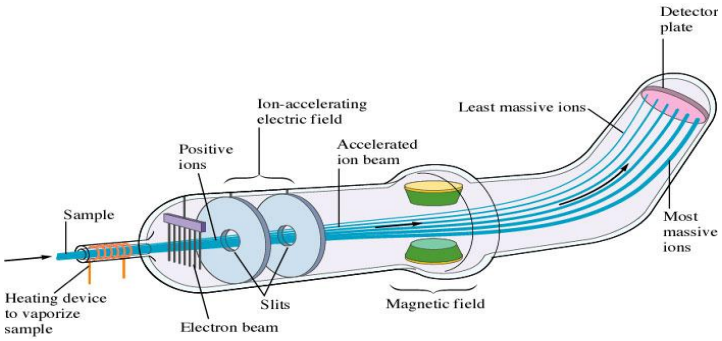
AP CHEMISTRY
CHAPTER 3
STOICHIOMETRY

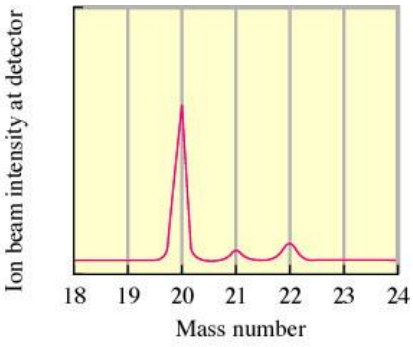
Avg. atomic mass- weighted avg. based on isotopic composition
This is determined using a mass spectrometer.

To calculate :
% Isotope A (mass of A) + % Isotope B (mass of B) + …= avg. atomic mass

Example:
What is average atomic mass in grams of lithium if 7.42% exists as ^{6}Li (6.015 g/mol) and 92.58% exists as ^{7}Li (7.016 g/mol)?

A mass spectrometer is an instrument used to determine the relative masses of atoms by the deflection of their ions in a magnetic field.
One use is to determine the isotopic abundance of a sample of an element. Samples are vaporized and ionized. The ions are then separated by mass and the data is graphed.





(b)

Mole -the # of C atoms in 12g of pure carbon-12

Avogadro's Number = 6.022×10^{23}

The mass of one mole of an element is equal to its atomic mass in grams.

Ex. Cody found a gold nugget that had a mass of 1.250 oz. How many moles was this? How many atoms? (1 lb = 16 oz, 453.59g = 1 lb)

Molar Mass = mass in grams of one mole of a substance

Ex. Calculate the molecular mass of cisplantin, $Pt(NH_3)_2Cl_2$

Ex. How many grams are 3.25 moles of cisplantin?

Percent Composition -"mass percent" or "percent by mass"

$$\frac{\text{Total mass of element}}{\text{Total mass of compound}} \times 100 = \%\text{ comp of element}$$

Ex. Find the percent composition of all elements in cisplantin, $Pt(NH_3)_2Cl_2$.

Determining the Formula of a Compound

Empirical formula- simplest whole number ratio of the various types of atoms in a compound

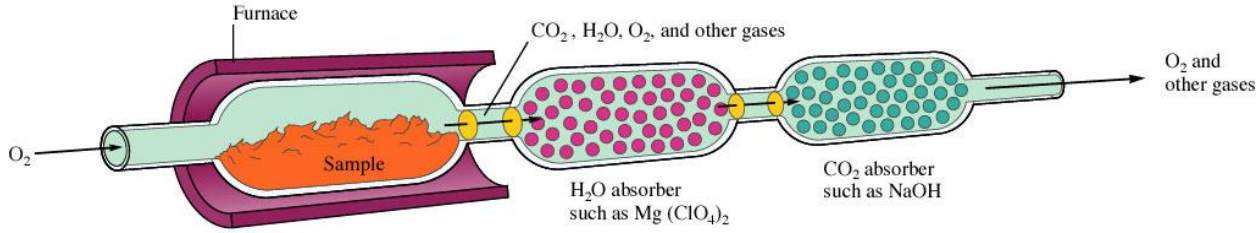
Molecular formula- the exact formula

- $(\text{empirical formula})_x$

Ex. A sample of a compound contains 11.66g of iron and 5.01g of oxygen. What is the empirical formula of this compound?

Ex. What is the empirical formula of hydrazine, which contains 87.5% N and 12.5%H?

Combustion Analysis



Combustion Analysis is done to determine the empirical formula of compounds containing C, H, and sometimes O. Additional O_2 is added to burn the sample of the compound. All of the H_2O is absorbed in the first chamber and all of the CO_2 produced is absorbed in the second chamber. Increases in the masses of the two chambers are used to determine the mass of CO_2 and H_2O produced.

Ex.
Suppose you isolate an acid from clover leaves and know that it contains only the elements C, H, and O. Heating 0.513g of the acid in oxygen produces 0.501g of CO_2 and 0.103g of H_2O. What is the empirical formula of the acid? Given that another experiment has shown that the molar mass of the acid is 90.04g/mol, what is its molecular formula?

Chemical Equations

Reactants → Products
Yields

A balanced equation must have the same # of atoms of each element on each side.

Symbols representing physical states: (*s*) (*l*) (*g*) (*aq*)

Balancing Chemical Equations

We balance equations by adding coefficients, never by changing formulas.

Most equations can be balanced by inspection. Some redox reactions require a different method.

Ex. $Al(s) + Cl_2(g) \rightarrow AlCl_3(s)$

$N_2O_5(s) + H_2O(l) \rightarrow HNO_3(l)$

$Pb(NO_3)_2(aq) + NaCl(aq) \rightarrow PbCl_2(s) + NaNO_3(aq)$

Ex. Phosphine, $PH_3(g)$ is combusted in air to form gaseous water and solid diphosphorus pentoxide.

Ex. When ammonia gas is passed over hot liquid sodium metal, hydrogen is released and sodium amide, $NaNH_2$, is formed as a solid product.

Stoichiometric Calculations

<u>Mole ratio</u> = moles required/moles given

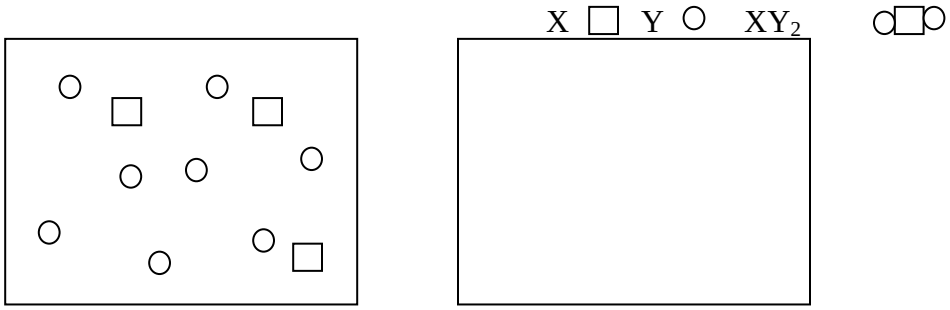
Ex. What mass of NH_3 is formed when 5.38g of Li_3N reacts with water according to the equation: $Li_3N(s) + 3H_2O \rightarrow 3LiOH(s) + NH_3(g)$?

Limiting Reagent

Limiting reagent- reagent that limits or determines the amount of product that can be formed

If you are given amounts of two or more reactants in a stoichiometry problem and asked to determine how much product forms, the easiest thing to do is to work a problem with each reactant and take the smaller of the answers.

$X + 2Y \rightarrow XY_2$



Assume that the reaction above goes to completion. Draw the resulting particles in the right-hand box. What is the limiting reagent?

Ex. How many moles of $Fe(OH)_3(s)$ can be produced by allowing 1.0 mol Fe_2S_3, 2.0 mol H_2O and 3.0 mol O_2 to react?

$2Fe_2S_3(s) + 6H_2O(l) + 3O_2(g) \rightarrow 4Fe(OH)_3(s) + 6S(s)$

Ex. If 17.0g of $NH_3(g)$ were reacted with 32.0g of oxygen in the following reaction, how many grams of $NO(g)$ would be formed?

$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(l)$

Theoretical yield- amount of product that should form according to stoichiometric calculations
Actual yield- experimental yield

$$\text{Percent yield} = \frac{\text{actual yield}}{\text{Theoretical yield}} \times 100$$

Ex. In the reaction of 1.00 mol of CH_4 with an excess of Cl_2, 83.5g of CCl_4 is obtained. What is the theoretical yield, actual yield and % yield?