Chemical Formulas

I. Chemical Formula - statement in chemical symbols that represents the composition of a substance.
- A. Symbol - represents a single atom of an element or a mole of that element (6.02×10^{23} atoms)
- B. Subscripts - applies to the element that precedes it
  - 1. No subscript - 1 is understood
  - 2. allows us to determine the ratio of atoms which combine in a compound
    - a. Qualitative analysis - finds out the kinds of elements in a substance
    - b. Quantitative analysis - determines how much of each element is present
- C. Empirical Formula - simplest ratio in which the atoms combine to form a compound
  - 1. use subscripts to determine the least common factor
- D. Molecular Formula - the total number of atoms of each element in one molecule of a substance
- E. Structural Formula - shows how atoms are joined together in a molecule

II. Ionic Compounds - only exist as empirical formulas
- A. the ionic charge is carried as a superscript
  - 1. Positive ions are called cations
  - 2. Negative ions are called anions
- B. The total charge of an ionic compound must equal 0
  - 1. ex. $Mg^{2+} + F^{-} \rightarrow Mg^{2+} F^{-}_{2}$
  - 2. this is also true of polyatomic ions (treat a PAI as a single ion with its charge)
- C. In simple ions (one atom), the oxidation number is equal to the charge on the ion (periodic table)
- D. The oxidation number of oxygen is -2, except in peroxides when it is -1
- E. The oxidation number of hydrogen is +1, except in hydrides when it is -1

III. Naming Compounds
- A. Binary compounds - the less electronegative element is named first and the second element ends in <u>ide</u>.
  - 1. Ex. $MgCl_2$ is magnesium chloride
- B. Ternary compounds (containing polyatomic ions) - name the element, then the polyatomic ion
  - 1. Ex. $MgSO_4$ is magnesium sulfate
- C. Acids - contains hydrogen with a nonmetal or polyatomic ion
  - 1. Binary acid - use prefix hydro with the nonmetal and change the end to <u>ic</u>.
    - a. Ex. HCL is Hydrochloric Acid
  - 2. Ternary acid (containing polyatomic ion) -
    - a. ion ends in ate, use <u>ic</u> ending
      - 1. Ex. H_2SO_4 is sulfuric acid
    - b. ion ends in ite, use <u>ous</u> ending
      - 1. Ex. H_2SO_3 is sulfurous acid
- D. Metals with multiple oxidation states: New Format - Stock System
  - 1. Name of element, roman numeral of ionic charge in parenthesis
- E. ***Metals with multiple oxidation states: Old Format***
  - 1. ***first ion (oxidation) state is named with <u>ous</u> ending***
  - 2. ***second ion (oxidation) state is named with a <u>ic</u> ending***
- F. ***Molecular Substances***
  - 1. ***Prefixes are used in naming the nonmetal molecules***
    - a. ***If first element is 1, then do not use a prefix for it, but you must use a prefix for***

the second element at all times (mono, di, tri, tetra,)

1. ***Ex. CCl_4 is carbon tetrachloride***

b. ***If there is more than one element for the first element in the formula, then use the prefix for the first element also.***

1. ***ex. N_2O_5 – dinitrogen pentoxide***

III. Stoichiometry - the study of the quantitative relationships that can be derived from formulas and equations.

A. Formula Information

1. elements present in a compound
2. relative number of atoms of each element in a compound

B. the number of atoms of each element present in 1 molecule of the substance

C. Gram Atomic Mass - the quantity of the element which has a mass in grams equal to the atomic mass

1. equals 1 mole of the element
2. equals 6.02 X 10^{23} atoms of the element
3. occupies a volume of 22.4L at STP if it is a gas

D. Formula Mass - the sum of all the atomic masses in the formula of the substance

1. equals 1 mole of the compound
2. equals 6.02 X 10^{23} molecules of the compound
3. occupies a volume of 22.4L at STP if it is a gas

a. H_2O

b. $Ca(OH)_2$

Element	Atomic Mass	# of Atoms/Formula	Product
H	1	2	2
O	16	1	16
		Total Mass =	18

Element	Atomic Mass	# of Atoms/Formula	Product
Ca	40	1	40
O	16	2	32
H	1	2	2
		Total Mass =	74

2. Mole Relationships – 1 mole of any substance = the GAM
3. Percentage Composition - the percentage by mass of the elements in a compound

A. Formula : Mass of element in sample

Total mass of sample

1. H_2O: 2g/18g = 11.1%

   16g/18g = 88.9%

2. $Ca(OH)_2$: 40g/74g = 54.1%

   2g/74g = 2.7%

   32g/74g = 43.2%

   = 100%

B. ***Determining the Empirical Formula for a Compound from given masses***
   1. ***Convert the gram masses to moles***
   2. ***Determine the smallest whole number ratio of the atoms in the atom***
   3. ***Write the empirical formula using the ratio***
   4. ***Anything other than a whole number ratio may have to be increased***
      a. ***1.5 : 1 = 3 : 2***
   5. ***Once the empirical formula is derived, determine the GMW and determine its multiple to arrive at the correct formula.***

C. ***Determining the Empirical Formula for a Compound from given % composition***
   1. ***Convert the % composition to grams of substance by assuming 100g of substance***
   2. ***Proceed the same as determining the empirical formula from given mass***

3. Density of a Gas
   A. Determine the GMW of the gas
   B. Divide the GMW by 22.4L to determine the density of the gas at STP
      1. One mole of any gas at STP will occupy 22.4L