UNIT 03: Inorganic Nomenclature

Nomenclature

Nomenclature is the language of chemistry, and a grasp of it is essential to studying the subject.

Symbols

Each element has a symbol displayed on the periodic table. Some elements have a symbol that is a single letter while others have a symbol made up of two letters. It is important when writing the two letter symbols to ensure that you use a lower case letter for the second letter. This may sound trivial but is very important, for example, Co (cobalt), a metal element, is not the same as CO (carbon monoxide), a gaseous compound made from carbon (C) and oxygen (O).

Binary compounds of metals and non-metals (ionic compounds)

Binary compounds are those formed between only two elements. In compounds where one is a metal and one a non-metal an *ionic* compound is formed. An ion is a charged particle and ionic formulae and names can be determined by considering the charge on the ions. To find the formula of an ionic compound the positive and negative charges must be balanced, i.e., there must be no net charge.

To name a binary compound of a metal and a non-metal, the unmodified name of the positive ion is written first followed by the root of the negative ion with the ending modified to -ide. For example, NaCl is sodium chloride.

A few common ions, their charges and formulae are listed below. You will need a more complete list, found here.

Negative ions (ANIONS)			Positive ions (CATIONS)		
Name	**Charge**	**Symbol**	**Name**	**Charge**	**Symbol**
Bromide	1-	Br^-	Aluminum	3+	Al^{3+}
Chloride	1-	Cl^-	Barium	2+	Ba^{2+}
Fluoride	1-	F^-	Calcium	2+	Ca^{2+}
Hydride	1-	H^-	Copper (I)	1+	Cu^+
Iodide	1-	I^-	Copper (II)	2+	Cu^{2+}
Nitride	3-	N^{3-}	Hydrogen	1+	H^+
Oxide	2-	O^{2-}	Iron (II)	2+	Fe^{2+}
Phosphide	3-	P^{3-}	Iron (III)	3+	Fe^{3+}
Sulfide	2-	S^{2-}	Lead (II)	2+	Pb^{2+}
			Lead (IV)	4+	Pb^{4+}
			Lithium	1+	Li^+
			Magnesium	2+	Mg^{2+}
			Manganese (II)	2+	Mn^{2+}
			Nickel (II)	2+	Ni^{2+}
			Potassium	1+	K^+
			Silver	1+	Ag^+
			Sodium	1+	Na^+
			Strontium	2+	Sr^{2+}
			Tin (II)	2+	Sn^{2+}
			Tin (IV)	4+	Sn^{4+}
			Zinc	2+	Zn^{2+}

Most transition metal ions (and a few other metal ions) include a Roman numeral after the name, for example, copper (II). These metals form ions with varying charges, and the Roman numeral identifies the charge in each case. Elements that commonly form an ion with only a single charge for example, sodium, do not have Roman numerals associated with them.

Task 03a

1. ***Name these binary compounds.***

   (a) NaCl
   (b) SrO
   (c) AlN
   (d) $BaCl_2$
   (e) K_2O
   (f) CuO
   (g) Cu_2O

2. ***Convert these names to formulae.***

   (a) Magnesium nitride
   (b) Barium bromide
   (c) Aluminum phosphide
   (d) Potassium iodide
   (e) Lithium chloride
   (f) Sodium fluoride
   (g) Tin (IV) bromide

Binary acids

Acids will be discussed at great length later in the course, but for the purposes of nomenclature, an acid can be defined as a compound that produces hydrogen ions (H^+) when it is dissolved in water, and the formulae of acids start with 'H'. *Binary acids* are formed when hydrogen ions combine with monatomic anions.

To name a binary acid use the prefix 'hydro' followed by the other non-metal name modified to an –ic ending. Then add the word 'acid'. For example, HCl is hydrochloric acid.

Polyatomic ions

Polyatomic ions are those where more than one element are combined together to create a species with a charge. Some of these ions can be named systematically, others names must be learned. Some common polyatomic ions, their charges and formulae are listed below. You will need a more complete list, found here.

Common Polyatomic ions

Name	Charge	Formula
Ammonium	1+	NH_4^+
Carbonate	2-	CO_3^{2-}
Chromate (VI)	2-	CrO_4^{2-}
Dichromate (VI)	2-	$Cr_2O_7^{2-}$
Ethanedioate	2-	$C_2O_4^{2-}$
Hydrogen carbonate	1-	HCO_3^-
Hydrogen sulfate	1-	HSO_4^-
Hydroxide	1-	OH^-
Manganate (VII) (permanganate)	1-	MnO_4^-
Nitrate	1-	NO_3^-
Nitrite	1-	NO_2^-
Phosphate	3-	PO_4^{3-}
Sulfate	2-	SO_4^{2-}
Sulfite	2-	SO_3^{2-}

Polyatomic anions where oxygen is combined with another non-metal are called oxoanions and can be named systematically. In these oxoanions certain non-metals (Cl, N, P and S) form a series of oxoanions containing different numbers of oxygen atoms. Their names are related to the number of oxygen atoms present, and are based upon the system below.

Name	Number of oxygen atoms
Hypo*(element)*ite	▼
*(element)*ite	Increase in number of oxygen atoms
*(element)*ate	
Per*(element)*ate	▼

Where there are only two members in such a series the endings are –ite and –ate. For example, sulfite (SO_3^{2-}) and sulfate (SO_4^{2-}). When there are four members in the series the hypo- and per- prefixes are used additionally.

Some oxoanions contain hydrogen and are named accordingly, for example, HPO_4^{2-}, hydrogen phosphate. The prefix thio- means that a sulfur atom has replaced an atom of oxygen in an anion.

To name an ionic compound that contains a polyatomic ion, the unmodified name of the positive ion is written first followed by unmodified name of the negative ion. For example, K_2CO_3 is potassium carbonate.

Oxoacids

Oxoacids are formed when hydrogen ions combine with polyatomic oxoanions. This gives a combination of hydrogen, oxygen and another non-metal.

To name an oxoacid use the name of the oxoanion and replace the -ite ending with –ous or the -ate ending with -ic. Then add the word 'acid'. For example, H_2SO_4 is sulfuric acid.

To illustrate the names of these oxoanions and oxoacids consider the following example using chlorine as the non-metal.

Formula and name of oxoacid		Formula and name of corresponding oxoanion	
HClO	Hypochlorous acid	ClO^-	Hypochlorite
$HClO_2$	Chlorous acid	ClO_2^-	Chlorite
$HClO_3$	Chloric acid	ClO_3^-	Chlorate
$HClO_4$	Perchloric acid	ClO_4^-	Perchlorate

Task 03b

1. ***What are the formulae for the following ionic compounds?***

   (a) Ammonium nitrate
   (b) Copper (II) bromide
   (c) Copper (I) bromide
   (d) Zinc hydrogen sulfate
   (e) Aluminum sulfate
   (f) Sodium perchlorate
   (g) Copper (II) iodite

2. ***Convert the following formulae to names.***

   (a) $NaNO_3$
   (b) $KMnO_4$
   (c) CaC_2O_4
   (d) $CuSO_4$
   (e) Cu_2SO_4
   (f) KNO_2
   (g) $LiClO_4$

Binary compounds of two non-metals (molecular compounds)

If the two elements in a binary compound are non-metals, then the compound is *molecular*.

To name a molecular compound of two non-metals, the unmodified name of the first element is followed by the root of the second element with ending modified to -ide. In order to distinguish between several different compounds with the same elements present use the prefixes mono, di, tri, tetra, penta and hexa to represent one, two, three, four, five and six atoms of the element respectively. For example, SO_2 is sulfur dioxide.

Some other examples are given below.

Formula	Name
BCl_3	Boron trichloride
CCl_4	Carbon tetrachloride
CO	Carbon monoxide
CO_2	Carbon dioxide
NO	Nitrogen monoxide
NO_2	Nitrogen dioxide

Note that the prefix mono is only applied to the second element present in such compounds, if the prefix ends with 'a' or 'o', and the element name begins with 'a' or 'o', then the final vowel of the prefix is often omitted.

Some compounds have trivial names that have come to supersede their systematic names, for example, H_2O is usually 'water', not dihydrogen monoxide!

Task 03c

1. ***Write formula or names for the following molecular compounds.***

   (a) Dinitrogen tetroxide
   (b) Phosphorous pentachloride
   (c) Iodine trifluoride
   (d) Nitrogen dioxide
   (e) Dihydrogen monoxide

2. ***Convert the following formulae to names.***

   (a) N_2O_5
   (b) PCl_3
   (c) SF_6
   (d) H_2O
   (e) Cl_2O

Hydrates

Hydrates are ionic formula units with water molecules associated with them. The water molecules are incorporated into the solid structure of the ions. Strong heating can generally drive off the water in these salts. Once the water has been removed the salts are said to be anhydrous (without water).

To name a hydrate use the normal name of the ionic compound followed by the term 'hydrate' with an appropriate prefix to show the number of water molecules per ionic formula unit. For example, $CuSO_4.5H_2O$ is copper (II) sulfate pentahydrate.