NAMES AND FORMULAS OF COMPOUNDS

This handout describes the systems that are used for ionic compounds and for binary molecular compounds. Also included is a list of several compounds which are known by common names.

****** IONIC COMPOUNDS ******

The name of an ionic compound is the name of the cation followed by the name of the anion. The charges of the ions need to be considered, since the compound as a whole must be neutral.

1. Constant charge monatomic cations

For our purposes, all metal elements in Groups 1, 2, and 13 are assumed to form cations of charges 1+, 2+ and 3+, respectively. In addition, Ag and Zn are assumed to be constant charge ions, forming Ag^+ and Zn^{2+} ions only. All ions in this category are named simply by the name of the element. Examples:

lithium ion, Li^+ magnesium ion, Mg^{2+} aluminum ion, Al^{3+}

potassium ion, _____ _____, Ca^{2+} gallium (Ga) ion, _____

2. Variable charge monatomic cations

Many metal elements can form cations of different charges depending on the circumstances. These charges are therefore not predictable unless some other information, such as the formula, is provided. For our purposes, the elements in this category include all metal elements other than the constant charge cases (above). Ions in this category are named with the actual charge specified; in written names, the charge is given by Roman numerals in parentheses. Examples:

chromium(II) ion, Cr^{2+} chromium(III) ion, Cr^{3+}

manganese(II) ion, Mn^{2+} manganese(III) ion, Mn^{3+} manganese(IV) ion, Mn^{4+}

tin(II) ion, _____ tin(IV) ion, _____

_____, Pb^{2+} _____, Pb^{4+}

gold(I) ion, _____ gold(III) ion, _____

3. Constant charge monatomic anions

The common anions formed by the nonmetals and the metalloids are of a charge equal to the quantity [Group number – 18]. The name of the ion is the root of the element name, then *-ide*. Examples:

nitride ion, N^{3-} oxide ion, O^{2-} chloride ion, Cl^-

phosphide ion, _____ _____, Se^{2-} iodide ion, _____

4. Hydrogen ions

The element hydrogen forms either a cation or an anion as follows.

hydrogen ion, H^+ hydride ion, H^-

5. Polyatomic ions

There is a very large number of polyatomic ions which are composed of two or more atoms and which can carry either a positive or negative charge. By far, the most common and most important of the polyatomic cations is:

ammonium ion, NH_4^+

Common polyatomic anions are quite numerous. These include the following.

1–	2–
acetate ion, CH_3COO^- or $CH_3CO_2^-$	carbonate ion, CO_3^{2-}
chlorate ion, ClO_3^-	chromate ion, CrO_4^{2-}
chlorite ion, ClO_2^-	oxalate ion, $C_2O_4^{2-}$
cyanide ion, CN^-	sulfate ion, SO_4^{2-}
hydroxide ion, OH^-	sulfite ion, SO_3^{2-}
hypochlorite ion, ClO^-	thiosulfate ion, $S_2O_3^{2-}$
nitrate ion, NO_3^-	
nitrite ion, NO_2^-	3–
perchlorate ion, ClO_4^-	arsenate ion, AsO_4^{3-}
permanganate ion, MnO_4^-	phosphate ion, PO_4^{3-}

Many of the ions above are oxyanions (oxoanions), and several are members of the oxyanion family of the same element. All oxyanions have either *-ate* or *-ite* suffixes; some also have *per-* or *hypo-* prefixes. The N, S, and Cl families are included in the list above. When there is more than one oxyanion of the same element, then the names are derived in relation to each other, according to the number of O's in the polyatomic unit.

	nitrate, NO_3^-	nitrite, NO_2^-	
	sulfate, SO_4^{2-}	sulfite, SO_3^{2-}	
perchlorate, ClO_4^-	chlorate, ClO_3^-	chlorite, ClO_2^-	hypochlorite, ClO^-

The members of these families can be more easily remembered if the oxyanion relationships are kept in mind. Notice that all members of an oxyanion family have the same charge but different numbers of oxygen in the formula.

There are other derivatives of anions which are related by the presence of hydrogen; these are called "hydrogen anions". These polyatomic ions are named by adding the word "hydrogen" (or "dihydrogen" if two) to the anion name. In some cases, an alternate method can be used which uses a *bi-* prefix instead of the word "hydrogen" when one hydrogen is present. The following are examples; others are also derived from other 2– and 3– polyatomic anions.

hydrogen carbonate ion (bicarbonate ion), HCO_3^- (from carbonate ion, CO_3^{2-})

hydrogen sulfate ion (bisulfate ion), HSO_4^- (from sulfate ion, SO_4^{2-})

_____ (_____), HSO_3^- (from sulfite, SO_3^{2-})

hydrogen phosphate ion, _____ (from phosphate ion, PO_4^{3-})

dihydrogen phosphate ion, _____ (also from phosphate ion, PO_4^{3-})

Notice that for each hydrogen in the ion, there is a reduction of charge by one.

This concludes the names and formulas of individual ions.

Having considered the names and formulas of individual ions, the name and formula of an ionic compound are given by cation first and then by anion, in such a ratio that all positive charges are exactly cancelled by all negative charges. When the formula requires two or more of a specific polyatomic ion, then that ion is in parentheses.

NAME	CATION	ANION	FORMULA
nickel(II) fluoride	Ni^{2+}	F^-	NiF_2
calcium carbonate	Ca^{2+}	CO_3^{2-}	$CaCO_3$
iron(II) nitrate	_____	_____	$Fe(NO_3)_2$
sodium hypochlorite	_____	_____	$NaClO$
_____	K^+	PO_4^{3-}	K_3PO_4
_____	Au^{3+}	Cl^-	$AuCl_3$
ammonium thiosulfate	NH_4^+	$S_2O_3^{2-}$	_____
aluminum oxalate	Al^{3+}	$C_2O_4^{2-}$	_____
uranium(IV) oxide	_____	_____	_____
lithium hydrogen sulfate	_____	_____	_____
_____	_____	_____	$PbCrO_4$

****** BINARY COVALENT COMPOUNDS ******

For the general formula, A_xB_y, the name of the compound is composed of two words, derived from the names of the elements involved. The first word is the name of the first element; the second word is the root name of the second element, with the ending *-ide*. For elements other than hydrogen, a numerical prefix is used. (Hydrogen never takes a prefix, even if more than one are present in the molecule.) The numerical prefixes are the following.

1: mono-	2: di-	3: tri-	4: tetra-
5: penta-	6: hexa-	10: deca-	

The prefix "mono" is never used with the first word of the name; it is used only with the second word of the name, and even then it is optional. All of the other prefixes are used for the first and second words of the name (except for hydrogen).

nitrogen dioxide	NO_2
dinitrogen monoxide	N_2O
sulfur hexafluoride	_____
tetraphosphorus decasulfide	_____
disilicon hexachloride	_____
_____	IF_5
_____	H_2Se
_____	$AsBr_3$

Since hydrogen does not take a numerical prefix, it may not be obvious how many H's are present in the molecule just by the name. The formula can be derived by pretending that the compound is ionic. Determine the number of H's by the charge of the "pretend" anion.

hydrogen sulfide	If it were ionic, the anion would be S^{2-} and two H^+ would be needed to be neutral. The formula is H_2S.
hydrogen iodide	_____

****** OTHERS ******

Alkanes are compounds which have a general formula of C_xH_{2x+2}. Although there is a separate system for naming this class, only three are required to be known.

methane, CH_4 propane, C_3H_8 butane, C_4H_{10}

Some molecular compounds are known by common names that do not conform to the above systems. The following examples need to be known.

water, H_2O ammonia, NH_3 hydrogen peroxide, H_2O_2 ozone, O_3

PRACTICE PROBLEMS. Give the formula for the following names.

iron(II) sulfate
calcium carbonate
copper(II) hydroxide
mercury(II) bromide
copper(I) chlorite
potassium chromate
manganese(II) oxide
hydrogen fluoride
hydrogen peroxide
phosphorus pentachloride
aluminum oxide
magnesium perchlorate
tin(II) chloride
lithium hydride
ammonium cyanide
lead(II) carbonate
sodium nitrite
silver thiosulfate
gold(I) iodide
calcium hypochlorite
copper(I) chlorate
ammonium oxalate
chromium(III) perchlorate
cobalt(III) thiosulfate
diselenium hexasulfide
potassium dihydrogen arsenate
sodium hypochlorite
calcium hydride
aluminum hydroxide
iron(III) sulfide
uranium(II) sulfate

potassium permanganate
iron(III) fluoride
propane
cobalt(II) sulfide
gold(III) bromide
nickel(III) nitrate
manganese(IV) oxide
iodine pentafluoride
sulfur trioxide
lithium nitride
lead(II) sulfate
magnesium phosphate
sodium oxalate
potassium hydrogen sulfite
silver acetate
tin(IV) chloride
barium acetate
nitrogen triiodide
nickel(III) phosphate
zinc chlorate
sodium dihydrogen phosphate
ammonium arsenate
silicon dioxide
zinc nitrate
carbon monoxide
carbon tetrachloride
lithium hydrogen phosphate
barium hydroxide
sodium hydrogen carbonate
ozone
arsenic tribromide

PRACTICE PROBLEMS. Name the compound from the given formula.

$NaClO_3$
$Mg(ClO_2)_2$
AlN
Ag_2CO_3
NiS_2O_3
$Cu(OH)_2$
$Au(NO_3)_3$
Na_2CrO_4
$Ba(ClO)_2$
$Ba(MnO_4)_2$
MgH_2
ClF_3
CH_4
$FeAsO_4$
$CuCl$
$PbSO_3$
Cr_2O_3
$Co(NO_3)_2$
PbO_2
CoS
$HgSO_3$
$NaClO_3$
$AuCN$
CO_2
SiF_4
NH_3
$NaNO_2$
$Ni(NO_3)_3$
$KHCO_3$
$NH_4H_2PO_4$
$Ni_3(PO_4)_2$
$Mn(CH_3COO)_3$
$Ca(NO_2)_2$
$Ca(ClO)_2$
$AgClO_4$
SF_6

UBr_4
UO
$Al_2(SO_4)_3$
NH_4I
Ag_2SO_4
$Ca_3(PO_4)_2$
Li_2CO_3
$(NH_4)_2C_2O_4$
$Cu(CN)_2$
$KClO_2$
$Ca(HCO_3)_2$
CSe_2
CrS
CrI_3
$HgCl_2$
$FeSe$
$Cu(CH_3COO)_2$
$SnCl_2$
SnF_4
HBr
HI
HCl
$Zn(MnO_4)_2$
KCN
$KHSO_4$
MnC_2O_4
$AgClO_4$
Zn_3P_2
$NaHSO_4$
Li_2HPO_4
K_2CrO_4
$Li_2S_2O_3$
As_2I_4
$ZnBr_2$
PCl_3
C_4H_{10}