SECTION 13

NOMENCLATURE OF INORGANIC COMPOUNDS

In some ways the naming of inorganic compounds is quite different from those of organic compounds. This section introduces the common everyday names of well known inorganic compounds, and to the more formal systematic rules which have been developed.

**Inorganic compound**: Compounds of elements other than carbon, but including carbon oxides, carbonates.

The Greek and Latin prefixes given in section 6 also play an important role in inorganic nomenclature.

Definitive rules for naming inorganic compounds have been agreed on internationally, but as these can lead to rather clumsy names many common names for well known compounds remain in use.

Ionic compounds are called *salts* except where the anion is \( \text{O}^{2-} \) or \( \text{OH}^- \) in which case the compounds are called *oxides* and *hydroxides* respectively.

Some polyatomic ions have accepted non-systematic names: \( \text{NH}_4^+ \), ammonium; \( \text{H}_2\text{O}^+ \), oxonium (hydronium) (also often just called hydrogen ion in aqueous solutions); \( \text{OH}^- \), hydroxide; \( \text{NH}_2^- \), amide; \( \text{CN}^- \), cyanide.

In nomenclature, polyatomic ions or molecules are often considered to be made up of a positively charged species, (the charge being indicated by an oxidation number), surrounded by *ligands*, (neutral or negatively charged species), which each have a pair of electrons on the atom bonded (coordinated) to the central cation. The names for the two common neutral ligands, water and ammonia, are *-aqua*, \( \text{H}_2\text{O} \), and *-ammine*, \( \text{NH}_3 \), respectively. Negatively charged ligands have the ending *-o*. [e.g. \( \text{Cl}^- \), *chloro*; \( \text{OH}^- \), *hydroxo*; \( \text{O}^{2-} \), *oxo*; \( \text{CN}^- \), *cyano*]. (The International Union of Pure and Applied Chemistry is considering changing the ending of simple anion ligands such as chloride to –ido. The examples above would be *chlorido*, *hydroxido*, *oxido*, *cyanido*.)

A brief outline of the definitive rules and traditional naming is given below. The examples should clarify the rules.

**Systematic naming rules**

1. The cation has its name unmodified (e.g. the name of the element).
2. If the anion is monatomic its name is modified to end in -ide.
3. If the anion is polyatomic its name is modified to end in -ate.
4. When oxidation states are to be indicated they are shown by Roman numerals in brackets following the name of the element.
5. The number of atoms or ligands attached to the central atom is denoted by Greek prefixes.

**Examples:**
KBr is potassium bromide      rules 1,2
Ca(OH)$_2$ is calcium hydroxide      rule 1
NaClO$_3$ is sodium trioxochlorate(V)      rules 1,3,4,5
FeCl$_3$ is iron trichloride or iron(III) chloride      rules 1,2,4,5

Cu(NH$_3$)$_4$F$_2$ is tetraamminecopper(II) fluoride      rules 1,2,4,5
NH$_4$BF$_4$ is ammonium tetrafluoroborate(III)      rules 3,4,5

The traditional names for the third and fourth examples are sodium chlorate and chromic chloride respectively. The following points concern this more traditional method of naming:
(a) The endings -ous and -ic are used for cations of elements existing in only two oxidation states, -ous representing the lower state.
(b) The ending -ite is used to indicate the oxoanion of oxidation state lower than the common one which ends in -ate. An even lower one is hypo.....ite, and one higher than -ate is per.....ate.
(c) The Latin or Greek stem is used for elements whose symbols come from those languages.

Examples:
FeCl$_2$ is ferrous chloride          FeCl$_3$ is ferric chloride
SnCl$_2$ is stannous chloride        SnCl$_4$ is stannic chloride
KNO$_2$ is potassium nitrite         KNO$_3$ is potassium nitrate
Na$_2$SO$_3$ is sodium sulfite       Na$_2$SO$_4$ is sodium sulfate
NH$_4$ClO is ammonium hypochlorite   NH$_4$ClO$_2$ is ammonium chlorite
NH$_4$ClO$_3$ is ammonium chlorate   NH$_4$ClO$_4$ is ammonium perchlorate

Salts can be thought of as the product of a reaction between an acid and a base. Where the base is an oxide or a hydroxide water is also a product.
[e.g. HNO$_3$ + NH$_3$ → NH$_4$NO$_3$ (NH$_4^+$ and NO$_3^-$)  
   H$_2$SO$_4$ + CaO → CaSO$_4$ + H$_2$O (Ca$^{2+}$ and SO$_4^{2-}$)  
   H$_3$PO$_4$ + 2NaOH → Na$_2$HPO$_4$ + 2H$_2$O (Na$^+$ and HPO$_4^{2-}$) ]

The oxoacid corresponding to an -ate anion is called the -ic acid; to an -ite anion the -ous acid. HClO is hypochlorous acid; HClO$_2$ is chlorous acid; HClO$_3$ is chloric acid; HClO$_4$ is perchloric acid. (Per is also used in two other ways; as shorthand for the peroxo group, -O-O- and for organic compounds where all hydrogens attached to carbon have been replaced by a halogen [e.g. perfluoroethane C$_2$F$_6$]. Thus one must look at the context of the term to determine the meaning.) For salts of polyprotic acids in which the anions still have hydrogen atoms attached, the word hydrogen is written before the anion. Thus NaH$_2$PO$_4$ is sodium dihydrogenphosphate, Na$_2$HPO$_4$ is sodium hydrogenphosphate, and NaHCO$_3$ is sodium hydrogen carbonate. In the past the word hydrogen in salts of diprotic acids was often replaced by bi- [e.g. NaHCO$_3$ sodium bicarbonate], but it is no longer approved nomenclature.
Most of the covalent oxides are named according to the relative number of atoms of the element and oxygens [e.g. SO$_2$, sulfur dioxide; SO$_3$, sulfur trioxide; N$_2$O$_3$, dinitrogen trioxide]. Oxoacids may be thought of as coming from the hydrolysis of the oxide containing the element in the same oxidation state.

[e.g. $\text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3$ sulfur dioxide giving sulfurous acid

$\text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4$ sulfur trioxide giving sulfuric acid

$\text{N}_2\text{O}_3 + \text{H}_2\text{O} \rightarrow 2\text{HNO}_2$ dinitrogen trioxide giving nitrous acid ]

**Acid anhydride**: The product from removing water from an acid. (Anhydride, a substance formed by removing the elements of water from a compound.) [e.g. the oxides in the above three reactions with water.]

N$_2$O and NO, two well known oxides of nitrogen, have the common names nitrous oxide and nitric oxide respectively. However they are not the anhydrides of nitrous acid and nitric acid. This emphasises the point that language of chemistry has developed historically and, as in any language, there are pitfalls for the beginner.

**EXERCISES**

Deduce the common names for the following compounds from the names given for related compounds.

1. Cu$_2$SO$_4$  CuSO$_4$ is cupric sulfate
2. Fe$_2$(SO$_4$)$_3$  FeSO$_4$ is ferrous sulfate
3. H$_3$PO$_3$  H$_3$PO$_4$ is phosphoric acid
4. K$_2$MnO$_4$  KMnO$_4$ is potassium permanganate