Naming Inorganic Compounds 1

There are a number of methods for naming a compound, depending on what kind of compound it is. This worksheet will focus on **inorganic compounds**, or compounds that do not contain carbon (except for cyanide salts, carbon oxides, and carbonates).

Inorganic compounds are classified as either ionic or molecular. In **ionic compounds**, cations and anions are held together by ionic bonds and form a lattice structure, or crystal. **Molecular compounds** are held together by covalent bonds and do not contain ions. Molecular compounds form discrete molecules that are not strongly bonded to each other. Ionic compounds tend to contain metals; molecular compounds don't. Ionic compounds can be further classified into **binary compounds**, which contain only two elements, and **polyatomic compounds** which contain more than two.

BINARY IONIC COMPOUNDS

Binary compounds are composed of two elements, a metal and a non-metal. The metal acts as a **cation** or positive ion, and the non-metal is an **anion** or negative ion. The positive ion takes the same name as the element; the negative ion takes the root of its name from the element and then adds the ending *-ide*. The general form of the name is **[metal] [root of non-metal]*ide***. So $NaC\ell$ is *sodium chloride*. Other roots are listed at the right.

Br	**brom**ine
Cℓ	**chlor**ine
F	**fluor**ine
I	**iod**ine
N	**nitr**ogen
O	**ox**ygen
P	**phosph**orus
S	**sulph**ur

Some metals can have more than one charge when they bond in an ionic compound. In these cases, we must say which charge it has. We indicate this with a roman numeral. Iron can have a charge of 2+ or 3+, so there is $FeC\ell_2$ (*iron (II) chloride*) and $FeC\ell_3$ (*iron (III) chloride*). Note that the roman numeral in the name doesn't give an indication of how many ions there are of iron, it only indicates the charge on the iron ion.

POLYATOMIC IONIC COMPOUNDS

There is one common polyatomic cation, NH_4^+, which is called **ammonium**. So $NH_4C\ell$ is *ammonium chloride*.

There are many polyatomic anions, mostly involving oxygen. These are called **oxyanions**. A table of the most common oxyanions is at the top of the next page. The rows of the table represent different elements (or in the case of chromate and dichromate, different forms of the same element). Prefixes (*hypo-* and *per-*) and suffixes (*-ite* and *-ate*) are added to indicate how many oxygen atoms are in the ion compared to the main oxyanions in the third column. In compounds containing these oxyanions, we just use the name of the anion given in the table, rather than something ending in *-ide*. Na_3PO_4 is *sodium phosphate*.

Other common polyatomic anions include OH^- (hydroxide ion), CN^- (cyanide ion) and O_2^{2-} (peroxide ion).

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				$C_2H_3O_2^-$	**acet**ate		
				BrO_3^-	**brom**ate		
				CO_3^{2-}	**carbon**ate		
$C\ell O^-$	hypo**chlor**ite	$C\ell O_2^-$	**chlor**ite	$C\ell O_3^-$	**chlor**ate	$C\ell O_4^-$	per**chlor**ate
				CrO_4^{2-}	**chrom**ate		
				$Cr_2O_7^{2-}$	**dichrom**ate		
		NO_2^-	**nitr**ite	NO_3^-	**nitr**ate		
						MnO_4^-	per**mangan**ate
		PO_3^{3-}	**phosph**ite	PO_4^{3-}	**phosph**ate		
		SO_3^{2-}	**sulph**ite	SO_4^{2-}	**sulph**ate		

MOLECULAR COMPOUNDS

Molecular compounds (or covalent compounds) can be divided into **acids**, covalent compounds containing hydrogen, and **nonacids**. Among acids, there are **oxyacids**, which derive from the oxyanions we saw among the polyatomic ionic compounds, and **nonoxyacids**.

MOLECULAR COMPOUNDS: BINARY NONACIDS

1	**mono- ***
2	**di-**
3	**tri-**
4	**tetra-**
5	**penta-**
6	**hexa-**

Among binary nonacids, there are often many ways that two elements can bond, so we include a count of the number of each type of atom. We must indicate how many of each atom there are using the list of prefixes on the right. (* Note that no prefix is used if there is only one atom of the first element in the compound). Otherwise, we use the same naming scheme as for the binary ionic compounds. So, $S_2C\ell_2$ is *disulphur dichloride*, PF_5 is *phosphorus pentafluoride* (<u>not</u> *monophosphorus pentafluoride*). With -oxide (or any other element whose name begins with a vowel), we drop the *o* or *a* at the ending of a prefix, so NO_2 is *nitrogen dioxide*, but N_2O_4 is *dinitrogen tetroxide*, not *tetraoxide*.

Hydrogen is a special case in binary nonacids. Since hydrogen is only able to bond once, it's never ambiguous how many atoms of the other element there are, so prefixes are not used. $H_2S_{(g)}$ is *hydrogen sulphide*, not *dihydrogen sulphide*. (Note that this compound only has this name as a gas; in aqueous solution it's an acid.)

NONOXYACIDS

The naming of nonoxyacids is simple. They are just hydrogen plus a nonmetal, and the names are of the form **hydro + [root name] + ic acid**. So $HC\ell$ is *hydrochloric acid*. The only exception is $H_2S_{(aq)}$, which we saw as hydrogen sulphide as a gas. The root name for sulphur is **sulph-** but the acid is *hydrosulph<u>ur</u>ic acid*. Similarly, we use **phosphor-** as the root for acids containing phosphorus. (H_2O is an exception, too.)

OXYACIDS

In oxyacids, which are based on the oxyanions at the top of the previous page, we never use the **hydro-** prefix. Oxyanions that end in *-ite* produce acids ending in *-ous*, (HNO_2 is *nitrous acid*) and oxyanions that end in *-ate* produce acids ending in *-ic* (HNO_3 is *nitric acid*). If the oxyanion has hypo- or per- as a prefix, the prefix is kept. It is also possible to use the groups on the periodic table to extrapolate the names for other oxyacids.

EXERCISES

A. Classify the following compounds as ionic or molecular.

1) HI
2) Na_2CO_3
3) HNO_3
4) KBr
5) $A\ell PO_4$
6) K_2O
7) H_2O
8) NH_4OH
9) $Ca(OH)_2$
10) N_2O_4

B. Name the following ionic compounds:

1) NaI
2) K_2SO_3
3) $(NH_4)_3PO_4$
4) $FeC\ell_2$
5) $FeC\ell_3$
6) K_2S
7) Cu_2CO_3
8) MgO
9) $CuBr$
10) $CuBr_2$

C. Name the following ions:

1) SO_4^{2-}
2) PO_4^{3-}
3) $Cr_2O_7^{2-}$
4) MnO_4^-
5) $C_2H_3O_2^-$
6) $C\ell O_4^-$
7) $C\ell O_2^-$
8) NO_2^-
9) AsO_4^{3-}
10) IO_4^-

D. Name the following binary molecular compounds:

1) CO_2
2) N_2O_5
3) OF_2
4) NO
5) NO_2
6) CO
7) $NC\ell_3$
8) N_2O_3
9) CI_4
10) N_2O_4

E. Name the following nonoxyacids:

1) H_2S
2) HF
3) HI
4) $HC\ell$
5) HBr

F. Determine the polyatomic ion present in the following acids. Then state the name of the acid. Ex) H_2SO_4 SO_4^{2-}, sulphate ion, sulphuric acid

1) H_3PO_4
2) HNO_3
3) $HC\ell O$
4) HNO_2
5) H_2CO_3
6) HIO_4

G. Classify and name these compounds:

1) Na_2O
2) $Fe(OH)_3$
3) $Ca(NO_3)_2$
4) $(NH_4)_2SO_4$
5) KCN
6) $HC_2H_3O_{2(aq)}$
7) $HC\ell O_{3(aq)}$
8) Na_2CO_3
9) N_2O
10) NH_4OH
11) $H_2SO_{3(aq)}$
12) $HBrO_4$

SOLUTIONS

A. (1) molecular (2) ionic (3) molecular (4) ionic (5) ionic (6) ionic (7) molecular (8) ionic (9) ionic (10) molecular

B. (1) sodium iodide (2) potassium sulphite (3) ammonium phosphate (4) iron (II) chloride (5) iron (III) chloride (6) potassium sulphide (7) copper (I) carbonate (8) magnesium oxide (9) copper (I) bromide (10) copper (II) bromide

C. (1) sulphate (2) phosphate (3) dichromate (4) permanganate (5) acetate (6) perchlorate (7) chlorite (8) nitrite (9) arsenate (10) periodate

D. (1) carbon dioxide (2) dinitrogen pentoxide (3) oxygen difluoride (4) nitrogen monoxide (5) nitrogen dioxide (6) carbon monoxide (7) nitrogen trichloride (8) dinitrogen trioxide (9) carbon tetriodide (10) dinitrogen tetroxide

E. (1) hydrosulphuric acid (2) hydrofluoric acid (3) hydroiodic acid (4) hydrochloric acid (5) hydrobromic acid

F. (1) PO_4^{3-}, phosphate, phosphoric acid (2) NO_3^-, nitrate, nitric acid (3) $C\ell O^-$, hypochlorite, hypochlorous acid (4) NO_2^-, nitrite, nitrous acid (5) CO_3^{2-}, carbonate, carbonic acid (6) IO_4^-, periodate, periodic acid

G. (1) binary ionic: sodium oxide (2) polyatomic ionic: iron (III) hydroxide (3) polyatomic ionic: calcium nitrate (4) polyatomic ionic: ammonium sulphate (5) polyatomic ionic: potassium cyanide (6) oxyacid: acetic acid (7) oxyacid: chloric acid (8) polyatomic ionic: sodium carbonate (9) binary molecular: dinitrogen monoxide (10) polyatomic ionic: ammonium hydroxide (11) oxyacid: sulphurous acid (12) oxyacid: perbromic acid