Ch 3 Atomic Math and Stoichiometry

- Spectrometer math
- Moles - Mass - Atoms math
- Equations
- Stoichiometry

Mass spectrophotometer

1. Charged particles pass through a __________ ____________
2. The __________ mass they have, the more they are affected by the _________________ ______________.

Summary steps to how the Mass. Spec. works:

1. **Vaporize** - Separate particles from each other (break intermolecular forces)
2. **Ionize -** +1 or +2 charge is given by bombarding with a stream of __________
3. **Accelerate** - Use of - plates to accelerate ions
4. **Deflection -** Pass through the magnetic field

   Degree of deflection depends on Mass/charge ratio
5. **Detection -** detects size and # of that size
6. **Recording -** % of total sample that is each side

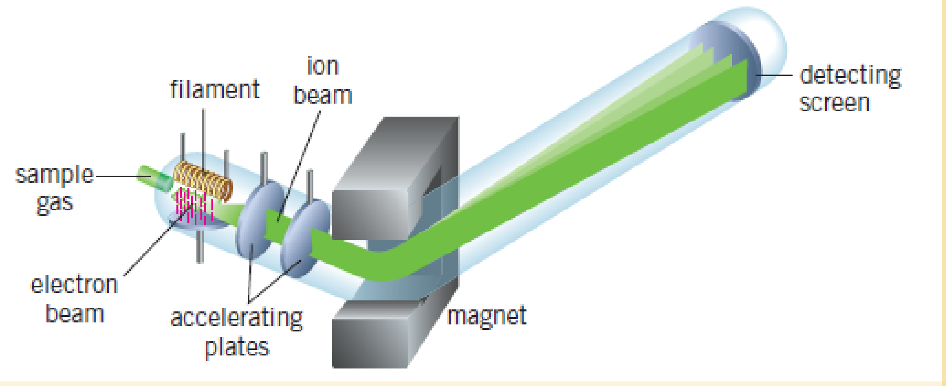
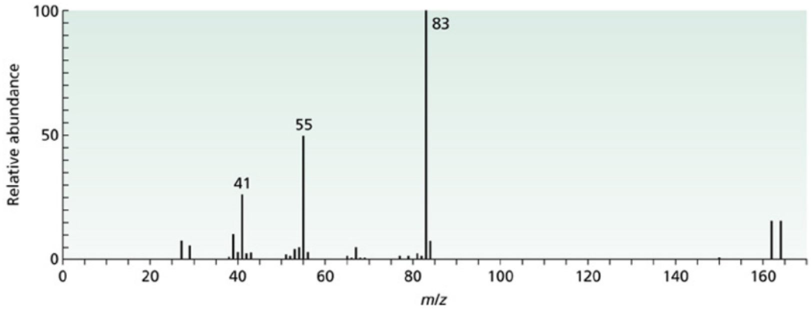


Figure 1.2.1 Schematic diagram of the major components of a mass spectrometer.

How to use the results of the Mass Spectrophotometer:

- The number of peaks in the mass spectrophotometer printout indicate the number of isotopes for that element

- % Abundance = (relative abundance $_{A)}$/(sum of total abundances) x 100



How to find the average atomic mass (the weighted average - just like your 9 weeks grade)

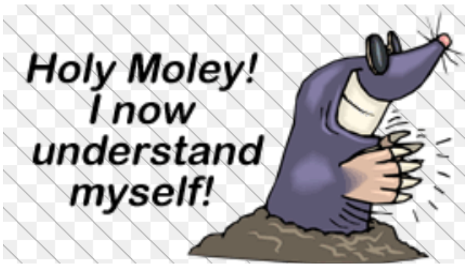
Average atomic mass = (isotope #1 mass * abundance) + (isotope #2 mass * abundance) ...

Example: 1. Use the data provided to determine the relative atomic mass of magnesium.

Isotope	Relative isotopic mass	Percentage abundance
^{24}Mg	23.99	78.70
^{25}Mg	24.99	10.13
^{26}Mg	25.98	11.17

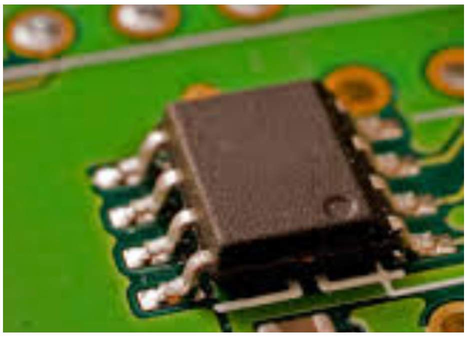
2. Gallium has two naturally occurring isotopes: ^{69}Ga with a relative isotopic mass of 68.93 and ^{71}Ga with a relative isotopic mass of 70.92. Given that the relative atomic mass of gallium is 69.72, determine the percentage abundances of each isotope.

A mole is....



Ex: How many pennies would contain 1 mole of Cu atoms. Pure copper pennies (before 1982) massed around 2.79 grams.

Ex: A silicon chip is used in a microcomputer and it has a mass of 5.68 mg. How many Si atoms are present?



Dimensional analysis is nice... but we can also just know our conversions for using the mole:

Moles =

Grams =

Molar mass =

<u>You may also need to ADD to find molar mass:</u>

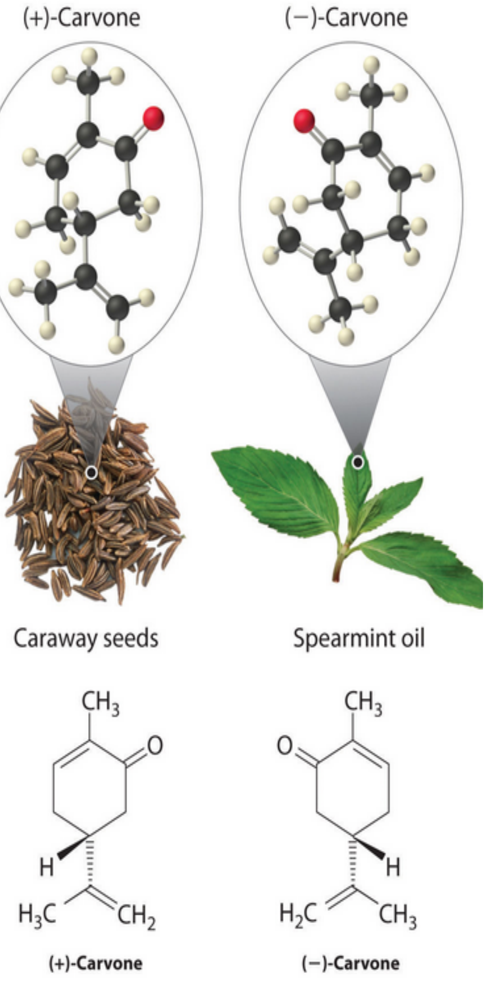
Ex: If you used 5.00 grams of baking soda, sodium bicarbonate to bake. How many moles did you use?

Ex: How many atoms of oxygen are present in the baking soda you used?

Ex: You were stung by a bee, who injected 1 microgram of isopentyl acetate into your skin. How many molecules of this substance was injected into you and how many carbon atoms were injected? Isopentyl acetate = $C_7H_{14}O_2$

Percent composition (by mass) calculations:

Carvone ($C_{10}H_{14}O$) is a chemical that has two isomers - one reponsible for spearmint smell, the other for caraway. Determine its % by mass composition of each element.



<u>Determining formulas of a compound:</u>

Empirical Formula-

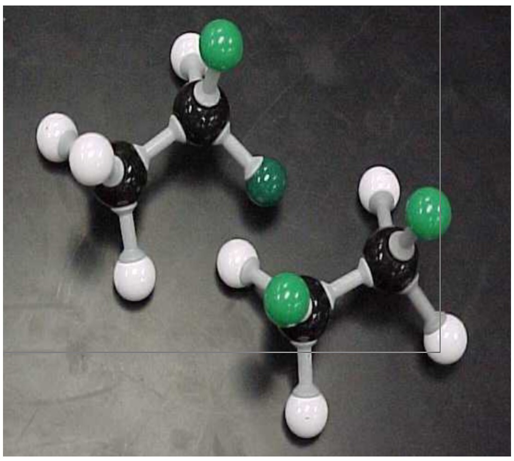
Molecular Formula-

Basic empirical formula math:

Ex: Determine the empirical formula for a compound found to contain 71.65% Cl, 24.27% C, and 4.07% H.

Using empirical formula data to also find Molecular formula for a compound:

Ex: Using the empirical formula data from above (and the empirical formula you found), determine the molecular formula if the compounds actual mass is 98.96 g/mol.



EMPIRICAL FORMULA DETERMINATION:

1) Convert % to grams if needed (just assume 100 grams total)

2) Determine the number of moles of each element present (divide by molar mass)

3) Divide the smallest mole value into all other mole values for this compound. If resulting subscripts is a whole number (± .05), these = subscripts of empirical formula.

4) If the numbers obtained in the previous step are not whole numbers, multiply EACH number by an integer so that the results are all whole numbers

0.25 x

0.33 x

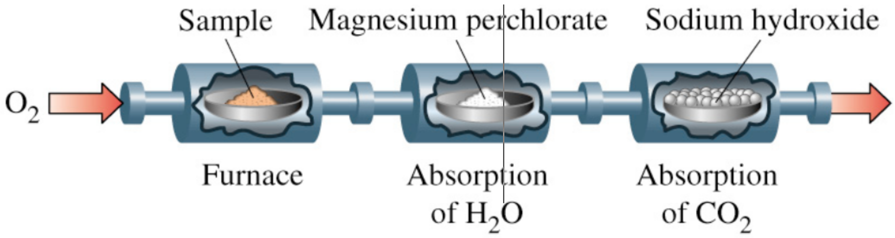
0.5 x

0.67 x

0.75 x

Determining formulas of a compound through "combustion analysis":

Ex: A substance contains Carbon, Hydrogen, and Nitrogen. When 0.1156 g of it was combusted with oxygen, 0.1638 g of CO_2 was produced and 0.1676 g of water was collected. Assume all carbon was converted to carbon dioxide and all hydrogen was converted to water, and calculate the empirical formula for it.



Steps:

1. Find mole fraction of Carbon and Hydrogen in CO_2 and H_2O
2. Multiply these fractions by the mass of water and carbon dioxide recovered. These resulting #s represent the mass of C and H that came from the compund.
3. Calculate the mass of the remaining 3rd element (in this case Nitrogen)
4. Complete empirical formula or % composition math based on the masses of C, H, and N that you just found.

Another Combustion analsysis example:

Ex 2: A compound containing carbon and hydrogen (a hydrocarbon) is burned. Combustion of 47.6-g of the compound produces 42.8-g of water and 156.8-g of carbon dioxide. Determine the empirical formula.

Chemical equations:

- Must follow the law of conservation of mass (How do we do that)

- Contain ________ on the left and ________ on the right

- Subscripts represent....

- Coefficients represent....

Let's try balancing a few equations:

Ex: $C_2H_5OH + O_2$ ----> $CO_2 + H_2O$

Ex: $Na_3PO_4 + ZnSO_4$ ---->

Ex: $NH_3 + O_2$ ----> $NO + H_2O$

Ex: Na + HOH ---->

https://www.youtube.com/watch?v=dmcfsEEogxs

Symbols you will see and use in a chemical equation:

(s) =

(g) =

(l) =

(aq) =

$\downarrow$ =

$\uparrow$ =

$\rightleftharpoons$ =

$\longrightarrow$ =

$\xrightarrow{\text{X temp}}$ =

$\xrightarrow{\text{Y atm}}$ =

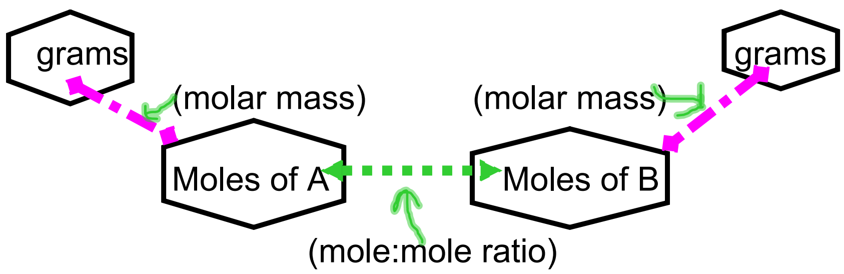
Stoichiometry

Use of a balanced equation to determine the amount of reactant needed or product produced.

1.) Always use a perfectly balanced equation

2.) Use the coefficients for the compounds involved in problem

3.) Use the double road map to complete ***Dimensional analysis*** problems



Stoichiometry examples:

Ex. 1: Solid lithium hydroxide is used in space shuttles to remove CO_2. Solid lithium carbonate and liquid water are formed as the reaction occurs. What mass of CO_2 can be absorbed by 1.00 kg of Lithium hydroxide?

Ex. 2: Sodium bicarbonate and magnesium hydroxide are both used as antacids in stomach medicines. Write and predict the reactions of each compound with HCl (found in your stomach). Then determine which is most effective per gram of antacid compound.

Limiting and Excess Stoichiometry:

2 Cracker Squares + 1 Marshmallow + 3 Chocolate Squares $\longrightarrow$ 1 S'more

$$2\ Cq + 1\ Mm + 3\ Ch \longrightarrow 1\ Cq_2MmCh_3$$

Use of a balanced equation and given amounts of reactants to calculate how much product can be made.

Notes:

1.) One reactant will normally "run out" and will STOP the reaction. This is your limiting reactant (LR) and dictates the amount of product expected

2.) One reactant will then be in excess (ER) - use LR to find ER leftover

3.) You typically don't get 100% of your expected yield in a lab setting (based on your stoichiometry predictions). You will be asked to calculate % yield.

$$\%\ \text{yield} = \frac{\text{g. experimental product}}{\text{g. theoretical product}} * 100$$

There are 2 ways to find your LR:

1. DA of each reactant ---> product (same)

   The lower product amount tells you who your LR is

2. DA of reactant to the other reactant

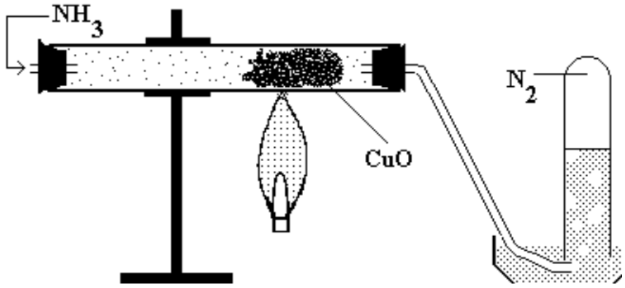
   *Reactant A predicted to amount of Reactant B needed

   *Reactant B predicted to amount of Reactant A needed

   * Then see who you didn't have enough of....

Practice for L/E stoichiometry:

Ex 1: Nitrogen gas is prepared by passing $NH_{3(g)}$ over $CuO_{(s)}$ at high temps. The other products of the reaction are $Cu_{(s)}$ and $H_2O_{(g)}$. If a sample containing 18.1 g of NH_3 is reacted with 90.4 g of CuO, Who is the LR and how many grams of N_2 are expected? If this reaction actually produces 6.63 g of product in the lab, what is the % yield?



<u>Another L/E Stoichiometry example:</u>

Methanol (CH_3OH) is manufactured by combining gaseous CO and H_2 . Suppose 68.5 kg of CO is reacted with 8.60 kg of H_2. Determine LR, and the amount of ER that was in excess. If 3.57 x 10^4 g is actually produced, what is the % yield?