Classification of Compounds

Compounds are classified based on the atoms that compose them. The IUPAC (International Union of Practical and Applied Chemistry) has designed a naming scheme for each compound group.

The following chart illustrates how we might subdivide the compounds for the purpose of naming them.

Compounds					
Covalent (contain nonmetal atoms combining with other nonmetal atoms)			Ionic (contain a metal or NH_4^+ ion)		
Binary Molecular contain only two different nonmetal atoms	Hydrocarbons contain hydrogen and carbon atoms only	Acids contain nonmetal atoms with hydrogen written first	Ammonium Compounds contain NH_4^+ ion	Monovalent Ionic Compound contain metal ions with only one charge	Divalent Ionic Compounds contain metal ions with two possible ionic charges

Example #1:

Formula	Group
$MnBr_2$	Ionic Compound; divalent metal cation (Note: Di because Mn has more than one possible charge)

Assignment #1: Determine the correct group to which each of the following compounds belongs.

Formula	Group
C_3H_6	
$(NH_4)_2SO_4$	
K_3PO_4	
FeO	
N_2O_5	
$HClO_4$	
$Ba(NO_3)_2$	

Naming Covalent Compounds

Covalent compounds contain nonmetal atoms combining with other nonmetal atoms. They can be classified into three groups based on the nonmetal atoms present. They are:

i) Binary Molecular Compounds

Binary molecular compounds contain only two nonmetals.

To Name:

- The first atom is named in full
- The second atoms name is shortened and -ide added.
- The prefixes below are added to the first and second name to indicate the number of atoms present in the compounds.
- The prefix mono is not placed on the first atom's name.

# of Atoms	Prefix	# of Atoms	Prefix
1	mono-	6	hexa-
2	di-	7	hepta-
3	tri-	8	oct-
4	tetra-	9	non-
5	penta-	10	dec-

Examples:
P_2O_5 = diphosphorus pentaoxide or diphosphorous pentoxide (either considered acceptable)
CO_2 = carbon dioxide

ii) Hydrocarbons(straight chained)

Hydrocarbons are compounds that contain only carbon and hydrogen.

To Name:

- The first part of the name is a prefix that indicates the number of carbon atoms. The prefixes are the same as those used by Binary Molecular compounds above except for the first four. These four are:

# of Carbon Atoms	Prefixes
1	meth -
2	eth -
3	prop -
4	but -

- The second part of the name is a suffix that describes if the compound contains single bonds, a double or a triple bond between the carbon atoms. The following table illustrates the naming and gives examples.

Group	Bonds between carbons	Suffix	Ratio of Carbon to Hydrogen	Example	Name
Alkane	all single	- ane	C_nH_{2n+2}	C_3H_8	propane
Alkene	one double	- ene	C_nH_{2n}	C_4H_8	butene
Alkyne	one triple	- yne	C_nH_{2n-2}	C_5H_8	pentyne

iii) Acids
Acids are substances formed when nonmetal ions combine with hydrogen. The hydrogen is written first in the compound and the naming is based on whether the anion (negative ion) is:

- simple (ion is mono)
- polyatomic. (ion is compound)

To Name Acids with Simple Anions: (Binary Acids)

- The first part of the name is the **prefix hydro.**
- This is followed by a the name of the **simple anion,** which is shortened and - ic added
  - for example chlorine (Cl-) would become chloric
- The last part of the name is the word **acid**

Acid	Ion	Name
HF	F^-	Hydrofluoric Acid
HI	I^-	Hydroiodic Acid

To Name Acids with polyatomic anions: (Ocyacids or Tertiary Acids)

- The first part of the name is the name of the anion which is shortened. One of two suffixes added to this name.
  - **- ic** if the anion name ends in **– ate** (more oxygen).
  - **- ous** if the anion name ends in **– ite** (less oxygen).
- The last part of the name is **acid**

Acid	Ion	Name
H_2SO_4	$SO_4{}^{2-}$	sulfuric acid (anion, sulfate)
$HClO_3$	$ClO_3{}^-$	perchlorous acid (anion, perchlorite)

To determine an acid formula from a name we:

1. Determine the anion present from the name.
2. Since the compound is an acid the cation (positive ion) is H +
3. Write down the formulas of the two ions. Make the value of the charge on the negative ion the subscript on the hydrogen ion

Example:
Sulfuric Acid

- sulfur**ic** ------> sulf**ate -------->** $SO_4{}^{2-}$
- acid -------> hydrogen --------> H^{+1}
- Formula -------> H_2SO_4

Naming ionic compounds

Ionic Compounds contain a metal or the ion NH_4^{+1}. All ionic compounds are named by listing the names of the two ions that are present. The cation always comes first.

Formulas for ionic compounds are termed **empirical.** This means that the ions are always listed in the simplest ratio.

In any ionic compound**: the total charge on the cation is equal and opposite to the total charge on the anion.** Overall, the compound is neutral.

This concept is illustrated in the table below

Formula	Ions charge	Number of ions present	Total charge
$Ca_3(PO_4)_2$	Ca^{2+}	3	+ 6
	PO_4^{3-}	2	- 6

- All ionic compounds contain a **cation** (ion with positive charge) and an **anion** (ion with negative charge)
- Ions (both anions and cations) can be either **simple** (one atom ions) or **complex** (polyatomic ions).

The ionic compounds can be broken into three groups, in order to name them.

i) Ammonium (NH_4 +) compounds

Ammonium compounds contain the complex cation NH_4^{+1}.

To Name: (using a table of common ions)

- The first part of the name is Ammonium
- Second part of name is the name of the anion.

Formula	Name
$(NH_4)_2SO_4$	Ammonium sulfate
$(NH_4)_3PO_4$	Ammonium phosphate

To determine formula from name

- Using a table of common ions determine the two ions that are present, the positive ion is NH_4^+ and then the anion.
- The subscript for the NH_4^{+1} ion in the formula will be the charge on the anion and the subscript for the anion will be one.
  For example: Ammonium carbonate

Ions present	NH_4^{+1}	CO_3^{2-}
Cross over charges to determine formula	$(NH_4)_2CO_3$	

ii) Monovalent Cations
Ionic compounds containing monovalent cations (cation with one charge) are named by simply listing the name of the cation and the name of the anion.

To Name (using a table of common ions):
- **Locate** the name of the metal cation (positive ion). Make sure it has only one charge.
- **Locate** the name of the anion.
- Place names together.
-

Formula	Name
AgCl	Silver chloride
$Mg(NO_3)_2$	Magnesium nitrate

To determine the formula from name: **(using a table of common ions)**
- locate the cation and anion in a table of common ions and write down the formula for each.
- Make the value of the charge for the cation the subscript for the anion and visa versa (cross over value of charges = cross-over method)
- simplify the formula to the simplest ratio of the ions. See table below
- if there is more than one complex ion needed in the formula then a bracket is placed around the ions and subscript used to indicate the number of ions needed.
-

Name	Ions charge	Formula	Empirical
Magnesium Oxide	Mg^{2+}	Mg_2O_2	MgO
	O^{2-}		

Divalent Cations
Ionic compounds containing divalent cations (metal ions with two possible ionic charges) can be named in two ways
1. Using the Stock system (Roman Numerals)
2. Using the Classical system (suffix - ic and - ous.)

A. Stock system:
- developed by **Alfred Stock** . This method places a Roman Numerals in brackets behind the name of the cation.
- The Roman Numerals is equal in value to the charge on the cation.

Cation	Name
Sn^{4+}	Tin (IV)
Cu^{+}	Copper (I)

To Name using Stock system given the formula:

- Locate the name of the anion and cation in a table of ions.
- Using the concept that the total charge of the anion and cation must be equal we can determine what the charge on the cation must be (anion charges are always fixed). See example below

Formula	Charge on Anion	**Total charge on anion**	**Total charge on Cation**	Number of Cation	Charge on Each Cation
Fe_2O_3	O^{2-}	**- 6**	**+6**	2	+3

- The name of the example above would be: Iron (III) oxide

To determine name then we: (using a table of common ions)

1. **Name the cation**
2. **Determine the charge on the cation using the method above.**
3. **Apply the correct Roman Numerals**
4. **Finally name of the anion.**

Formula	Name of Cation	Total Charge on Anion	Total charge on Cation	Charge on Cation	Name
Cu_2O	Copper	-2	+2	+1	Copper (I) oxide
$CrCl_3$	Chromium	-3	+3	+3	Chromium (III) chloride

To determine formula from name. See monovalent cations (on previous page)

1.3 Assignment: Nomenclature of Compounds

Complete the table:

Formula	Group	Name
HClO	Covalent; Acid	Hypochlorous Acid

Formula	**Group**	**Name**
C_2H_6		
		Copper(II) Oxide
H_3PO_4		
		Potassium Carbonate
C_6H_{10}		
		Pentene
Cl_2O		
		Hydroflouric Acid
$Co\ (SO_4)$		
		Tin(IV) Sulfide
XeF_6		
		Arsenic trifluoride
HI		
		Gold(III) Chloride
NaOH		