FORMULA WRITING AND NOMENCLATURE OF INORGANIC COMPOUNDS

I. OXIDATION NUMBERS

When chemical elements combine in a chemical reaction to form a chemical compound, they will lose, gain, or share electrons in forming a chemical bond. The number of electrons that an atom loses, gains, or shares when it bonds with another atom is known as the **oxidation number** of the atom. Elements which lose electrons in a chemical reaction, or which have electrons which are shared with another element deficient in electrons, are assigned **positive oxidation numbers**. Elements which gain electrons, or are deficient in electrons, are assigned **negative oxidation numbers**.

As an example, consider the formation of sodium chloride, table salt, from its elements:

$$2\ Na + Cl_2 \rightarrow 2\ Na^+Cl^-$$

In this reaction, each sodium atom is considered to have transferred one electron to each chlorine atom forming, as a result, charged atoms or **ions**. Since each sodium atom has lost one electron, it is assigned an oxidation number of +1, while each chlorine atom has gained one electron and is assigned an oxidation number of -1. The two ions are held together as a result of their opposite charges in what is called an **ionic bond**.

As a second example, consider the formation of water from hydrogen and oxygen:

$$2\ H_2 + O_2 \rightarrow 2\ H_2O$$

In this case, ions are not formed. Instead, the hydrogen and oxygen atoms are sharing electrons to form a **covalent bond**. Each hydrogen has contributed one electron to the chemical bond while the oxygen has contributed two electrons to chemical bonds (i.e., one electron to each hydrogen atom). Experimentally, it has been determined that the oxygen atom has a greater attraction for electrons than does the hydrogen atoms, so the oxygen has been assigned an oxidation number of -2 (the minus sign denotes the stronger attraction for electrons) and the hydrogen atoms are each assigned an oxidation number of +1.

Frequently, in chemistry, we come across a group of atoms that behave as if it were a single atom when it combines with another atom or group of atoms. Such a group of atoms is called a radical or **polyatomic ion**. For example, consider the following reaction between silver nitrate and ammonium chloride to form silver chloride and ammonium nitrate:

$$AgNO_3 + NH_4Cl \rightarrow AgCl + NH_4NO_3$$

Notice that the NO_3 and the NH_4 groups are transferred intact without any change in their formula or oxidation numbers of any of the elements. They act as if they were single atoms and are, according to the definition, **polyatomic ions**.

A list of common elements and polyatomic ions with their symbols and oxidation numbers appears in Table 1 on page 2. This information should be committed to memory.

Table 1. Names, Symbols, and Oxidation Numbers of Common Elements and Polyatomic Ions

+1 Oxidation No.

Hydrogen	H
Lithium	Li
Sodium	Na
Potassium	K
Rubidium	Rb
Cesium	Cs
Silver	Ag
Copper(I)	Cu
Mercury(I)	Hg
Ammonium	NH_4

+2 Oxidation No.

Beryllium	Be
Magnesium	Mg
Calcium	Ca
Strontium	Sr
Barium	Ba
Chromium(II)	Cr
Manganese(II)	Mn
Iron(II)	Fe
Cobalt(II)	Co
Nickel(II)	Ni
Copper(II)	Cu
Zinc	Zn
Cadmium	Cd
Mercury(II)	Hg
Tin(II)	Sn
Lead(II)	Pb

+3 Oxidation No.

Boron	B
Aluminum	Al
Nitrogen	N
Phosphorus	P
Arsenic(III)	As
Antimony(III)	Sb
Bismuth(III)	Bi
Chromium(III)	Cr
Iron(III)	Fe
Cobalt(III)	Co
Nickel(III)	Ni

NOTE: Certain elements such as copper, iron, tin, and others exhibit more than one oxidation number. In these cases, the name of the element is followed by the oxidation number in Roman numerals in parenthesis. (These elements are summarized in Table 2) The case of nitrogen and phosphorus are discussed in Section IV.

+4 Oxidation No.

Carbon	C
Silicon	Si
Tin(IV)	Sn
Lead(IV)	Pb
Manganese(IV)	Mn

+5 Oxidation No.

Nitrogen	N
Phosphorus	P
Arsenic(V)	As
Antimony(V)	Sb
Bismuth(V)	Bi

-1 Oxidation No.

Fluoride	F
Chloride	Cl
Bromide	Br
Iodide	I
Hypochlorite	ClO
Chlorite	ClO_2
Chlorate	ClO_3
Perchlorate	ClO_4
(also Br and I in place of Cl)	
Bicarbonate	HCO_3
Bisulfite	HSO_3
Bisulfate	HSO_4
Nitrite	NO_2
Nitrate	NO_3
Cyanide	CN
Cyanate	CNO
Thiocyanate	CNS
Hydroxide	OH
Permanganate	MnO_4
Acetate	$C_2H_3O_2$

-2 Oxidation No.

Oxide	O
Sulfide	S
Peroxide	O_2
Sulfite	SO_3
Sulfate	SO_4
Thiosulfate	S_2O_3
Dithionite	S_2O_4
Dithionate	S_2O_6
Persulfate	S_2O_8
Carbonate	CO_3
Oxalate	C_2O_4
Chromate	CrO_4
Dichromate	Cr_2O_7
Silicate	SiO_3
Stannate	SnO_3
Tetraborate	B_4O_7

-3 Oxidation No.

Nitride	N
Phosphide	P
Phosphite	PO_3
Phosphate	PO_4
Arsenate	AsO_4
Ferricyanide	$Fe(CN)_6$

-4 Oxidation No.

Pyrophosphate	P_2O_7
Ferrocyanide	$Fe(CN)_6$

Table 2. Common Elements Having More Than One Oxidation Number			
Elements with oxidation numbers of +1 and +2:		**Elements with oxidation numbers of +2 and +3:**	
Copper	Cu	Chromium	Cr
Mercury	Hg	Iron	Fe
		Cobalt	Co
		Nickel	Ni
Elements with oxidation numbers of +2 and +4:		**Elements with oxidation numbers of +3 and +5:**	
Manganese	Mn	Arsenic	As
Tin	Sn	Antimony	Sb
Lead	Pb	Bismuth	Bi

II. WRITING FORMULAS OF COMPOUNDS

Using the table of oxidation numbers (Table 1), it is not difficult to write the formula of a chemical compound. There is one important rule that must be remembered:

> **The total oxidation number of the first, or positive, part of the compound must be equal but opposite in charge to the total oxidation number of the second, or negative, part of the compound.**

This can be paraphrased as:

> **The algebraic sum of the oxidation numbers of the elements and polyatomic ions in a chemical compound is zero.**

The following examples will demonstrate how this rule is applied in writing the formula of a compound:

1. Write the formula for potassium bromide.

   Looking at the list of oxidation numbers in Table 1, it is found that potassium, K, has an oxidation number of +1 and bromide (the combined form of bromine), Br, has an oxidation number of -1. Writing the symbol of the positive element or polyatomic ion first, the formula is:

   $$KBr$$

   The algebraic sum of the oxidation numbers is $+1 + (-1) = 0$ Thus, the positive and negative oxidation numbers match and the formula of potassium bromide is correct as written above.

   The formula of potassium bromide is interpreted to mean that a molecule of the compound contains one atom of potassium and one atom of bromine.

2. Write the formula of iron(II) bromide.

   In this example, it is found that the oxidation number of iron, Fe, is +2 (as indicated by the Roman numeral) and the oxidation number of bromide, Br, is -1. If the formula of iron(II) bromide is written as:

   $$FeBr$$

the algebraic sum of the oxidation numbers of the elements in this formula is +2 + (-1) = +1 There is an excess of the positive oxidation number and the addition of a second bromide ion will be needed to make the sum zero. Thus, for the formula:

$$FeBrBr$$

the algebraic sum of the oxidation numbers is +2 + [2 x (-1)] = 0. This formula, as written, is in an inconvenient form since the formula of bromide appears twice. In order to simplify the formula, a **subscript** is used to indicate the number of bromine atoms required. In this example, two bromine atoms are needed, so the proper formula for iron(II) bromide is written as:

$$FeBr_2$$

The formula of iron(II) bromide is interpreted to mean that a molecule of the compound contains one atom of iron and two atoms of bromine. Make note of the fact that **the subscript applies only to the element it directly follows.**

3. Write the formula of calcium acetate.

Checking the list of oxidation numbers in Table 1, it is found that the oxidation number of calcium, Ca, is +2 and the oxidation number of acetate, $C_2H_3O_2$, (a polyatomic ion) is -1. This is similar to the situation in the preceding example and, following the same pattern, one calcium atom will combine with two acetate polyatomic ions. Again, a subscript will be used to indicate that two acetate polyatomic ions will be needed. Since the subscript applies only to the element it directly follows, in the case of a polyatomic ion the formula of the polyatomic ion must be placed in parentheses if the subscript is two or larger. This will indicate that **the subscript applies to all the elements within the parentheses.** The correct formula for calcium acetate is:

$$Ca(C_2H_3O_2)_2$$

The algebraic sum of the oxidation numbers is +2 + [2 x (-1)] = 0

The formula is interpreted to mean that a molecule of calcium acetate contains one calcium atom, and two acetate polyatomic ions. In more detail this can be stated as one calcium atom, four carbon atoms, six hydrogen atoms, and four oxygen atoms. Note that **all the subscripts inside the parentheses are multiplied by the subscript that directly follows the parentheses**.

4. Write the formula of aluminum sulfate.

The oxidation number of aluminum, Al, as listed in Table 1, is +3. The oxidation number of sulfate, SO_4 is -2. If the formula is written as:

$$AlSO_4$$

the sum of the oxidation numbers is +3 + (-2) = +1. Addition of a second sulfate ion will increase the negative oxidation number and give the formula:

$$AlSO_4SO_4$$

The sum of the oxidation numbers will now be +3 + [2 x (-2)] = -1. The addition of another aluminum ion increases the positive oxidation number and the formula becomes:

$$AlAlSO_4SO_4$$

The sum of the oxidation numbers, for this formula, is [2 x +3] + [2 x (-2)] = +2. In order to have the sum equal to zero, another sulfate ion must be added to the formula:

$$AlAlSO_4SO_4SO_4$$

Rather than repeat the formulas of the aluminum and sulfate ions several times, subscripts are used to give the final formula:

$$Al_2(SO_4)_3$$

Note that the sulfate polyatomic ion is enclosed in parentheses and that the subscript 3 applies to the whole sulfate polyatomic ion.

A molecule of aluminum sulfate contains two aluminum atoms, three sulfur atoms, and twelve oxygen atoms.

III. DETERMINING THE OXIDATION NUMBER OF AN ELEMENT IN A COMPOUND

In a chemical compound, some elements exhibit oxidation states other than their most common oxidation state. It is desirable to be able to determine these less common oxidation states as well as to determine which state an element with several oxidation numbers is in. To do this, we must make use of the rule that the algebraic sum of the oxidation numbers is zero along with the use of elements that have only a single oxidation state as references for the calculation. The elements with single oxidation states are:

Hydrogen has an oxidation number of +1 except in the case of metal hydrides where it is -1. (A metal hydride has a formula consisting of the symbol of a metal followed by the symbol of hydrogen. An example of a metal hydride is sodium hydride, NaH.)

Lithium, sodium, potassium, rubidium and cesium (the alkali metals - Group IA) **always have oxidation numbers of +1**.

Beryllium, magnesium, calcium, strontium, and barium (the alkaline earth metals - Group IIA) **always have oxidation numbers of +2**.

Boron and aluminum (Group IIIA) **always have oxidation numbers of +3**.

Oxygen has an oxidation number of -2 except in peroxides where it is -1. (An example of a peroxide is sodium peroxide, Na_2O_2)

Fluorine always has an oxidation number of -1.

A table of the oxidation numbers of most of the elements appears as Table 3, on page 6.

The following examples will demonstrate how to determine the oxidation number of an element in a compound:

1. Determine the oxidation number of Mn in $KMnO_4$.

   Using the rules given above, the oxidation number of K is +1 and the oxidation number of O is -2. To determine the total charge contributed by each element, multiply the oxidation number of atoms of the element by the number of atoms in the compound:

Table 3. Oxidation Numbers of the Elements

The most common oxidation number of each element is printed in bold type

1 IA	2 IIA	3 IIIB		4 IVB	5 VB	6 VIB	7 VIIB	8 ⟵	9 VIII	10 ⟶	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 Noble Gas
1 H **+1** **-1**																		2 He
3 Li **+1**	4 Be **+2**												5 B **+3**	6 C **+4** +2 -4	7 N **+5** +4 +3 +2 -3	8 O -1 **-2**	9 F **-1**	10 Ne
11 Na **+1**	12 Mg **+2**												13 Al **+3**	14 Si **+4** -4	15 P **+5** +3 -3	16 S **+6** +4 +2 **-2**	17 Cl +7 +5 +3 +1 **-1**	18 Ar
19 K **+1**	20 Ca **+2**	21 Sc **+3**		22 Ti **+4** +3 +2	23 V +5 **+4** +3 +2	24 Cr +6 **+3** +2	25 Mn +7 +6 **+4** +3 +2	26 Fe **+3** +2	27 Co **+3** +2	28 Ni **+2** +3	29 Cu **+2** +1	30 Zn **+2**	31 Ga **+3**	32 Ge **+4** +2	33 As +5 **+3** -3	34 Se **+6** +4 -2	35 Br +7 +5 +1 **-1**	36 Kr
37 Rb **+1**	38 Sr **+2**	39 Y **+3**		40 Zr **+4**	41 Nb **+5** +4	42 Mo **+6** +4 +3	43 Tc **+7** +6 +4	44 Ru +8 +6 +4 **+3**	45 Rh +4 **+3** +2	46 Pd +4 **+2**	47 Ag **+1**	48 Cd **+2**	49 In **+3**	50 Sn **+4** +2	51 Sb +5 **+3** -3	52 Te **+6** +4 -2	55 I +7 +5 +1 **-1**	54 Xe
55 Cs **+1**	56 Ba **+2**	57 **La** **+3**	58-71 Ce – Lu **+3**	72 Hf **+4**	73 Ta **+5**	74 W **+6** +4	75 Re **+7** +6 +4	76 Os +8 +4	77 Ir +4 +3	78 Pt **+4** +2	79 Au **+3** +1	80 Hg **+2** +1	81 Tl **+3** +1	82 Pb +4 **+2**	83 Bi +5 **+3**	84 Po **+4**	85 At **-1**	86 Rn
87 Fr **+1**	88 Ra **+2**	89 Ac +3	90-103 Th - Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Uub	113 Uut	114 Uuq	115 Uup	116 Uuh	117 Uus	118 Uuo

The total positive charge contributed by K is: 1 x (+1) = +1
The total negative charge contributed by O is: 4 x (-2) = -8

The algebraic sum of the charges is -7

The oxidation number of Mn required to make the net charge of $KMnO_4$ zero is +7.

2. Determine the oxidation number of S in CaS_2O_6.

This compound contains Ca with the oxidation number of +2 and O with the oxidation number of -2. Using these values, the total charge contributed by each element is calculated:

The total positive charge contributed by Ca is: 1 x (+2) = +2
The total negative charge contributed by O is: 6 x (-2) = -12

The algebraic sum of the charges is -10

The two S atoms in the compound must contribute a total charge of +10 in order for the net charge of CaS_2O_6 to be zero. Therefore, each S atom must have an oxidation number of +5.

3. Determine the oxidation number of Cu in $CuSO_4$.

Cu is an element that can have more than one oxidation state (see Tables 1 and 2). To determine the oxidation number of Cu in this compound, it is easier to use the oxidation number of the sulfate polyatomic ion instead of determining the oxidation number of each element. The sulfate polyatomic ion has an oxidation number of -2. Since one Cu atom combines with one SO_4 polyatomic ion, the oxidation number of Cu is +2.

4. Determine the oxidation number of Fe in $Fe_3(PO_4)_2$.

Fe is an element that can have more than one oxidation state. To determine the oxidation number of Fe in this compound, use the oxidation number of the phosphate polyatomic ion to determine its total charge. There are two PO_4 polyatomic ions with an oxidation number of -3. The total charge of the phosphate polyatomic ions is -6. In order for the net charge of the compound to be zero, the three Fe atoms must have a total charge of +6. Dividing the total charge by 3 atoms gives an oxidation number of +2 for each Fe atom.

IV. NOMENCLATURE OF COMPOUNDS

1. Naming Binary Compounds

A binary compound is one that consists of only two elements (no polyatomic ions). To name a binary compound, the following rule is used:

Name the first element in the formula (the one with the positive oxidation number) **followed by the stem name of the second element** (the one with the negative oxidation number) **with an <u>-ide</u> ending.**

There are two different types of binary compounds, those formed from a **metal and a non-metal** and those formed from **two non-metals**.

A. Binary compounds formed from a metal and a non-metal.

These compounds consist of a metal and a non-metal in an atom ratio determined by their oxidation numbers. It is customary to write the metal first and the non-metal second. The rule for naming these compounds is:

Name the metal followed by the stem name of the non-metal with an -ide ending.

Examples: (the stem name of the non-metal is underlined)

NaCl = sodium chloride

AgI = silver iodide

CaO = calcium oxide

If the metal exhibits more than one oxidation state, the oxidation state of the metal, in the compound of interest, is indicated by a Roman numeral placed in parentheses following the name of the metal. (This number in parentheses is part of the metal name and is included in the list in Table 1)

Examples:

HgBr is named mercury(I) bromide

$HgBr_2$ is named mercury(II) bromide

mercury can have oxidation states of +1 and +2

$CoCl_2$ is named cobalt(II) chloride

$CoCl_3$ is named cobalt(III) chloride

cobalt can have oxidation states of +2 and +3

B. Binary compounds formed from two non-metals.

In compounds that occur between non-metals, the positive and negative oxidation numbers are assigned to the elements according to their electronegativities. The element with the lowest electronegativity is named first. The common non-metals, arranged in order of increasing electronegativity are:

Si, B, P, H, C, S, I, Br, N, Cl, O, F

When naming these compounds, prefixes are often used to indicate the number of atoms of each element present in the compound. A list of common prefixes used is given in Table 4.

Table 4. Common Latin and Greek prefixes used in naming compounds.

Prefix	Number	Prefix	Number
mono-	1	hexa-	6
di-	2	hepta-	7
tri-	3	octa-	8
tetra-	4	nona-	9
pent-/penta-	5	deca-	10

To name a binary non-metal compound **name each element in the order they appear in the formula using the appropriate prefix to indicate the number of atoms of the element in the compound. The second element uses an <u>-ide</u> ending.** The prefix *mono-* is generally omitted unless it is needed to -distinguish between two or more compounds of the same elements.

Examples:

CO	carbon monoxide
CO_2	carbon dioxide.
PCl_3	phosphorus trichloride
PCl_5	phosphorus pentachloride
NO	nitrogen oxide
NO_2	nitrogen dioxide
N_2O	dinitrogen monoxide
N_2O_3	dinitrogen trioxide
N_2O_5	dinitrogen pentoxide

There is an alternate method to naming binary non-metal compounds. Instead of using numerical prefixes, this method uses the oxidation numbers of the first element in parentheses, similar to the method used for binary compounds composed of a metal and a non-metal. Using this method, the above examples would be named:

CO	carbon(II) oxide
CO_2	carbon(IV) oxide.
PCl_3	phosphorus(III) chloride
PCl_5	phosphorus(V) chloride
NO	nitrogen(II) oxide
NO_2	nitrogen(IV) oxide
N_2O	nitrogen(I) oxide
N_2O_3	nitrogen(III) oxide
N_2O_5	nitrogen(V) oxide

2. Naming of Bases

Bases are compounds which consist of a metal ion combined with the hydroxide polyatomic ion (OH). **To name a base, name the metal** (include the oxidation number in parentheses if the metal is one which has more than one oxidation state) **followed by the word <u>hydroxide</u>**.

Examples:

$NaOH$ is named sodium hydroxide
$Ba(OH)_2$ is named barium hydroxide
$Fe(OH)_2$ is named iron(II) hydroxide
$Fe(OH)_3$ is named iron(III) hydroxide

NOTE: There is no molecular form of ammonium hydroxide, NH_4OH. An aqueous solution of ammonia, NH_3, contains ammonium ions, NH_4^+, and hydroxide ions, OH^-.

3. Naming of Acids

An acid is a compound consisting of hydrogen combined with a non-metallic element or with a polyatomic ion that has a negative oxidation number. In the formula for an acid, **hydrogen is always listed as the first element**. (The only exception to this is water, H_2O)

There are several types of acids encountered in chemistry: binary acids, oxygen containing acids, and organic acids. Their names are well established in traditional origins and there has been no acceptable systematic scheme for naming these substances.

A. Binary or Non-oxygen Acids

Binary acids consist of hydrogen combined with a non-metal element. **Binary acids are named by using the prefix <u>hydro-</u> followed by the stem name of the non-metal element** (the second element in the formula) **with an <u>-ic</u> ending. The name is followed by the word acid.**

Examples:

HCl is named **hydro**chlor**ic acid**
HBr is named **hydro**brom**ic acid**
HI is named **hydro**iod**ic acid**
H_2S is named **hydro**sulfur**ic acid**

B. Oxygen-containing Acids

Oxygen-containing acids consist of three elements: hydrogen, a non-metal, and oxygen. If there are only two common forms of the acid, suffixes <u>-ous</u> and <u>-ic</u> are used to denote different oxidation states of the non-metal. **Oxygen-containing acids are named by using the stem name of the non-metal element** (the middle element) **with an <u>-ous</u> ending if the element is in its lower oxidation state** (see Table 10.3, page 6) **or an <u>-ic</u> ending if the element is in its higher oxidation state, followed by the word acid**.

Examples:

HNO_2 is named nitr**ous** acid (the oxidation number of N = +3)
HNO_3 is named nitr**ic** acid (the oxidation number of N = +5)
(NOTE: Nitrogen only forms these two acids.)

H_2SO_3 is named sulfur**ous** acid (the oxidation number of S = +4)
H_2SO_4 is named sulfur**ic** acid (the oxidation number of S = +6)
(NOTE: These are the most common oxygen acids of sulfur.)

H_3PO_3 is named phosphor**ous** acid (the oxidation state of P = +3)
H_3PO_4 is named phosphor**ic** acid (the oxidation state of P = +5)
(NOTE: These are the most common oxygen acids of phosphorus.)

NOTE: There is no molecular form of carbonic acid, H_2CO_3. An aqueous solution of carbon dioxide, CO_2, contains hydrogen carbonate ions, HCO_3^-, and hydrogen ions, H^+.

Sometimes an element may form more than two oxygen-containing acids. In these cases, additional prefixes <u>hypo-</u> and <u>per-</u> are used. An example of this is chlorine which forms the acids: HClO, $HClO_2$, $HClO_3$, and $HClO_4$. The most common oxygen acids of chlorine are:

$HClO_2$ which is named chlor**ous** acid
$HClO_3$ which is named chlor**ic** acid

In the case of HClO, which contains one atom of oxygen less than chlorous acid, $HClO_2$, (the **-ous** ending acid) chlorine has a lower oxidation number and the prefix **hypo-** is added to the **-ous** acid name. This results in the name **hypo**chlor**ous acid** for HClO.

In the case of $HClO_4$, the acid contains one more oxygen than chloric acid, $HClO_3$, (the acid with the name ending in **-ic**) chlorine has a higher oxidation number and the prefix **per-** is added to the **-ic** acid name. This results in the name **per**chlor**ic acid** for $HClO_4$.

These names of the oxygen-containing halogen acids are summarized in the following examples: (Note: For practice, calculate the oxidation numbers of Cl in these acids.)

HClO = **hypo**chlor**ous acid**	(oxidation no. of Cl = _________)
$HClO_2$ = chlor**ous acid**	(oxidation no. of Cl = _________)
$HClO_3$ = chlor**ic acid**	(oxidation no. of Cl = _________)
$HClO_4$ = **per**chlor**ic acid**	(oxidation no. of Cl = _________)

Similar names are used for the acids formed by bromine and iodine, the two elements that are found in the same family below chlorine in the periodic table.

HBrO = **hypo**brom**ous acid**	HIO = **hypo**iod**ous acid**
$HBrO_3$ = brom**ic acid**	HIO_3 = iod**ic acid**
$HBrO_4$ = **per**brom**ic acid**	HIO_4 = **per**iod**ic acid**

(**Note:** $HBrO_2$ and HIO_2 are not stable and do not exist.)

Occasionally, there are other forms of oxygen acids that may require additional prefixes. An example of this is:

H_5IO_6 **paraper**iod**ic acid**

These acids are beyond the scope of this tutorial and will not be referred to.

C. Organic Acids

Naming of organic acids, for use in general chemistry, follows nonsystematic or trivial names, although these acids do have systematic names in organic chemistry. Some important organic acids, with their common or nonsystematic names and their systematic names, are:

Formula	**Common Name**	**Systematic (IUPAC) Name**
$HCHO_2$	formic acid	methanoic acid
$HC_2H_3O_2$	acetic acid	ethanoic acid
$H_2C_2O_4$	oxalic acid	ethandioic acid
$H_2C_4H_4O_6$	tartaric acid	2,3-dihydroxybutanedioic acid

You should learn the **common names and formulas** for these organic acids.

4. Naming of Salts of Oxygen Acids

A salt of an oxygen containing acid results from the reaction of the acid with a metal hydroxide or an aqueous ammonia solution. These salts consist of a metal or ammonium polyatomic ion combined with a negative polyatomic ion which contains one or more atoms of oxygen. To name these compounds, **name the metal** (be sure to include the oxidation number in parentheses when needed) **followed by the name of the acid polyatomic ion.** If the polyatomic ion comes from an acid that has an **-ous** ending, then the polyatomic ion name will end with **-ite**. If the polyatomic ion comes from an acid that has an **-ic** ending, then the name of the polyatomic ion ends in **-ate**. Prefixes such as **hypo-** and **per-** remain as part of the polyatomic ion name.

Examples:

$KClO$	potassium **hypo**chlor**ite** (The ClO polyatomic ion comes from **hypo**chlor**ous** acid.)
$KClO_2$	potassium chlor**ite** (The ClO_2 polyatomic ion comes from chlor**ous** acid.)
$KClO_3$	potassium chlor**ate** (The ClO_3 polyatomic ion comes from chlor**ic** acid.)
$KClO_4$	potassium **per**chlor**ate** (The ClO_4 polyatomic ion comes from **per**chlor**ic** acid.)
$FeSO_3$	iron(II) sulf**ite** (The iron has an oxidation number of +2. The SO_3 polyatomic ion comes from H_2SO_3, sulfur**ous** acid.)
$Fe_2(SO_4)_3$	iron(III) sulf**ate** (The iron has an oxidation number of +3. The SO_4 polyatomic ion comes from H_2SO_4, sulfur**ic** acid.)

If a salt is formed from an acid that contained two or more acid hydrogen atoms without replacing all of the hydrogens, then a hydrogen salt is formed. Such salts contain the word **hydrogen**, or the prefix **bi-**, in the middle of the salt names. (The use of hydrogen is currently preferred.) Prefixes are also used to distinguish compounds where three hydrogens were replaceable.

Examples:

$NaHCO_3$	sodium **hydrogen** carbonate or sodium **bi**carbonate (The HCO_3 polyatomic ion is formed from a hydrogen carbonate ion, HCO_3^- Carbonic acid, H_2CO_3, does not exist in the molecular form.)	
$KHSO_4$	potassium **hydrogen** sulfate or potassium **bi**sulfate (The HSO_4 polyatomic ion is formed from sulfuric acid, H_2SO_4)	
NaH_2PO_4	sodium **dihydrogen** phosphate	These hydrogen phosphate ions are formed from phosphoric acid, H_3PO_4
Na_2HPO_4	d**i**sodium **hydrogen** phosphate Also known as sodium **hydrogen** phoshate	
Na_3PO_4	**tri**sodium phosphate Also known as sodium phoshate	

Problems: Formula writing and nomenclature of inorganic compounds

1. Determine the oxidation number of S in each of the following compounds.

   a) $Na_2S_2O_3$ ans. a)____________________

   b) H_2SO_3 b)____________________

   c) SO_2 c)____________________

   d) $K_2S_2O_4$ d)____________________

   e) Al_2S_3 e)____________________

   f) BaS_2O_8 f)____________________

2. Name the following compounds.

   a) PbI_2 ans. a)____

   b) $FeSO_4$ b)____

   c) Ag_2CO_3 c)____

   d) NaCN d)____

   e) $Ca(C_2H_3O_2)_2$ e)____

   f) $Cu(NO_3)_2$ f)____

   g) $K_2C_2O_4$ g)____

   h) HgCl h)____

3. Write formulas for the following compounds.

   a) ammonium sulfide ans. a)____________________

   b) magnesium phosphate b)____________________

   c) mercury(II) thiocyanate c)____________________

   d) sodium iodate d)____________________

   e) chromium(III) chloride e)____________________

   f) potassium permanganate f)____________________

   g) zinc bromide g)____________________

   h) cobalt(II) perchlorate h)____________________

4. Determine the oxidation number of Cr in each of the following compounds.

a) $CaCrO_4$ ans. a)____________________

b) $CrBr_2$ b)____________________

c) $Ag_2Cr_2O_7$ c)____________________

d) $Cr_2(SO_4)_3$ d)____________________

e) Li_2CrO_4 e)____________________

5. Name the following binary non-metal compounds.

a) PBr_3 ans. a)____

b) CO b)____

c) N_2O_4 c)____

d) CCl_4 d)____

e) SiO_2 e)____

f) BCl_3 f)____

g) CS_2 g)____

h) S_2Cl_2 h)____

6. Write formulas for the following binary non-metal compounds.

a) phosphorus pentachloride ans. a)____________________

b) oxygen difluoride b)____________________

c) sulfur trioxide c)____________________

d) dinitrogen pentoxide d)____________________

e) silicon tetrabromide e)____________________

f) carbon dioxide f)____________________

g) boron triiodide g)____________________

h) sulfur hexafluoride h)____________________

7. Name the following acids and bases.

a) H_2SO_3 ans. a)____________________________________

b) $Sn(OH)_4$ b)____________________________________

c) HNO_3 c)____________________________________

d) KOH d)____________________________________

e) HIO_4 e)____________________________________

f) HF f)____________________________________

g) $Fe(OH)_3$ g)____________________________________

h) H_2SO_4 h)____________________________________

i) H_3PO_3 i)____________________________________

j) $HC_2H_3O_2$ j)____________________________________

k) HClO k)____________________________________

l) HBr l)____________________________________

8. Write formulas for the following acids and bases.

a) nitrous acid ans. a)__________________

b) phosphoric acid b)__________________

c) sodium hydroxide c)__________________

d) bromic acid d)__________________

e) tin(II) hydroxide e)__________________

f) hydroiodic acid f)__________________

g) hypobromous acid g)__________________

h) aluminum hydroxide h)__________________

i) zinc hydroxide i)__________________

j) oxalic acid j)__________________

k) perchloric acid k)__________________

l) hydrosulfuric acid l)__________________

9. Name the following compounds.

a) $BaCrO_4$ ans. a)____________________

b) $Ni_2Fe(CN)_6$ b)____________________

c) HIO c)____________________

d) KCNO d)____________________

e) H_2O_2 e)____________________

f) $AlPO_4$ f)____________________

g) CuO g)____________________

h) $Pb(C_2H_3O_2)_2$ h)____________________

i) KH_2PO_3 i)____________________

j) NH_4CN j)____________________

k) NiC_2O_4 k)____________________

l) Na_2SiO_3 l)____________________

m) $Ca(BrO_4)_2$ m)____________________

n) $AgMnO_4$ n)____________________

o) SnF_2 o)____________________

p) As_2S_3 p)____________________

q) Na_2O q)____________________

r) $Mg(IO_3)_2$ r) ____________________

s) Hg_2SO_4 s)____________________

t) H_3AsO_4 t)____________________

u) $CoCl_2$ u)____________________

v) NaClO v)____________________

w) $NaHCO_3$ w)____________________

x) $(NH_4)_2SO_3$ x)____________________

y) $Bi(OH)_3$ y)____________________

z) FeS_2O_3 z)____________________

10. Write formulas for the following compounds.

a) chromium(III) nitrate	ans. a)____________________
b) manganese(II) hydroxide	b)____________________
c) nitrogen trichloride	c)____________________
d) sodium tetraborate	d)____________________
e) zinc carbonate	e)____________________
f) ammonium nitrite	f)____________________
g) magnesium oxalate	g)____________________
h) copper(II) sulfite	h)____________________
i) sodium hydrogen sulfite	i)____________________
j) lead(II) chromate	j)____________________
k) silver cyanide	k)____________________
l) sodium bicarbonate	l)____________________
m) calcium dithionate	m) ____________________
n) antimony(III) sulfide	n)____________________
o) potassium oxide	o)____________________
p) boron trifluoride	p)____________________
q) tin(IV) nitrate	q)____________________
r) barium chloride	r)____________________
s) aluminum acetate	s)____________________
t) copper(I) oxide	t)____________________
u) manganese(II) pyrophosphate	u)____________________
v) chromium(III) sulfate	v)____________________
w) lithium hydride	w)____________________
x) iron(II) phosphate	x)____________________
y) ammonium oxalate	y)____________________
z) mercury(II) iodate	z)____________________

11. Name the following compounds.

a) $K_2S_2O_8$ ans. a)______________________

b) Mg_3N_2 b)______________________

c) HIO c)______________________

d) $Sr(OH)_2$ d)______________________

e) Na_3PO_3 e)______________________

f) $Ag_2Cr_2O_7$ f)______________________

g) $CdCO_3$ g)______________________

h) $HC_2H_3O_2$ h)______________________

i) $LiHSO_4$ i)______________________

j) $Ni_2P_2O_7$ j)______________________

k) AsP k)______________________

l) $KHSO_4$ l)______________________

m) $HBrO_4$ m)______________________

n) MnC_2O_4 n)______________________

o) $Co(ClO_4)_2$ o)______________________

p) Sb_2S_3 p)______________________

q) $Ca(HCO_3)_2$ q)______________________

r) $NaClO_2$ r)______________________

s) $PbSO_4$ s)______________________

t) $H_2C_2O_4$ t)______________________

u) CuCl u)______________________

v) BaO_2 v)______________________

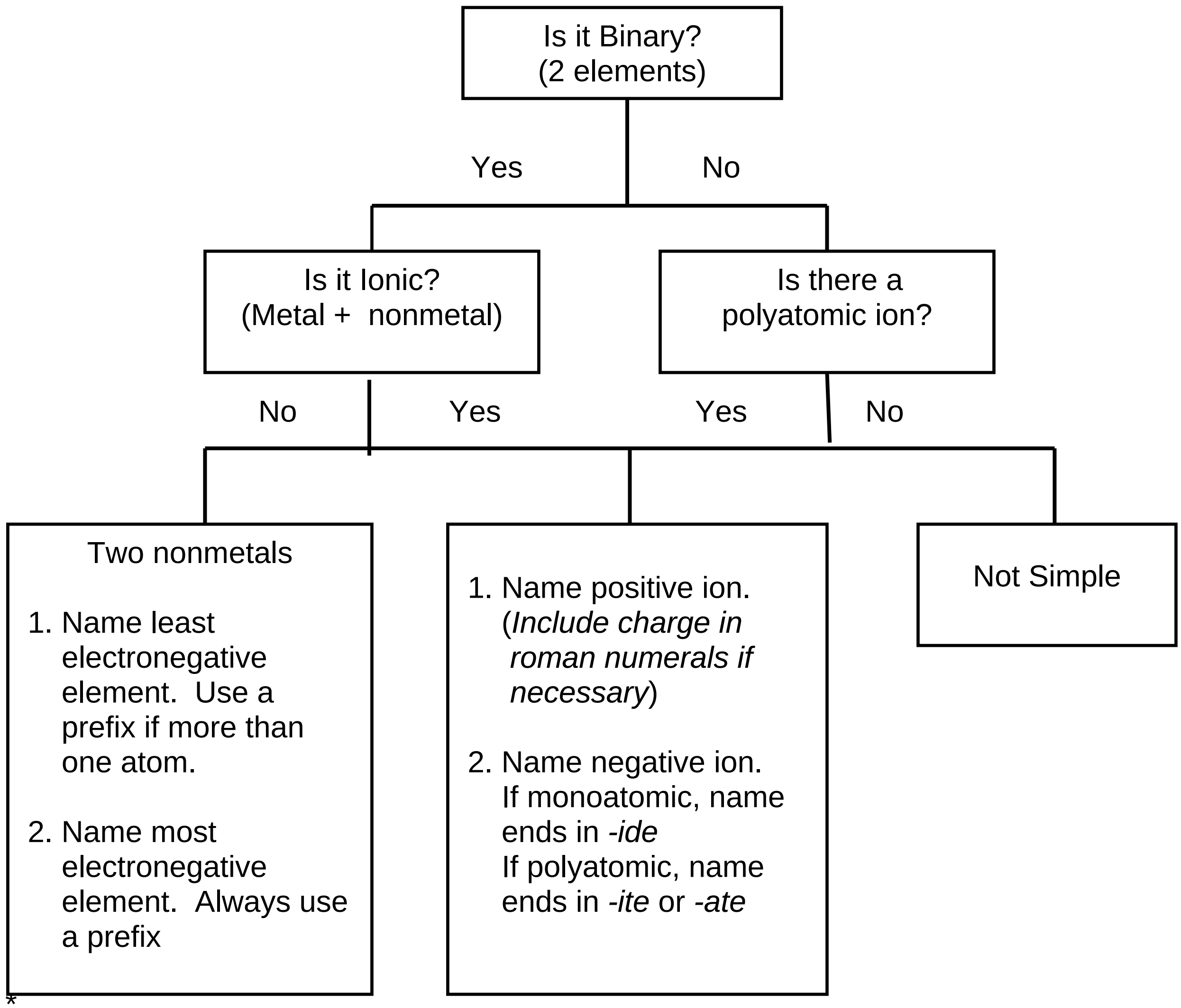
w) HClO w)______________________

x) RbOH x)______________________

y) CO y)______________________

z) PI_3 z)______________________

SUMMARY: NAMING COMPOUNDS



SUMMARY: NAMING COMMON ACIDS