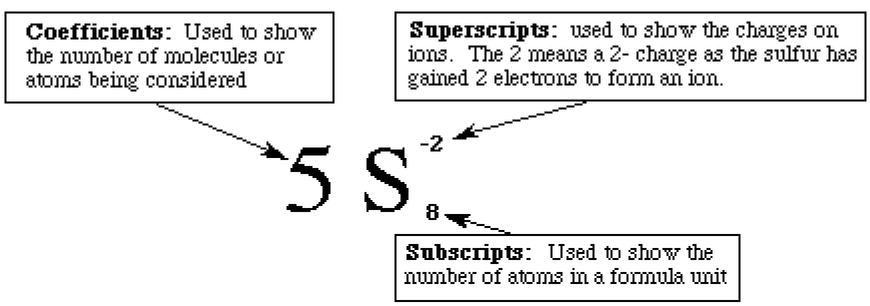
Chemical Nomenclature

Few topics in Chemistry affect your ability to succeed in later Chemistry courses as much as your ability to name compounds. If the chemical symbols are letters of the chemical alphabet, then chemical formulas are the words of chemistry, and it is these "words" that you will use throughout the remainder of your Chemistry career, however short that may be. Taken all together, the rules for naming compounds are many and varied, and often confusing, but if we learn a system of classifying compounds into types first, we can then apply the rules more easily. First, some terminology. Consider these to be **memorizable facts.**

- anion (an-eye-on) - another name for a negative ion (e.g. Cl^-)
- cation (cat-eye-on) - another name for a positive ion (e.g. Na^+)
- metal - elements that tend to lose electrons in reactions (form cations)
- non-metals - elements that tend to gain electrons in reactions (form anions or share electrons)
- binary compound - contains two elements
- ternary compound - contains three elements
- ionic compound - composed of bonded positive and negative ions
- molecular compound - atoms share electrons in bond (composed of 2 or more non-metals)
- covalent compounds - same as molecular compound
- chemical formula - shows number and kind of atoms in a molecule
- structural formula - shows how atoms are connected
- monoatomic - one atom
- diatomic - two atoms
- hydrates - some compounds have water molecules attached $CuSO_4 \cdot 5H_2O$



Chemical compounds generally fall into one of two major categories. **Organic Chemistry** is the study of carbon based compounds. **Inorganic Chemistry** is the study of compounds formed by everything else in the Periodic table, and were the focus of your learning activities in Science 10. Inorganic compounds can be classified according to "type" using the following system:

I. Binary Compounds

Are composed of two elements. e.g. H_2O, $FeCl_3$, Al_2S_3 etc.

A. **Salts** - Composed of any metal and any non-metal except oxygen. e.g. NaCl, BaF_2
B. **Oxides** - Composed of any metal plus oxygen. e.g. BaO, Li_2O etc.
C. **Peroxides** - Some oxides possess ***one more*** oxygen than you can explain using normal valence rules e.g BaO_2, Li_2O_2
D. **Acids** - Composed of Hydrogen and a non-metal in aqueous solution. e.g. $HCl_{(aq)}$, $HBr_{(aq)}$, $H_2S_{(aq)}$
E. **Molecular Compounds** - Composed of two non-metals. e.g. PCl_5, NH_3, P_2O_5 etc.

If you can look at a compound and classify it as one of the above, naming compounds becomes much easier.

Naming Binary Compounds

Note: Except for binary molecular compounds, you ***never*** attempt to indicate the number of each atom present in the formula of a binary compound. Just name the metal, name the non-metal and end it in **ide** (except for molecular compounds). That's all!

A. Binary Salts

Remember that binary compounds consist of ***two*** elements only. The positive (or metallic) ion is customarily written first.

1. Just name the metal,
2. name the non-metal and
3. end the name with the suffix "**ide**."

For example:

NaCl Sodium chlor**ide**
BaF_2 Barium Fluor**ide**
$AlBr_3$ Aluminum brom**ide**
K_2O Potassium ox**ide**
$CaBr_2$ Calcium brom**ide**
LiH Lithium hydr**ide**

Try these four.

$MgBr_2$ is ____________________ and Al_2S_3 is ____________________.

The formula for Beryllium nitride is ____________________.

The formula for Potassium phosphide is ____________________.

(Answers: magnesium bromide; aluminum sulfide, Be_3N_2; K_3P)

B. Oxides and Peroxides

Again, only 2 elements are present, one of which is **oxygen**.

1. name the metal,
2. name the non-metal (which is oxygen obviously) and
3. end the name with the suffix "**ide**."

Na_2O Sodium oxide	Ag_2O Silver oxide
BaO Barium oxide	Al_2O_3 Aluminum oxide

In some cases, compounds of oxygen exist which do not conform to normal rules of combining capacity (or valence). They possess one more atom of oxygen per formula unit than the normal oxide. Such oxides are designated by the prefix "**per -**".

For example: Na_2O_2 is Sodium **per**oxide and H_2O_2 is Hydrogen **per**oxide

Try these three.

The formula for **barium peroxide** is _________________.

The formula for **lithium peroxide** is ____________________.

K_2O_2 is the formula for ______________________.

(Answers: BaO_2; Li_2O_2; potassium peroxide)

What to do with metals having more than one valence?

Some metals have more than one combining capacity or valence, and in the naming of a compound containing one of these metals, you must indicate which metallic ion is being used. There are two ways of doing this. The first one (Classical) is old and out of favor and the second one (Stock System) is the one that we use in Chemistry. Both are shown here in case you want to know everything but you can just skip the Classical Method and focus on the Stock System.

The "old" method - the Classical Method

This method involves using the suffixes **-ous** and **-ic to distinguish between the low and high valence versions of the metal**. The suffix **-ous** is used to denote the presence of ion with the **lower** combining capacity or valence, and **–ic** denotes the presence of the metallic ion with the **higher** combining capacity or valence. For example, copper forms two ions; Cu^{+}, and Cu^{2+}. So copper and bromine could form two compounds; CuBr or $CuBr_2$.

1. Just name the metal, (using "ous" or "ic" where necessary)
2. name the non-metal and
3. end the name with the suffix "**ide**."

Naming these two compounds then goes as follows:

$CuBr$ Cupr**ous** bromide

$CuBr_2$ Cupr**ic** bromide

In a similar manner;

FeO is Ferr**ous** oxide

Fe_2O_3 is Ferr**ic** oxide

Hg_2O is Mercur**ous** oxide

HgO is Mercur**ic** oxide

$SnCl_2$ is Stann**ous** oxide

$SnCl_4$ is Stann**ic** oxide

Note: The problem with this method of distinguishing between the high and low valence versions of the metallic ion is that it is not consistent. Some metals are described using their Latin names, while others are written in English. Some metals can have more than two valences. Some metals have Latin names and only one valence so "ous" and "ic" are not necessary at all. It can get confusing. Here is a list of the names used for a selection of the "irregular" metallic elements. One of these Latin named divalent substances is a non-metal (just to confuse things further). If this method is to be used, this chart must be memorized.

Metal Name	Symbol	Latin Name	Name used in Nomenclature
Sodium	Na	Natrium	Sodium (only one valence)
Potassium	K	Kalium	Potassium (only one valence)
Iron	Fe	Ferrum	Ferr - ous or Ferr-ic
Copper	Cu	Cuprum	Cupr - ous or Cupr - ic
Silver	Ag	Argentum	Silver (only one valence)
Tin	Sn	Stannum	Stann - ous or Stann - ic
Antimony (non-metal)	Sb	Stibnum	Antimoni - ous or Antimon - ic or Stibn-ous or Stibn-ic
Tungsten	W	Wolfram (German) or Tungsten (English)	Tungsten
Gold	Au	Aurum	Gold
Mercury	Hg	Hydrargyrum	Mercur-ous or mercur-ic
Lead	Pb	Plumbum	Plumb-ous or Plumb-ic

Try using this method of naming divalent metals to name the following.

$HgBr_2$ is named _________________.

The formula for Stibn**ic** nitride is ________________.

The formula for Stann**ous** chloride is ___________.

(mercuric bromide; Sb_3N_5; $SnCl_2$)

The Stock System: The "newer" (and much simpler) method that is used in Chemistry today.

The other and much favored method is to denote the combining capacity of the metallic ion using **Roman Numerals**.

1. Just name the metal (using the roman numeral to indicate which valence is present)
2. name the non-metal and
3. end the name with the suffix "**ide**."

In this case:

CuBr is Copper**(I)** bromide

$CuBr_2$ is Copper**(II)** bromide

In a similar manner;

FeO is Iron**(II)** oxide

Fe_2O_3 is Iron**(III)** oxide

Hg_2O is Mercury**(I)** oxide

HgO is Mercury**(II)** oxide

$SnCl_2$ is Tin**(II)** chloride

$SnCl_4$ is Tin**(IV)** chloride

Try these four.

CuO is named ______________________.

The formula for Mercury(II) nitride is _________________________.

The formula for Tin(IV) sulfide is ________________________.

$FeCl_3$ is named ______________________.

(Copper (II) oxide; Hg_3N_2; SnS_2; Iron (III) chloride)

C. Binary Acids

Like other binary compounds, binary acids are made up of two elements only, one of which is hydrogen. However, if these compounds are not dissociated in water to form an aqueous solution they are not considered to be, and therefore are not named as acids. The symbol "$_{\mathbf{(aq)}}$" following the formula for these compounds tells us that the substance is in**aq**ueous solution and should be named as an acid. The name of a binary acid begins with the prefix **hydro-** and ends with the suffix **-ic** .

For example:

$HCl_{(aq)}$ is **hydro**chlor**ic** acid
$HF_{(aq)}$ is **hydro**fluor**ic** acid
$H_2S_{(aq)}$ is **hydro**sulfur**ic** acid
$HI_{(aq)}$ is **hydro**iod**ic** acid

Try these two.

The formula for Hydroselenic acid is ____________.

The formula for Hydrobromic acid is ______________.

($H_2Se_{(aq)}$; $HBr_{(aq)}$-acids are indicated with an (aq) subscript)

The **hydro-** in the name refers to the **water** in which the acid is dissociated, and **not the hydrogen** in the compound. In the gas phase, (no water!!) these compounds are named as ordinary binary compounds.

For example:
$HCl_{(g)}$ is hydrogen chloride
$HF_{(g)}$ is hydrogen fluoride

Note that systematically, these two compounds are molecular (see below) and should be named hydrogen **mono**chloride gas and hydrogen **mono**fluoride gas, but in common usage the prefix "**mono"** is omitted.

Try these two.

The formula for **Hydrogen selenide** is _____________.

The formula for **Hydrogen bromide** is _______________.

($H_2Se_{(g)}$; $HBr_{(g)}$)

D. Molecular Compounds

These compounds are **composed of two non-metals**, so the bond formed between the atoms in the molecule are of a different type than the ionic bonds in the compounds we have named so far. Since two reacting non-metals do not form ions when they bond, we cannot look for their charges on a table when we are trying to name them, so the naming rules change considerably. This then, is the first and only group of compounds whose name must include information about how many of each atom is present in the molecule. To do this, we use the following **prefixes.**

mono - means 1	hexa - means 6
di - means 2	hepta - means 7
tri - means 3	octo - means 8
tetra - means 4	nona - means 9
penta - means 5	deca - means 10

For example:

$CO_{(g)}$ is carbon **mono**xide

$CO_{2(g)}$ is carbon **di**oxide

$CCl_{4(l)}$ is carbon **tetra**chloride

P_2O_5 is **di**phosphorus **pent**oxide

If there is only one atom of the first element present, the prefix mono is not used in the name. However if there is more than one atom of the first element present in the compound the appropriate prefix must be used.

For example:

NH_3 is nitrogen **tri**hydride

N_2H_4 is **di**nitrogen **tetra**hydride

Note that NH_3 is more commonly referred to by its common or trivial name of **ammonia**.

Try these.

P_4O_{10} is ________________________________.

The formula for diarsenic pentasulfide is ________________.

SO_3 is named ____________________.

The formula for dinitrogen tetroxide is ____________________.

(tetraphosphorus decaoxide; As_2S_5; sulfur trioxide; N_2O_4)