sub> <sup>2+</sup> , dinitrogen(2+) -N <sup>+</sup> ≡N, diazyn-1-ium-1-yl	N <sub>2</sub> <sup>2-</sup> , dinitride(2-) N <sub>2</sub> <sup>4-</sup> , dinitride(4-), diazanetetraide; hydrazinetetraide	N <sub>2</sub> , dinitrogen N <sub>2</sub> <sup>2-</sup> , dinitride(2-) N <sub>2</sub> <sup>4-</sup> , dinitride(4-), diazanetetraide; hydrazinetetraide
N <sub>2</sub> H		N≡NH <sup>+</sup> , diazynium	N=NH <sup>-</sup> , diazenide NNH <sup>3-</sup> , diazanetriide, hydrazinetriide	N=NH <sup>-</sup> , diazenido NNH <sup>3-</sup> , diazanetriido, hydrazinetriido
N <sub>2</sub> H <sub>2</sub>	HN=NH, diazene N=NH <sub>2</sub> <sup>+</sup> , diazen-2-ium-1-ide H <sub>2</sub> NN <sup>2•</sup> , diazanylidene, hydrazinylidene =NNH <sub>2</sub> , diazanylidene; hydrazinylidene •HNNH <sup>•</sup> , diazane-1,2-diyl; hydrazine-1,2-diyl -HNNH-, diazane-1,2-diyl; hydrazine-1,2-diyl	HNNH <sup>2+</sup> , diazynylium	HNNH <sup>2-</sup> , diazane-1,2-diide, hydrazine-1,2-diide H <sub>2</sub> NN <sup>2-</sup> , diazane-1,1-diide, hydrazine-1,1-diide	HN=NH, diazene N=NH <sub>2</sub> <sup>+</sup> , diazen-2-ium-1-ido HNNH <sup>2-</sup> , diazane-1,2-diido, hydrazine-1,2-diido H <sub>2</sub> NN <sup>2-</sup> , diazane-1,1-diido, hydrazine-1,1-diido
N <sub>2</sub> H <sub>3</sub>	H <sub>2</sub> NNH <sup>•</sup> , diazanyl, trihydridodinitrogen(N—N)(•); hydrazinyl -NHNH <sub>2</sub> , diazanyl; hydrazinyl 2-NNH <sub>3</sub> <sup>+</sup> , diazan-2-ium-1,1-diide	HN=NH <sub>2</sub> <sup>+</sup> , diazenium	H <sub>2</sub> NNH <sup>-</sup> , diazanide, hydrazinide	2-NNH <sub>3</sub> <sup>+</sup> , diazan-2-ium-1,1-diido H <sub>2</sub> NNH <sup>-</sup> , diazanido, hydrazinido

$N_2H_4$	$H_2NNH_2$ , diazane (parent hydride name), hydrazine (parent name for organic derivatives) $\overline{N}NHNH_3^+$ , diazan-2-ium-1-ide	$H_2NNH_2^{\bullet+}$ , diazaniumyl, bis(dihydridonitrogen)( $N-N$ )( $\bullet 1+$ ); hydraziniumyl $H_2N=NH_2^{2+}$ , diazenedidium $H_2NNH_3^+$ , diazanium, hydrazinium	$H_2NNH_2$ , diazane, hydrazine $\overline{N}NHNH_3^+$ , diazan-2-ium-1-ido
$N_2H_5$			
$N_2H_6$		$H_3NNH_3^{2+}$ , diazanedidium, hydrazinedidium	
$N_2O$	$N_2O$ , dinitrogen oxide ( <i>not</i> nitrous oxide) NNO, oxidodinitrogen( $N-N$ ) $-N(O)=N-$ , azoxy	$N_2O^{\bullet-}$ , oxidodinitrate( $\bullet 1-$ )	$N_2O$ , dinitrogen oxide (general) NNO, oxidodinitrogen( $N-N$ ) $N_2O^{\bullet-}$ , oxidodinitrate( $\bullet 1-$ )
$N_2O_2$	$N_2O_2$ , dinitrogen dioxide ONNO, bis(oxidonitrogen)( $N-N$ )		$N_2O_2^{2-}$ , bis(oxidonitrate)( $N-N$ )(2-)
$N_2O_3$	$N_2O_3$ , dinitrogen trioxide $O_2NNO$ , trioxido-1 $\kappa^2O_2$ 2 $\kappa O$ - dinitrogen( $N-N$ ) $NO^+NO_2^-$ , oxidonitrogen(1+) dioxidinitrate(1-) ONONO, dinitrosooxidane, $\mu$ -oxido-bis(oxidonitrogen)	$N_2O_2^{2-}$ , diazenediolate, bis(oxidonitrate)( $N-N$ )(2-) $N_2O_3^{2-} = [O_2NNO]^{2-}$ , trioxido-1 $\kappa^2O_2$ 2 $\kappa O$ - dinitrate( $N-N$ )(2-)	
$N_2O_4$	$N_2O_4$ , dinitrogen tetraoxide $O_2NNO_2$ , bis(dioxidonitrogen)( $N-N$ ) ONONO, 1,2-dinitrosodioxidane, bis(nitrosyloxygen)( $O-O$ ), 2,5-diazy-1,3,4,6- tetraoxy-[6]catena $NO^+NO_3^-$ , oxidonitrogen(1+) trioxidinitrate(1-)		

Table IX Continued

Name				
Formula for uncharged atom or group	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
N <sub>2</sub> O <sub>5</sub>	N <sub>2</sub> O <sub>5</sub> , dinitrogen pentaoxide O <sub>2</sub> NONO <sub>2</sub> , dinitrooxidane, μ-oxido- bis(dioxidonitrogen)(N—N) NO <sub>2</sub> <sup>+</sup> NO <sub>3</sub> <sup>−</sup> , dioxidonitrogen(1+) trioxidonitrate(1−)			
N <sub>3</sub>	N <sub>3</sub> <sup>•</sup> , trinitrogen(•) −N≡N <sup>+</sup> =N <sup>−</sup> , azido		N <sub>3</sub> <sup>−</sup> , trinitride(1−); azide	N <sub>3</sub> <sup>−</sup> , trinitrido(1−); azido
N <sub>3</sub> H	N <sub>3</sub> H, hydrogen trinitride(1−); hydrogen azide [NNNH], hydrido-1κ <i>H</i> -trinitrogen(2 <i>N</i> — <i>N</i> )			
N <sub>3</sub> H <sub>2</sub>	−NHN=NH, triaz-2-en-1-yl			
N <sub>3</sub> H <sub>4</sub>	−NHNHNH <sub>2</sub> , triazan-1-yl			
N <sub>5</sub>		N <sub>5</sub> <sup>+</sup> , pentanitrogen(1+)		
N <sub>6</sub>			N <sub>6</sub> <sup>•−</sup> , hexanitride(•1−)	N <sub>6</sub> <sup>•−</sup> , hexanitrido(•1−)
Na	sodium	sodium (general) Na <sup>+</sup> , sodium(1+)	sodide (general) Na <sup>−</sup> , sodide(1−); sodide	sodido Na <sup>−</sup> , sodido(1−); sodido
NaCl	NaCl, sodium chloride [NaCl], chloridosodium	NaCl <sup>1+</sup> , chloridosodium(1+)	NaCl <sup>−</sup> , chloridosodate(1−)	
Na <sub>2</sub>	Na <sub>2</sub> , disodium	Na <sub>2</sub> <sup>+</sup> , disodium(1+)	Na <sub>2</sub> <sup>−</sup> , disodide(1−)	Na <sub>2</sub> <sup>−</sup> , disodido(1−)
Nb	niobium	niobium	niobide	niobido
Nd	neodymium	neodymium	neodymide	neodymido

Ne	neon	neon (general) Ne <sup>+</sup> , neon(1+)	neonide	neonido
NeH		NeH <sup>+</sup> , hydridoneon(1+)		
NeHe		NeHe <sup>+</sup> , helidoneon(1+)		
Ni	nickel	nickel (general) Ni <sup>2+</sup> , nickel(2+) Ni <sup>3+</sup> , nickel(3+)	nickelide	nickelido
No	nobelium	nobelium	nobelide	nobelido
Np	neptunium	neptunium	neptunide	neptunido
NpO <sub>2</sub>	NpO <sub>2</sub> , neptunium dioxide	NpO <sub>2</sub> <sup>+</sup> , dioxidoneptunium(1+) [ <i>not</i> neptunyl(1+)] NpO <sub>2</sub> <sup>2+</sup> , dioxidoneptunium(2+) [ <i>not</i> neptunyl(2+)]		
O	oxygen (general) O, monooxygen O <sup>2•</sup> , oxidanylidene, monooxygen(2•) >O, oxy, epoxy (in rings) =O, oxo	oxygen (general) O <sup>•+</sup> , oxygen(•1+)	oxide (general) O <sup>•-</sup> , oxidanidyl, oxide(•1-) O <sup>2-</sup> , oxide(2-); oxide -O <sup>-</sup> , oxido	O <sup>2-</sup> , oxido
OBr	OBr, oxygen (mono)bromide <sup>f</sup> OBr <sup>•</sup> , bromidooxygen(•) <sup>f</sup> ; bromosyl -BrO, oxo-λ <sup>3</sup> -bromanyl; bromosyl -OBr, bromooxy	OBr <sup>+</sup> , bromidooxygen(1+) <sup>f</sup> ( <i>not</i> bromosyl)	OBr <sup>-</sup> , bromidooxygenate(1-) <sup>f</sup> ; oxidobromate(1-) <sup>f</sup> , hypobromite	OBr <sup>-</sup> , bromidooxygenato(1-) <sup>f</sup> ; oxidobromato(1-) <sup>f</sup> , hypobromito
OCN, see CNO				
OCl	OCl, oxygen (mono)chloride <sup>f</sup> OCl <sup>•</sup> , chloridooxygen(•) <sup>f</sup> ; chlorosyl -ClO, oxo-λ <sup>3</sup> -chloranyl; chlorosyl -OCl, chlorooxy		OCl <sup>-</sup> , chloridooxygenate(1-) <sup>f</sup> ; oxidochlorate(1-) <sup>f</sup> , hypochlorite	OCl <sup>-</sup> , chloridooxygenato(1-) <sup>f</sup> ; oxidochlorato(1-) <sup>f</sup> , hypochlorito
OD <sub>2</sub> , see H <sub>2</sub> O				

Table IX Continued

Name				
Formula for uncharged atom or group	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
OF	OF, oxygen (mono)fluoride OF <sup>•</sup> , fluoridooxygen(•) -FO, oxo-λ <sup>3</sup> -fluoranyl; fluorosyl	OF <sup>+</sup> , fluoridooxygen(1+)	OF <sup>-</sup> , fluoridooxygenate(1-)	
OF <sub>2</sub>	OF <sub>2</sub> , oxygen difluoride [OF <sub>2</sub> ], difluoridooxygen			
OH <sub>n</sub> , see H <sub>n</sub> O (n = 1-4)				
O <sup>1</sup> H <sub>2</sub> , see H <sub>2</sub> O				
OI	OI, oxygen (mono)iodide <sup>f</sup> OI <sup>•</sup> , iodidooxygen(•) <sup>f</sup> ; iodosyl -IO, oxo-λ <sup>3</sup> -iodanyl; iodosyl -OI, iodoxy	OI <sup>+</sup> , iodidooxygen(1+) <sup>f</sup> (not iodosyl)	OI <sup>-</sup> , iodidooxygenate(1-) <sup>f</sup> ; oxidoiodate(1-) <sup>f</sup> ; hypiodite OI <sup>•2-</sup> , iodidooxygenate(•2-) <sup>f</sup>	OI <sup>-</sup> , iodidooxygenato(1-) <sup>f</sup> ; oxidoiodato(1-) <sup>f</sup> ; hypiodito
ONC, see CNO				
OT <sub>2</sub> , see H <sub>2</sub> O				
O <sub>2</sub>	O <sub>2</sub> , dioxygen O <sub>2</sub> <sup>2•</sup> , dioxidanediyl, dioxygen(2•) -OO-, dioxidanediyl; peroxy	O <sub>2</sub> <sup>•+</sup> , dioxidanilylumyl, dioxygen(•1+) O <sub>2</sub> <sup>2+</sup> , dioxidanebis(ylium), dioxygen(2+)	O <sub>2</sub> <sup>•-</sup> , dioxidanidyl, dioxide(•1-); superoxide (not hyperoxide) O <sub>2</sub> <sup>2-</sup> , dioxidanediide, dioxide(2-); peroxide	dioxido (general) O <sub>2</sub> , dioxygen O <sub>2</sub> <sup>•-</sup> , dioxide(•1-); superoxido O <sub>2</sub> <sup>2-</sup> , dioxidanediido, dioxido(2-); peroxido
O <sub>2</sub> Br	O <sub>2</sub> Br, dioxygen bromide <sup>f</sup> BrO <sub>2</sub> <sup>•</sup> , dioxidobromine(•) -BrO <sub>2</sub> , dioxo-λ <sup>5</sup> -bromanyl; bromyl -OBrO, oxo-λ <sup>3</sup> -bromanyloxy	BrO <sub>2</sub> <sup>+</sup> , dioxidobromine(1+) (not bromyl)	BrO <sub>2</sub> <sup>-</sup> , dioxidobromate(1-); bromite	BrO <sub>2</sub> <sup>-</sup> , dioxidobromato(1-); bromito

$O_2Cl$	$O_2Cl$ , dioxygen chloride <sup>f</sup> $ClO_2^\bullet$ , dioxidochlorine( $\bullet$ ) $ClOO^\bullet$ , chloridodioxygen( $O-O$ )( $\bullet$ ) - $ClO_2$ , dioxo- $\lambda^5$ -chloranyl; chloryl - $OCIO$ , oxo- $\lambda^3$ -chloranyloxy	$ClO_2^+$ , dioxidochlorine(1+) ( <i>not</i> chloryl)	$ClO_2^-$ , dioxidochlorate(1-); chlorite	$ClO_2^-$ , dioxidochlorato(1-); chlorito
$O_2Cl_2$		$O_2Cl_2^+$ , (dioxygen dichloride)(1+) <sup>f</sup>		
$O_2F_2$	$O_2F_2$ , dioxygen difluoride FOOF, difluorodioxidane, bis(fluoridooxygen)( $O-O$ )			
$O_2I$	$O_2I$ , dioxygen iodide <sup>f</sup> $IO_2^\bullet$ , dioxidoiodine( $\bullet$ ) - $IO_2$ , dioxo- $\lambda^5$ -iodanyl; iodyl - $OIO$ , oxo- $\lambda^3$ -iodanyloxy	$IO_2^+$ , dioxidoiodine(1+) ( <i>not</i> iodyl)	$IO_2^-$ , dioxidoiodate(1-); iodite	$IO_2^-$ , dioxidoiodato(1-); iodito
$O_3$	$O_3$ , trioxxygen; ozone - $OOO-$ , trioxidanediyl		$O_3^\bullet$ , trioxidanidyl, trioxide( $\bullet$ 1-); ozonide	$O_3$ , trioxxygen; ozone $O_3^\bullet$ , trioxido( $\bullet$ 1-); ozonido
$O_3Br$	$O_3Br$ , trioxxygen bromide <sup>f</sup> $BrO_3^\bullet$ , trioxidobromine( $\bullet$ ) - $BrO_3$ , trioxo- $\lambda^7$ -bromanyl; perbromyl - $OBRO_2$ , dioxo- $\lambda^5$ -bromanyloxy	$BrO_3^+$ , trioxidobromine(1+) ( <i>not</i> perbromyl)	$BrO_3^-$ , trioxidobromate(1-); bromate	$BrO_3^-$ , trioxidobromato(1-); bromato
$O_3Cl$	$O_3Cl$ , trioxxygen chloride <sup>f</sup> $ClO_3^\bullet$ , trioxidochlorine( $\bullet$ ) - $ClO_3$ , trioxo- $\lambda^7$ -chloranyl; perchloryl - $OCIO_2$ , dioxo- $\lambda^5$ -chloranyloxy	$ClO_3^+$ , trioxidochlorine(1+) ( <i>not</i> perchloryl)	$ClO_3^-$ , trioxidochlorate(1-); chlorate	$ClO_3^-$ , trioxidochlorato(1-); chlorato
$O_3I$	$O_3I$ , trioxxygen iodide <sup>f</sup> $IO_3^\bullet$ , trioxidoiodine( $\bullet$ ) - $IO_3$ , trioxo- $\lambda^7$ -iodanyl; periodyl - $OIO_2$ , dioxo- $\lambda^5$ -iodanyloxy	$IO_3^+$ , trioxidoiodine(1+) ( <i>not</i> periodyl)	$IO_3^-$ , trioxidoiodate(1-); iodate	$IO_3^-$ , trioxidoiodato(1-); iodato
$O_4Br$	$O_4Br$ , tetraoxxygen bromide <sup>f</sup> $BrO_4^\bullet$ , tetraoxidobromine( $\bullet$ ) - $OBRO_3$ , trioxo- $\lambda^7$ -bromanyloxy		$BrO_4^-$ , tetraoxidobromate(1-); perbromate	$BrO_4^-$ , tetraoxidobromato(1-); perbromato



Table IX Continued

Name				
Formula for uncharged atom or group	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
O <sub>4</sub> Cl	O <sub>4</sub> Cl, tetraoxygen chloride <sup>f</sup> ClO <sub>4</sub> •, tetraoxidochlorine(•) -OCIO <sub>3</sub> , trioxo-λ <sup>7</sup> -chloranyloxy		ClO <sub>4</sub> <sup>-</sup> , tetraoxidochlorate(1-); perchlorate	ClO <sub>4</sub> <sup>-</sup> , tetraoxidochlorato(1-); perchlorato
O <sub>4</sub> I	O <sub>4</sub> I, tetraoxygen iodide <sup>f</sup> IO <sub>4</sub> •, tetraoxidoiodine(•) -OIO <sub>3</sub> , trioxo-λ <sup>7</sup> -iodanyloxy		IO <sub>4</sub> <sup>-</sup> , tetraoxidoiodate(1-); periodate	IO <sub>4</sub> <sup>-</sup> , tetraoxidoiodato(1-); periodato
O <sub>5</sub> I			IO <sub>5</sub> <sup>3-</sup> , pentaaxidoiodate(3-)	IO <sub>5</sub> <sup>3-</sup> , pentaaxidoiodato(3-)
O <sub>6</sub> I			IO <sub>6</sub> <sup>5-</sup> , hexaaxidoiodate(5-); orthoperiodate	IO <sub>6</sub> <sup>5-</sup> , hexaaxidoiodato(5-); orthoperiodato
O <sub>9</sub> I <sub>2</sub>			I <sub>2</sub> O <sub>9</sub> <sup>4-</sup> , nonaaxidodiiodate(4-) [O <sub>3</sub> I(μ-O) <sub>3</sub> IO <sub>3</sub> ] <sup>4-</sup> , tri-μ-oxido-bis(trioxidoiodate)(4-)	I <sub>2</sub> O <sub>9</sub> <sup>4-</sup> , nonaaxidodiiodato(4-) [O <sub>3</sub> I(μ-O) <sub>3</sub> IO <sub>3</sub> ] <sup>4-</sup> , tri-μ-oxido-bis(trioxidoiodato)(4-)
Os	osmium	osmium	osmide	osmido
P	phosphorus (general) P•, phosphorus(•), monophosphorus >P-, phosphanetriyl	phosphorus (general) P <sup>+</sup> , phosphorus(1+)	phosphide (general) P <sup>-</sup> , phosphide(1-) p <sup>3-</sup> , phosphide(3-), phosphanetriide; phosphide	P <sup>3-</sup> , phosphido, phosphanetriido
PF			PF <sup>2-</sup> , fluorophosphanediide, fluoridophosphate(2-)	PF <sup>2-</sup> , fluorophosphanediido, fluoridophosphato(2-)
PF <sub>2</sub>			PF <sub>2</sub> <sup>-</sup> , difluorophosphanide, difluoridophosphate(1-)	PF <sub>2</sub> <sup>-</sup> , difluorophosphanido, difluoridophosphato(1-)
PF <sub>3</sub>	PF <sub>3</sub> , phosphorus trifluoride [PF <sub>3</sub> ], trifluorophosphane, trifluoridophosphorus			

PF <sub>4</sub>		PF <sub>4</sub> <sup>+</sup> , tetrafluorophosphanium, tetrafluoridophosphorus(1+)	PF <sub>4</sub> <sup>-</sup> , tetrafluorophosphanuide, tetrafluoridophosphate(1-)	PF <sub>4</sub> <sup>-</sup> , tetrafluorophosphanuido, tetrafluoridophosphato(1-)
PF <sub>5</sub>	PF <sub>5</sub> , phosphorus pentafluoride [PF <sub>5</sub> ], pentafluoro-λ <sup>5</sup> -phosphane, pentafluoridophosphorus			
PF <sub>6</sub>			PF <sub>6</sub> <sup>-</sup> , hexafluoro-λ <sup>5</sup> -phosphanuide, hexafluoridophosphate(1-)	PF <sub>6</sub> <sup>-</sup> , hexafluoro-λ <sup>5</sup> -phosphanuido, hexafluoridophosphato(1-)
PH	PH <sup>2•</sup> , phosphanylidene, hydridophosphorus(2•) >PH, phosphanediyl =PH, phosphanylidene	PH <sup>•+</sup> , phosphanyliumyl, hydridophosphorus(•1+) PH <sup>2+</sup> , phosphanebis(ylium), hydridophosphorus(2+)	PH <sup>•-</sup> , phosphanidyl, hydridophosphate(•1-) PH <sup>2-</sup> , phosphanediide, hydridophosphate(2-)	PH <sup>2-</sup> , phosphanediido, hydridophosphato(2-)
PH <sub>2</sub>	PH <sub>2</sub> <sup>•</sup> , phosphanyl, dihydridophosphorus(•) -PH <sub>2</sub> , phosphanyl	PH <sub>2</sub> <sup>+</sup> , phosphanylium, dihydridophosphorus(1+)	PH <sub>2</sub> <sup>-</sup> , phosphanide, dihydridophosphate(1-)	PH <sub>2</sub> <sup>-</sup> , phosphanido, dihydridophosphato(1-)
PH <sub>3</sub>	PH <sub>3</sub> , phosphorus trihydride [PH <sub>3</sub> ], phosphane (parent hydride name), trihydridophosphorus -PH <sub>4</sub> , λ <sup>5</sup> -phosphanyl	PH <sub>3</sub> <sup>•+</sup> , phosphaniumyl, trihydridophosphorus(•1+) -PH <sub>3</sub> <sup>+</sup> , phosphaniumyl	PH <sub>3</sub> <sup>•-</sup> , phosphanuidyl, trihydridophosphate(•1-) <sup>e</sup>	PH <sub>3</sub> , phosphane
PH <sub>4</sub>		PH <sub>4</sub> <sup>+</sup> , phosphanium, tetrahydridophosphorus(1+)	PH <sub>4</sub> <sup>-</sup> , phosphanuide, tetrahydridophosphate(1-)	PH <sub>4</sub> <sup>-</sup> , phosphanuido, tetrahydridophosphato(1-)
PH <sub>5</sub>	PH <sub>5</sub> , phosphorus pentahydride [PH <sub>5</sub> ], λ <sup>5</sup> -phosphane (parent hydride name), pentahydridophosphorus			
PN	P≡N, nitridophosphorus >P≡N, azanylidyne-λ <sup>5</sup> -phosphanediyl; phosphoronitridoyl			

Table IX Continued

Name				
Formula for uncharged atom or group	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
PO	PO <sup>•</sup> , oxophosphanyl, oxidophosphorus(•), phosphorus mon(o)oxide; phosphoryl >P(O)–, oxo-λ <sup>5</sup> -phosphanetriyl; phosphoryl =P(O)–, oxo-λ <sup>5</sup> -phosphanylidene; phosphorylidene ≡P(O), oxo-λ <sup>5</sup> -phosphanylidyne; phosphorylidyne	PO <sup>+</sup> , oxidophosphorus(1+) (not phosphoryl)	PO <sup>–</sup> , oxidophosphate(1–)	
PO <sub>2</sub>	–P(O) <sub>2</sub> , dioxo-λ <sup>5</sup> -phosphanyl		PO <sub>2</sub> <sup>–</sup> , dioxidophosphate(1–)	PO <sub>2</sub> <sup>–</sup> , dioxidophosphato(1–)
PO <sub>3</sub>			PO <sub>3</sub> <sup>–</sup> , trioxidophosphate(1–) PO <sub>3</sub> <sup>•2–</sup> , trioxidophosphate(•2–) PO <sub>3</sub> <sup>3–</sup> , trioxidophosphate(3–); phosphite (PO <sub>3</sub> <sup>–</sup> ) <sub>n</sub> = {P(O) <sub>2</sub> O} <sub>n</sub> <sup>n–</sup> , catena-poly[(dioxidophosphate-μ- oxido)(1–)]; metaphosphate –P(O)(O <sup>–</sup> ) <sub>2</sub> , dioxidooxo-λ <sup>5</sup> -phosphanyl; phosphonato	PO <sub>3</sub> <sup>–</sup> , trioxidophosphato(1–) PO <sub>3</sub> <sup>•2–</sup> , trioxidophosphato(•2–) PO <sub>3</sub> <sup>3–</sup> , trioxidophosphato(3–); phosphito

$\text{PO}_4$			$\text{PO}_4^{\bullet 2-}$ , tetraoxidophosphate( $\bullet 2-$ ) $\text{PO}_4^{3-}$ , tetraoxidophosphate( $3-$ ); phosphate	$\text{PO}_4^{3-}$ , tetraoxidophosphato( $3-$ ); phosphato
$\text{PO}_5$			$\text{PO}_5^{\bullet 2-} = \text{PO}_3(\text{OO})^{\bullet 2-}$ , trioxidoperoxidophosphate( $\bullet 2-$ ) $\text{PO}_5^{3-} = \text{PO}_3(\text{OO})^{3-}$ , trioxidoperoxidophosphate( $3-$ ); peroxyphosphato, phosphoroperoxoato	$\text{PO}_5^{3-} = \text{PO}_3(\text{OO})^{3-}$ , trioxidoperoxidophosphato( $3-$ ); peroxyphosphato, phosphoroperoxoato
PS	$\text{PS}^\bullet$ , sulfidophosphorus( $\bullet$ ); -PS, thiophosphoryl	$\text{PS}^+$ , sulfidophosphorus( $1+$ ) ( <i>not</i> thiophosphoryl)		
$\text{PS}_4$			$\text{PS}_4^{3-}$ , tetrasulfidophosphate( $3-$ )	$\text{PS}_4^{3-}$ , tetrasulfidophosphato( $3-$ )
$\text{P}_2$	$\text{P}_2$ , diphosphorus	$\text{P}_2^+$ , diphosphorus( $1+$ )	$\text{P}_2^-$ , diphosphide( $1-$ ) $\text{P}_2^{2-}$ , diphosphide( $2-$ )	$\text{P}_2$ , diphosphorus $\text{P}_2^-$ , diphosphido( $1-$ ) $\text{P}_2^{2-}$ , diphosphido( $2-$ )
$\text{P}_2\text{H}$			$\text{HP} = \text{P}^-$ , diphosphenide $\text{PPH}^{3-}$ , diphosphanetriide	$\text{HP} = \text{P}^-$ , diphosphenido $\text{PPH}^{3-}$ , diphosphanetriido
$\text{P}_2\text{H}_2$	$\text{HP} = \text{PH}$ , diphosphene (parent hydride name) $\text{H}_2\text{PP}^{2\bullet}$ , diphosphanylidene $= \text{PPH}_2$ , diphosphanylidene $= \text{HPPH}^-$ , diphosphane-1,2-diyl		$\text{HPPH}^{2-}$ , diphosphane-1,2-diide $\text{H}_2\text{PP}^{2-}$ , diphosphane-1,1-diide	$\text{HP} = \text{PH}$ , diphosphene $\text{HPPH}^{2-}$ , diphosphane-1,2-diido $\text{H}_2\text{PP}^{2-}$ , diphosphane-1,1-diido
$\text{P}_2\text{H}_3$	$\text{H}_2\text{PPH}^\bullet$ , diphosphanyl, trihydridodiphosphorus( $P-P$ )( $\bullet$ ) $= \text{HPPH}_2$ , diphosphanyl		$\text{H}_2\text{PPH}^-$ , diphosphanide	$\text{H}_2\text{PPH}^-$ , diphosphanido
$\text{P}_2\text{H}_4$	$\text{H}_2\text{PPH}_2$ , diphosphane (parent hydride name)			$\text{H}_2\text{PPH}_2$ , diphosphane
$\text{P}_2\text{O}_6$			$\text{O}_3\text{PPO}_3^{3-}$ , bis(trioxidophosphate)( $P-P$ )( $4-$ ); hypodiphosphate	$\text{O}_3\text{PPO}_3^{3-}$ , bis(trioxidophosphato)( $P-P$ )( $4-$ ); hypodiphosphato
$\text{P}_2\text{O}_7$			$\text{O}_3\text{POPO}_3^{4-}$ , $\mu$ -oxido- bis(trioxidophosphate)( $4-$ ); diphosphate	$\text{O}_3\text{POPO}_3^{4-}$ , $\mu$ -oxido- bis(trioxidophosphato)( $4-$ ); diphosphato

Table IX Continued

Formula for uncharged atom or group	Name			
	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
P <sub>2</sub> O <sub>8</sub>			O <sub>3</sub> POOPO <sub>3</sub> <sup>4-</sup> , μ-peroxido-1κO,2κO'- bis(trioxidophosphate)(4-); peroxydiphosphate	O <sub>3</sub> POOPO <sub>3</sub> <sup>4-</sup> , μ-peroxido-1κO,2κO'- bis(trioxidophosphate)(4-); peroxydiphosphate
P <sub>4</sub>	P <sub>4</sub> , tetraphosphorus			P <sub>4</sub> , tetraphosphorus
Pa	protactinium	protactinium	protactinide	protactinido
Pb	lead	lead (general) Pb <sup>2+</sup> , lead(2+) Pb <sup>4+</sup> , lead(4+)	plumbide	plumbido
PbH <sub>4</sub>	PbH <sub>4</sub> , plumbane (parent hydride name), tetrahydrido-lead, lead tetrahydride			
Pb <sub>9</sub>			Pb <sub>9</sub> <sup>4-</sup> , nonaplumbide(4-)	
Pd	palladium	palladium (general) Pd <sup>2+</sup> , palladium(2+) Pd <sup>4+</sup> , palladium(4+)	palladiide	palladiido
Pm	promethium	promethium	promethide	promethido
Po	polonium	polonium	polonide	polonido
PoH <sub>2</sub> , see H <sub>2</sub> Po				
Pr	praseodymium	praseodymium	praseodymide	praseodymido
Pt	platinum	platinum (general) Pt <sup>2+</sup> , platinum(2+) Pt <sup>4+</sup> , platinum(4+)	platinide	platinido

Pu	plutonium	plutonium	plutonide	plutonido
PuO <sub>2</sub>	PuO <sub>2</sub> , plutonium dioxide	PuO <sub>2</sub> <sup>+</sup> , dioxidoplutonium(1+) [not plutonyl(1+)] PuO <sub>2</sub> <sup>2+</sup> , dioxidoplutonium(2+) [not plutonyl(2+)]		
Ra	radium	radium	radide	radio
Rb	rubidium	rubidium	rubidide	rubidido
Re	rhénium	rhénium	rhénide	rhénido
ReO <sub>4</sub>			ReO <sub>4</sub> <sup>-</sup> , tetraoxidorhenate(1-) ReO <sub>4</sub> <sup>2-</sup> , tetraoxidorhenate(2-)	ReO <sub>4</sub> <sup>-</sup> , tetraoxidorhenato(1-) ReO <sub>4</sub> <sup>2-</sup> , tetraoxidorhenato(2-)
Rf	rutherfordium	rutherfordium	rutherfordide	rutherfordido
Rg	roentgenium	roentgenium	roentgenide	roentgenido
Rh	rhodium	rhodium	rhodide	rhodido
Rn	radon	radon	radonide	radonido
Ru	ruthénium	ruthénium	ruthénide	ruthénido
S	sulfur (general) S, monosulfur =S, sulfanylidene; thioxo -S-, sulfanedyl	sulfur (general) S <sup>+</sup> , sulfur(1+)	sulfide (general) S <sup>•-</sup> , sulfamidyl, sulfide(•1-) S <sup>2-</sup> , sulfanedide, sulfide(2-); sulfide -S-, sulfido	sulfido (general) S <sup>•-</sup> , sulfamidyl, sulfido(•1-) S <sup>2-</sup> , sulfanedido, sulfido(2-)
SCN, see CNS				
SH, see HS				
SH <sub>2</sub> , see H <sub>2</sub> S				
SNC, see CNS				
SO	SO, sulfur mon(o)oxide [SO], oxidosulfur > SO, oxo-λ <sup>4</sup> -sulfanedyl; sulfinyl	SO <sup>•+</sup> , oxidosulfur(•1+) (not sulfinyl or thionyl)	SO <sup>•-</sup> , oxidosulfate(•1-)	[SO], oxidosulfur
SO <sub>2</sub>	SO <sub>2</sub> , sulfur dioxide [SO <sub>2</sub> ], dioxidosulfur >SO <sub>2</sub> , dioxo-λ <sup>6</sup> -sulfanedyl; sulfonyl, sulfonyl		SO <sub>2</sub> <sup>•-</sup> , dioxidosulfate(•1-) SO <sub>2</sub> <sup>2-</sup> , dioxidosulfate(2-), sulfanediolate	[SO <sub>2</sub> ], dioxidosulfur SO <sub>2</sub> <sup>2-</sup> , dioxidosulfato(2-), sulfanediolato

Table IX Continued

Name				
Formula for uncharged atom or group	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
SO <sub>3</sub>	SO <sub>3</sub> , sulfur trioxide		SO <sub>3</sub> <sup>•-</sup> , trioxidosulfate(•1-) SO <sub>3</sub> <sup>2-</sup> , trioxidosulfate(2-); sulfite -S(O) <sub>2</sub> (O <sup>-</sup> ), oxidodioxo-λ <sup>6</sup> -sulfanyl; sulfonato	SO <sub>3</sub> <sup>2-</sup> , trioxidosulfato(2-); sulfito
SO <sub>4</sub>	-OS(O) <sub>2</sub> O <sup>-</sup> , sulfonylbis(oxy)		SO <sub>4</sub> <sup>•-</sup> , tetraoxidosulfate(•1-) SO <sub>4</sub> <sup>2-</sup> , tetraoxidosulfate(2-); sulfate	SO <sub>4</sub> <sup>2-</sup> , tetraoxidosulfato(2-); sulfato
SO <sub>5</sub>			SO <sub>5</sub> <sup>•-</sup> = SO <sub>3</sub> (OO) <sup>•-</sup> , trioxidoperoxidosulfate(•1-) SO <sub>5</sub> <sup>2-</sup> = SO <sub>3</sub> (OO) <sup>2-</sup> , trioxidoperoxidosulfate(2-); peroxysulfate, sulfuroperoxoate	SO <sub>5</sub> <sup>2-</sup> = SO <sub>3</sub> (OO) <sup>2-</sup> , trioxidoperoxidosulfato(2-); peroxysulfato, sulfuroperoxoato
S <sub>2</sub>	S <sub>2</sub> , disulfur -SS-, disulfanediyl >S=S, sulfanylidene-λ <sup>4</sup> -sulfanediyl; sulfinothioyl	S <sub>2</sub> <sup>•+</sup> , disulfur(•1+)	S <sub>2</sub> <sup>•-</sup> , disulfanidylyl, disulfide(•1-) S <sub>2</sub> <sup>2-</sup> , disulfide(2-), disulfanediide -SS-, disulfanidylyl	S <sub>2</sub> <sup>2-</sup> , disulfido(2-), disulfanediido
S <sub>2</sub> O	>S(=O)(=S), oxosulfanylidene-λ <sup>6</sup> -sulfanediyl; sulfonothioyl			

$S_2O_2$			$S_2O_2^{2-} = OSSO_2^{2-}$ , disulfanediolate, bis(oxidosulfate)( $S-S$ )(2-) $S_2O_2^{2-} = SOOS^{2-}$ , dioxidanedithiolate, peroxybis(sulfanide), bis(sulfidoxygenate)( $O-O$ )(2-) $S_2O_2^{2-} = SO_2S^{2-}$ , dioxido-1 $\kappa^2O$ -disulfate( $S-S$ )(2-), dioxidosulfidosulfate(2-); thiosulfite, sulfurothioite	$S_2O_2^{2-} = OSSO_2^{2-}$ , disulfanediolate, bis(oxidosulfate)( $S-S$ )(2-) $S_2O_2^{2-} = SOOS^{2-}$ , dioxidanedithiolate, peroxybis(sulfanide), bis(sulfidoxygenate)( $O-O$ )(2-) $S_2O_2^{2-} = SO_2S^{2-}$ , dioxido-1 $\kappa^2O$ -disulfate( $S-S$ )(2-), dioxidosulfidosulfate(2-); thiosulfite, sulfurothioite
$S_2O_3$			$S_2O_3^{\bullet-} = SO_3S^{\bullet-}$ , trioxido-1 $\kappa^3O$ -disulfate( $S-S$ )(•1-), trioxidosulfidosulfate(•1-) $S_2O_3^{2-} = SO_3S^{2-}$ , trioxido-1 $\kappa^3O$ -disulfate( $S-S$ )(2-), trioxidosulfidosulfate(2-); thiosulfate, sulfurothioate	$S_2O_3^{2-} = SO_3S^{2-}$ , trioxido-1 $\kappa^3O$ -disulfate( $S-S$ )(2-), trioxidosulfidosulfate(2-); thiosulfate, sulfurothioate
$S_2O_4$			$S_2O_4^{2-} = O_2SSO_2^{2-}$ , bis(dioxidosulfate)( $S-S$ )(2-); dithionite	$S_2O_4^{2-} = O_2SSO_2^{2-}$ , bis(dioxidosulfate)( $S-S$ )(2-); dithionite
$S_2O_5$			$S_2O_5^{2-} = O_3SSO_2^{2-}$ , pentaoxido- 1 $\kappa^3O, 2\kappa^2O$ -disulfate( $S-S$ )(2-) $S_2O_5^{2-} = O_2SOSO_2^{2-}$ , $\mu$ -oxido-bis(dioxidosulfate)(2-) $S_2O_6^{2-} = O_3SSO_3^{2-}$ , bis(trioxidosulfate)( $S-S$ )(2-); dithionate	$S_2O_5^{2-} = O_3SSO_2^{2-}$ , pentaoxido- 1 $\kappa^3O, 2\kappa^2O$ -disulfate( $S-S$ )(2-) $S_2O_5^{2-} = O_2SOSO_2^{2-}$ , $\mu$ -oxido-bis(dioxidosulfate)(2-) $S_2O_6^{2-} = O_3SSO_3^{2-}$ , bis(trioxidosulfate)( $S-S$ )(2-); dithionate
$S_2O_6$				
$S_2O_7$			$S_2O_7^{2-} = O_3SOSO_3^{2-}$ , $\mu$ -oxido-bis(trioxidosulfate)(2-); disulfate	$S_2O_7^{2-} = O_3SOSO_3^{2-}$ , $\mu$ -oxido-bis(trioxidosulfate)(2-); disulfate



Table IX Continued

Name				
Formula for uncharged atom or group	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
$S_2O_8$			$S_2O_8^{2-} = O_3SOOSO_3^{2-}$ , $\mu$ -peroxido-1κO,2κO'-bis(trioxidosulfate)(2-); peroxydisulfate	$S_2O_8^{2-} = O_3SOOSO_3^{2-}$ , $\mu$ -peroxido-1κO,2κO'-bis(trioxidosulfate)(2-); peroxydisulfate
$S_3$	$S_3$ , trisulfur -SSS-, trisulfanediyl >S(=S) <sub>2</sub> , bis(sulfanylidene)-λ <sup>6</sup> -sulfanediyl; sulfonodithioyl, dithiosulfonyl	$S_3^{2+}$ , trisulfur(2+)	$S_3^{\bullet-}$ , trisulfide(•1-) SSS <sup>•-</sup> , trisulfanediyl $S_3^{2-}$ , trisulfide(2-) SSS <sup>2-</sup> , trisulfanediide	$S_3^{\bullet-}$ , trisulfido(•1-) SSS <sup>•-</sup> , trisulfanediyl $S_3^{2-}$ , trisulfido(2-) SSS <sup>2-</sup> , trisulfanediido
$S_4$	$S_4$ , tetrasulfur -SSSS-, tetrasulfanediyl	$S_4^{2+}$ , tetrasulfur(2+)	$S_4^{2-}$ , tetrasulfide(2-) SSSS <sup>2-</sup> , tetrasulfanediide	$S_4^{2-}$ , tetrasulfido(2-) SSSS <sup>2-</sup> , tetrasulfanediido
$S_4O_6$			$S_4O_6^{2-} = O_3SSSO_3^{2-}$ , disulfanedisulfonate, bis[(trioxidosulfato)sulfate]⊖ (S-S)(2-); tetrathionate $S_4O_6^{\bullet 3-} = O_3SSSO_3^{\bullet 3-}$ , bis[(trioxidosulfato)sulfate]⊖ (S-S)(•3-)	$S_4O_6^{2-} = O_3SSSO_3^{2-}$ , disulfanedisulfonate, bis[(trioxidosulfato)sulfate]⊖ (S-S)(2-); tetrathionate $S_4O_6^{\bullet 3-} = O_3SSSO_3^{\bullet 3-}$ , bis[(trioxidosulfato)sulfate]⊖ (S-S)(•3-)
$S_5$	$S_5$ , pentasulfur		$S_5^{2-}$ , pentasulfide(2-) SSSSS <sup>2-</sup> , pentasulfanediide	$S_5^{2-}$ , pentasulfido(2-) SSSSS <sup>2-</sup> , pentasulfanediido
$S_8$	$S_8$ , octasulfur	$S_8^{2+}$ , octasulfur(2+)	$S_8^{2-}$ , octasulfide(2-) S[S] <sub>6</sub> S <sup>2-</sup> , octasulfanediide	$S_8$ , octasulfur $S_8^{2-}$ , octasulfido(2-) S[S] <sub>6</sub> S <sup>2-</sup> , octasulfanediido

Sb	antimony >Sb-, stibanetriyl	antimony	antimonide (general) Sb <sup>3-</sup> , antimonide(3-), stibanetriide; antimonide	antimonido (general) Sb <sup>3-</sup> , antimonido, stibanetriido
SbH	SbH <sup>•</sup> , stibanylidene, hydridoantimony(2•) >SbH, stibanediyl =SbH, stibanylidene	SbH <sup>2+</sup> , stibanebis(ylum), hydridoantimony(2+)	SbH <sup>2-</sup> , stibanediide, hydridoantimonate(2-)	SbH <sup>2-</sup> , stibanediido, hydridoantimonato(2-)
SbH <sub>2</sub>	SbH <sub>2</sub> <sup>•</sup> , stibanyl, dihydridoantimony(•) -SbH <sub>2</sub> , stibanyl	SbH <sub>2</sub> <sup>+</sup> , stibanylium, dihydridoantimony(1+)	SbH <sub>2</sub> <sup>-</sup> , stibanide, dihydridoantimonate(1-)	SbH <sub>2</sub> <sup>-</sup> , stibanido, dihydridoantimonato(1-)
SbH <sub>3</sub>	SbH <sub>3</sub> , antimony trihydride [SbH <sub>3</sub> ], stibane (parent hydride name), trihydridoantimony -SbH <sub>4</sub> , λ <sup>5</sup> -stibanyl	SbH <sub>3</sub> <sup>•+</sup> , stibaniumyl, trihydridoantimony(•1+) -SbH <sub>3</sub> <sup>+</sup> , stibaniumyl	SbH <sub>3</sub> <sup>•-</sup> , stibanuidyl, trihydridoantimonate(•1-) <sup>e</sup>	SbH <sub>3</sub> , stibane
SbH <sub>4</sub>		SbH <sub>4</sub> <sup>+</sup> , stibanium, tetrahydridoantimony(1+)		
SbH <sub>5</sub>	SbH <sub>5</sub> , antimony pentahydride [SbH <sub>5</sub> ], λ <sup>5</sup> -stibane (parent hydride name), pentahydridoantimony			
Sc	scandium	scandium	scandide	scandido
Se	Se (general) Se, monoselenium >Se, selanediyl =Se, selanylidene; selenoxo	selenium	selenide (general) Se <sup>•-</sup> , selanidyl, selenide(•1-) Se <sup>2-</sup> , selanediide, selenide(2-); selenide	selenido (general) Se <sup>•-</sup> , selanidyl, selenido(•1-) Se <sup>2-</sup> , selanediido, selenido(2-)
SeCN, see CNSe				
SeH, see HSe				
SeH <sub>2</sub> , see H <sub>2</sub> Se				
SeO	SeO, selenium mon(o)oxide [SeO], oxidoselenium > SeO, seleninyl			[SeO], oxidoselenium

Table IX Continued

Name				
Formula for uncharged atom or group	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
SeO <sub>2</sub>	SeO <sub>2</sub> , selenium dioxide [SeO <sub>2</sub> ], dioxidoselenium >SeO <sub>2</sub> , selenonyl		SeO <sub>2</sub> <sup>2-</sup> , dioxidoselenate(2-)	[SeO <sub>2</sub> ], dioxidoselenium SeO <sub>2</sub> <sup>2-</sup> , dioxidoselenato(2-)
SeO <sub>3</sub>	SeO <sub>3</sub> , selenium trioxide		SeO <sub>3</sub> <sup>•-</sup> , trioxidoselenate(•1-) SeO <sub>3</sub> <sup>2-</sup> , trioxidoselenate(2-); selenite	SeO <sub>3</sub> <sup>2-</sup> , trioxidoselenato(2-); selenito
SeO <sub>4</sub>			SeO <sub>4</sub> <sup>2-</sup> , tetraoxidoselenate(2-); selenate	SeO <sub>4</sub> <sup>2-</sup> , tetraoxidoselenato(2-); selenato
Sg	seaborgium	seaborgium	seaborgide	seaborgido
Si	silicon >Si<, silanetetrayl =Si=, silanediylidene	silicon (general) Si <sup>+</sup> , silicon(•1+) Si <sup>4+</sup> , silicon(4+)	silicide (general) Si <sup>-</sup> , silicide(•1-) Si <sup>4-</sup> , silicide(4-); silicide	silicido (general) Si <sup>-</sup> , silicido(•1-) Si <sup>4-</sup> , silicido(4-); silicido
SiC	SiC, silicon carbide [SiC], carbidosilicon	SiC <sup>+</sup> , carbidosilicon(1+)		
SiH		SiH <sup>+</sup> , silanyliumdiyl, hydridosilicon(1+)	SiH <sup>-</sup> , silanediyl, hydridosilicate(1-)	
SiH <sub>2</sub>	SiH <sub>2</sub> <sup>2•</sup> , silylidene, dihydridosilicon(2•) >SiH <sub>2</sub> , silanediyl =SiH <sub>2</sub> , silylidene			
SiH <sub>3</sub>	SiH <sub>3</sub> <sup>•</sup> , silyl, trihydridosilicon(•) -SiH <sub>3</sub> , silyl	SiH <sub>3</sub> <sup>+</sup> , silylium, trihydridosilicon(1+)	SiH <sub>3</sub> <sup>-</sup> , silanide, trihydridosilicate(1-)	SiH <sub>3</sub> <sup>-</sup> , silanido

SiH <sub>4</sub>	SiH <sub>4</sub> , silicon tetrahydride [SiH <sub>4</sub> ], silane (parent hydride name), tetrahydrosilicon			
SiO	SiO, oxidosilicon, silicon mon(o)oxide	SiO <sup>+</sup> , oxidosilicon(1+)		
SiO <sub>2</sub>	SiO <sub>2</sub> , silicon dioxide			
SiO <sub>3</sub>			SiO <sub>3</sub> <sup>•-</sup> , trioxidosilicate(•1-) (SiO <sub>3</sub> <sup>2-</sup> ) <sub>n</sub> = 4Si(O <sub>2</sub> O <sub>2</sub> ) <sub>n</sub> <sup>2n-</sup> , <i>catena</i> -poly[(dioxidosilicate- μ-oxido)(1-)]; metasilicate	SiO <sub>3</sub> <sup>•-</sup> , trioxidosilicato(•1-)
SiO <sub>4</sub>			SiO <sub>4</sub> <sup>4-</sup> , tetraoxidosilicate(4-); silicate	SiO <sub>4</sub> <sup>4-</sup> , tetraoxidosilicato(4-); silicato
Si <sub>2</sub>	Si <sub>2</sub> , disilicon	Si <sub>2</sub> <sup>+</sup> , disilicon(1+)	Si <sub>2</sub> <sup>-</sup> , disilicide(1-)	
Si <sub>2</sub> H <sub>4</sub>	>SiHSiH <sub>3</sub> , disilane-1,1-diyl -SiH <sub>2</sub> SiH <sub>2</sub> <sup>-</sup> , disilane-1,2-diyl = SiHSiH <sub>3</sub> , disilanylidene			
Si <sub>2</sub> H <sub>5</sub>	Si <sub>2</sub> H <sub>5</sub> <sup>•</sup> , disilanyl, pentahydridosilicon(Si—Si)(•) -Si <sub>2</sub> H <sub>5</sub> , disilanyl	Si <sub>2</sub> H <sub>5</sub> <sup>+</sup> , disilanylium	Si <sub>2</sub> H <sub>5</sub> <sup>-</sup> , disilanide	Si <sub>2</sub> H <sub>5</sub> <sup>-</sup> , disilanido
Si <sub>2</sub> H <sub>6</sub>	Si <sub>2</sub> H <sub>6</sub> , disilane (parent hydride name)			Si <sub>2</sub> H <sub>6</sub> , disilane
Si <sub>2</sub> O <sub>7</sub>			Si <sub>2</sub> O <sub>7</sub> <sup>6-</sup> , μ-oxido-bis(trioxidosilicate)(6-); disilicate	Si <sub>2</sub> O <sub>7</sub> <sup>6-</sup> , μ-oxido-bis(trioxidosilicato)(6-); disilicato
Si <sub>4</sub>			Si <sub>4</sub> <sup>4-</sup> , tetrasilicide(4-)	
Sm	samarium	samarium	samaride	samarido
Sn	tin	tin (general) Sn <sup>2+</sup> , tin(2+) Sn <sup>4+</sup> , tin(4+)	stannide	stannido
SnCl <sub>3</sub>			SnCl <sub>3</sub> <sup>-</sup> , trichloridostannate(1-)	SnCl <sub>3</sub> <sup>-</sup> , trichloridostannato(1-)
SnH <sub>4</sub>	SnH <sub>4</sub> , tin tetrahydride [SnH <sub>4</sub> ], stannane (parent hydride name), tetrahydridotin			

Table IX Continued

Name				
Formula for uncharged atom or group	Uncharged atoms or molecules (including zwitterions and radicals) or substituent groups <sup>a</sup>	Cations (including cation radicals) or cationic substituent groups <sup>a</sup>	Anions (including anion radicals) or anionic substituent groups <sup>b</sup>	Ligands <sup>c</sup>
Sn <sub>5</sub>			Sn <sub>5</sub> <sup>2-</sup> , pentastannide(2-)	Sn <sub>5</sub> <sup>2-</sup> , pentastannido(2-)
Sr	strontium	strontium	strontide	strontido
T, see H				
T <sub>2</sub> , see H <sub>2</sub>				
T <sub>2</sub> O, see H <sub>2</sub> O				
Ta	tantalum	tantalum	tantalide	tantalido
Tb	terbium	terbium	terbide	terbido
Tc	technetium	technetium	technetide	technetido
TcO <sub>4</sub>			TcO <sub>4</sub> <sup>-</sup> , tetraoxido technetate(1-) TcO <sub>4</sub> <sup>2-</sup> , tetraoxido technetate(2-)	TcO <sub>4</sub> <sup>-</sup> , tetraoxido technetato(1-) TcO <sub>4</sub> <sup>2-</sup> , tetraoxido technetato(2-)
Te	tellurium >Te, tellanediyl =Te, tellanylidene; telluroxo	tellurium	telluride (general) Te <sup>•-</sup> , tellanidylyl, telluride(•1-) Te <sup>2-</sup> , tellanediide, telluride(2-); telluride	tellurido (general) Te <sup>•-</sup> , tellanidylyl, tellurido(•1-) Te <sup>2-</sup> , tellanediido, tellurido(2-)
TeH, see HTe				
TeH <sub>2</sub> , see H <sub>2</sub> Te				
TeO <sub>3</sub>			TeO <sub>3</sub> <sup>•-</sup> , trioxido tellurate(•1-) TeO <sub>3</sub> <sup>2-</sup> , trioxido tellurate(2-)	TeO <sub>3</sub> <sup>•-</sup> , trioxido tellurato(•1-) TeO <sub>3</sub> <sup>2-</sup> , trioxido tellurato(2-)
TeO <sub>4</sub>			TeO <sub>4</sub> <sup>2-</sup> , tetraoxido tellurate(2-); tellurate	TeO <sub>4</sub> <sup>2-</sup> , tetraoxido tellurato(2-); tellurato
TeO <sub>6</sub>			TeO <sub>6</sub> <sup>6-</sup> , hexaoxido tellurate(6-); orthotellurate	TeO <sub>6</sub> <sup>6-</sup> , hexaoxido tellurato(6-); orthotellurato
Th	thorium	thorium	thoride	thorido

Ti	titanium	titanium	titanide	titanido
TiO	TiO, titanium(II) oxide	TiO <sup>2+</sup> , oxidotitanium(2+)		
Tl	thallium	thallium	thallide	thallido
TlH <sub>2</sub>	-TlH <sub>2</sub> , thallanyl			
TlH <sub>3</sub>	TlH <sub>3</sub> , thallium trihydride [TlH <sub>3</sub> ], thallane (parent hydride name), trihydridothallium			
Tm	thulium	thulium	thulide	thulido
U	uranium	uranium	uranide	uranido
UO <sub>2</sub>	UO <sub>2</sub> , uranium dioxide	UO <sub>2</sub> <sup>+</sup> , dioxidouranium(1+) [ <i>not</i> uranyl(1+)] UO <sub>2</sub> <sup>2+</sup> , dioxidouranium(2+) [ <i>not</i> uranyl(2+)]		
V	vanadium	vanadium	vanadide	vanadido
VO	VO, vanadium(II) oxide, vanadium mon(o)oxide	VO <sup>2+</sup> , oxidovanadium(2+) ( <i>not</i> vanadyl)		
VO <sub>2</sub>	VO <sub>2</sub> , vanadium(IV) oxide, vanadium dioxide	VO <sub>2</sub> <sup>+</sup> , dioxidovanadium(1+)		
W	tungsten	tungsten	tungstide	tungstido
Xe	xenon	xenon	xenonide	xenonido
Y	yttrium	yttrium	yttride	yttrido
Yb	ytterbium	ytterbium	ytterbide	ytterbido
Zn	zinc	zinc	zincide	zincido
Zr	zirconium	zirconium	zirconide	zirconido
ZrO	ZrO, zirconium(II) oxide	ZrO <sup>2+</sup> , oxidozirconium(2+)		

<sup>a</sup> Where an element symbol occurs in the first column, the unmodified element name is listed in the second and third columns. The unmodified name is generally used when the element appears as an electropositive constituent in the construction of a stoichiometric name (Sections IR-5.2 and IR-5.4). Names of homoatomic cations consisting of the element are also constructed using the element name, adding multiplicative prefixes and charge numbers as applicable (Sections IR-5.3.2.1 to IR-5.3.2.3). In selected cases, examples are given in the Table of specific cation names, such as gold(1+), gold(3+); mercury(2+), dimercury(2+). In such cases, the unmodified element name appears with the qualifier '(general)'.

- <sup>b</sup> Where an element symbol occurs in the first column, the fourth column gives the element name appropriately modified with the ending 'ide' (argentide, americide, ferride, etc.). The 'ide' form of the element name is generally used when the element appears as an electronegative constituent in the construction of a stoichiometric name (Sections IR-5.2 and IR-5.4). Names of homoatomic anions consisting of the element in question are also constructed using this modified form, adding multiplicative prefixes and charge numbers as applicable (Sections IR-5.3.3.1 to IR-5.3.3.3). Examples are given in the Table of names of some specific anions, e.g. arsenide(3-), chloride(1-), oxide(2-), dioxide(2-). In certain cases, a particular anion has the 'ide' form itself as an accepted short name, e.g. arsenide, chloride, oxide. If specific anions are named, the 'ide' form of the element name with no further modification is given as the first entry in the fourth column, with the qualifier '(general)'.
- <sup>c</sup> Ligand names must be placed within enclosing marks whenever necessary to avoid ambiguity, cf. Section IR-9.2.2.3. Some ligand names must always be enclosed. For example, if 'dioxido' is cited as it must be enclosed so as to distinguish it from two 'oxido' ligands; if combined with a multiplicative prefix it must be enclosed because it starts with a multiplicative prefix itself. A ligand name such as 'nitridocarbonato' must always be enclosed to avoid interpreting it as two separate ligand names, 'nitrido' and 'carbonato'. In this table, however, these enclosing marks are omitted for the sake of clarity. Note that the ligand names given here with a charge number can generally also be used without if it is not desired to make any implication regarding the charge of the ligand. For example, the ligand name '[dioxido(•1-)]' may be used if one wishes explicitly to consider the ligand to be the species dioxido(•1-), whereas the ligand name '(dioxido)' can be used if no such implications are desirable.
- <sup>d</sup> The ending 'ide' in 'actinide' and 'lanthanide' indicates a negative ion. Therefore, 'actinoid' should be used as the collective name for the elements Ac, Th, Pa, U, Np, Pu, Am, Cm, Bk, Cf, Es, Fm, Md, No, Lr, and 'lanthanoid' as a collective name for the elements La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu (cf. Section IR-3.5).
- <sup>e</sup> The radical names in the present recommendations sometimes differ from those given in "Names for Inorganic Radicals", W.H. Koppenol, *Pure Appl. Chem.*, **72**, 437-446 (2000). Firstly, the exceptional status of anion radicals consisting of hydrogen and only one other element has been lifted. For example, the coordination-type additive name of  $\text{BH}_3^{\bullet-}$  is 'trihydroborate(•1-)' (not 'boride'). Secondly, concatenation of ligand names, such as in 'hydridodioxido' (meaning the ligand 'dioxidanido'), which is otherwise never used in additive nomenclature, is not recommended here. Thirdly, additive names of dinuclear compounds are based here on selecting the most centrally placed atoms in the molecule as central atoms (see the general principles described in Section IR-7.1.2), e.g.  $\text{NCSSCN}^{\bullet-}$  is named here 'bis[cyanidosulfur](S-S)(•1-)' rather than 'bis(nitridosulfidocarbonato)(S-S)(•1-)'.
- <sup>f</sup> Due to the strict adherence in these recommendations to the element sequence in Table VI, the order of oxygen and the elements chlorine, bromine and iodine, respectively, has been reversed relative to traditional names. This applies to binary stoichiometric names such as dioxigen chloride (cf. Section IR-5.2) and to additive names for the hypohalites, where the rules for selecting central atoms (Section IR-7.1.2) dictate the selection of oxygen rather than the halide. However, because of the additive names for the last three members of the series  $\text{OX}^-$ ,  $\text{XO}_2^-$ ,  $\text{XO}_3^-$ ,  $\text{XO}_4^-$  ( $\text{X} = \text{Cl}, \text{Br}, \text{I}$ ), namely dioxidohalogenate(1-), trioxidohalogenate(1-) and tetraoxidohalogenate(1-) (the halogen is chosen as the central atom because it has the central position in the structure), the additive names oxidochlorate(1-), oxidobromate(1-) and oxidoiodate(1-) are acceptable alternatives to the systematic 'oxygenate' names. Similar remarks apply to  $\text{HOCl}$ ,  $\text{HOCl}^{\bullet-}$ , etc.

**Table X** Anion names, 'a' terms used in substitutive nomenclature and 'y' terms used in chains and rings nomenclature

<i>Element name</i>	<i>Anion name<sup>a</sup></i>	<i>'a' term</i>	<i>'y' term</i>
actinium	actinate	actina	actiny
aluminium	aluminate	alumina	aluminy
americium	americite	america	americy
antimony	antimonate	stiba <sup>b</sup>	stiby <sup>b</sup>
argon	argonate	argona	argony
arsenic	arsenate	arsa	arsy
astatine	astatate	astata	astaty
barium	barate	bara	bary
berkelium	berkelate	berkela	berkely
beryllium	beryllate	berylla	beryllly
bismuth	bismuthate	bisma	bismy
bohrium	bohrate	bohra	bohry
boron	borate	bora	bory
bromine	bromate	broma	bromy
cadmium	cadmate	cadma	cadmy
caesium	caesate	caesa	caesy
calcium	calcate	calca	calcy
californium	californate	california	californy
carbon	carbonate	carba	carby
cerium	cerate	cera	cery
chlorine	chlorate	chlora	chlory
chromium	chromate	chroma	chromy
cobalt	cobaltate	cobalta	cobalty
copper	cuprate <sup>c</sup>	cupra <sup>c</sup>	cupry <sup>c</sup>
curium	curate	cura	cury
darmstadtium	darmstadtate	darmstadta	darmstadty
deuterium	deuterate	deutera	deutery
dubnium	dubnate	dubna	dubny
dysprosium	dysprosate	dysprosa	dysprosy
einsteinium	einsteinate	einsteina	einsteinly
erbium	erbate	erba	erby
europium	europate	europa	europy
fermium	fermate	ferma	fermy
fluorine	fluorate	fluora	fluory
francium	francate	franca	francy
gadolinium	gadolate	gadolina	gadolinly
gallium	gallate	galla	gally
germanium	germanate	germa	germy
gold	aurate <sup>d</sup>	aura <sup>d</sup>	aury <sup>d</sup>
hafnium	hafnate	hafna	hafny
hassium	hassate	hassa	hassy
helium	helate	hela	hely
holmium	holmate	holma	holmy
hydrogen	hydrogenate	—	hydrony
indium	indate	inda	indy
iodine	iodate	ioda	iody
iridium	iridate	irida	iridy
iron	ferrate <sup>c</sup>	ferra <sup>c</sup>	ferry <sup>c</sup>
krypton	kryptonate	kryptona	kryptony
lanthanum	lanthanate	lanthana	lanthany
lawrencium	lawrencate	lawrenca	lawrenly



Table X Continued

<i>Element name</i>	<i>Anion name<sup>a</sup></i>	<i>'a' term</i>	<i>'y' term</i>
lead	plumbate <sup>f</sup>	plumba <sup>f</sup>	plumby <sup>f</sup>
lithium	lithate	litha	lithy
lutetium	lutetate	luteta	lutety
magnesium	magnesate	magnesia	magnesy
manganese	manganate	mangana	mangany
meitnerium	meitnerate	meitnera	meitnery
mendelevium	mendelevate	mendeleva	mendelevy
mercury	mercurate	mercura	mercury
molybdenum	molybdate	molybda	molybdy
neodymium	neodymate	neodyma	neodymy
neon	neonate	neona	neony
neptunium	neptunate	neptuna	neptuny
nickel	nickelate	nickela	nickely
niobium	niobate	nioba	nioby
nitrogen	nitrate	aza <sup>g</sup>	azy <sup>g</sup>
nobelium	nobelate	nobela	nobely
osmium	osmate	osma	osmy
oxygen	oxygenate	oxa	oxy
palladium	palladate	pallada	pallady
phosphorus	phosphate	phospha	phosphy
platinum	platinate	platina	platiny
plutonium	plutonate	plutona	plutony
polonium	polonate	polona	polony
potassium	potassate	potassa	potassy
praseodymium	praseodymate	praseodyma	praseodymy
promethium	promethate	prometha	promethy
protactinium	protactinate	protactina	protactiny
protium	protate	prota	proty
radium	radate	rada	rady
radon	radonate	radona	radony
rhenium	rhenate	rhena	rheny
rhodium	rhodate	rhoda	rhody
roentgenium	roentgenate	roentgena	roentgeny
rubidium	rubidate	rubida	rubidy
ruthenium	ruthenate	ruthena	rutheny
rutherfordium	rutherfordate	rutherforda	rutherfordy
samarium	samarate	samara	samary
scandium	scandate	scanda	scandy
seaborgium	seaborgate	seaborga	seaborgy
selenium	selenate	selena	seleny
silicon	silicate	sila	sily
silver	argentate <sup>h</sup>	argenta <sup>h</sup>	argenty <sup>h</sup>
sodium	sodate	soda	sody
strontium	strontate	stronta	stronty
sulfur	sulfate	thia <sup>i</sup>	sulfy
tantalum	tantalate	tantala	tantaly
technetium	technetate	techneta	technety
tellurium	tellurate	tellura	tellury
terbium	terbate	terba	terby
thallium	thallate	thalla	thally
thorium	thorate	thora	thory
thulium	thulate	thula	thuly

**Table X** *Continued*

<i>Element name</i>	<i>Anion name<sup>a</sup></i>	<i>'a' term</i>	<i>'y' term</i>
tin	stannate <sup>j</sup>	stanna <sup>j</sup>	stanny <sup>j</sup>
titanium	titanate	titana	titany
tritium	tritrate	trita	trity
tungsten	tungstate	tungsta	tungsty <sup>k</sup>
uranium	uranate	urana	urany
vanadium	vanadate	vanada	vanady
xenon	xenonate	xenona	xenony
ytterbium	ytterbate	ytterba	ytterby
yttrium	yttrate	yttra	yttry
zinc	zincate	zinca	zincy
zirconium	zirconate	zircona	zircony

<sup>a</sup> Modified element name used in additive names for heteroatomic anions containing the element as the central atom.

<sup>b</sup> From the name stibium.

<sup>c</sup> From the name cuprum.

<sup>d</sup> From the name aurum.

<sup>e</sup> From the name ferrum.

<sup>f</sup> From the name plumbum.

<sup>g</sup> From the name azote.

<sup>h</sup> From the name argentum.

<sup>i</sup> From the name theion.

<sup>j</sup> From the name stannum.

<sup>k</sup> 'Wolframy' was used in "Nomenclature of Inorganic Chains and Ring Compounds", E.O. Fluck and R.S. Laitinen, *Pure Appl. Chem.*, **69**, 1659–1692 (1997)" and in Chapter II-5 of *Nomenclature of Inorganic Chemistry II, IUPAC Recommendations 2000*, eds. J.A. McCleverty and N.G. Connelly, Royal Society of Chemistry, 2001.

# Subject Index

Element names, parent hydride names and systematic names derived using any of the nomenclature systems described in this book are, with very few exceptions, not included explicitly in this index. If a name or term is referred to in several places in the book, only the more informative references may be indexed.

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## H

$\eta$  (see Eta)

*H* designator

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