Unit 6: Stoichiometry

Resources:
- ✓ Periodic Table
- ✓ Polyatomic Ions List

Chemical Equations:
- Reactants --> Products
  - Reactants are the substances that exists before a chemical reaction occurs
  - Products are the substances that exist after a chemical reaction has occurred
  - Reactants are always on the left, products always on the right

Balancing Equations
- The Law of Conservation of Mass - the number of atoms of each element must be the same before and after any chemical reaction
- Add COEFFICIENTS in front of any compound's formula to change the ratio
- No coefficient is written if the number is 'one'
- These coefficients represent the ratio of moles of each substance that participate in the reaction

The Mole
- The mole is the fundamental unit of amount, representing Avogadro's Number of particles
- Avogadro's Number = 6.02×10^{23} atoms/molecules/formula units/particles/etc.
- The MOLAR MASS of an element is the mass of 6.02×10^{23} atoms of that element
  - The molar mass is the atomic mass in grams
- The molar mass of a compound is the sum of the molar masses of the elements that make it up
- Use DIMENSIONAL ANALYSIS to interconvert between moles and grams

EXAMPLE #1: What is the mass of 3.2mol of lithium nitrate?

The molar mass of $LiNO_3$ is 68.95g/mol (6.94 = 14.01 + 3(16.00) = 68.95)

$$3.2 \text{ mol } LiNO_3 \times \frac{68.95 g\ LiNO3}{1\ mol\ LINO3} = 220.64 g\ LiNO_3$$

EXAMPLE #2: How many formula units are in 25.0g of ammonium carbonate?

The molar mass of $(NH_4)_2CO_3$ is 96.11g/mol [2(14.01) + 8(1.01) + 12.01 + 3(16.00) = 96.11]

$$25.0 g\ (NH_4)_2CO_3 \times \frac{1 mol\ (NH4)2CO3}{96.11 g\ (NH4)2CO3} \times \frac{6.02x10^{23} formula\ units}{1\ mol\ (NH4)2CO3} = 1.57x10^{23} \text{ formula units}$$

Stoichiometry
- Used when the amount of one substance is used to determine the amount of a different substance involved in the same chemical reaction.
- Substances are related by the mole ratio (coefficients of the balanced equation)
  - Convert to moles
  - Compare moles
  - Convert from moles

Limiting Reactants

- A reaction will stop when one reactant is completely used up
- The limiting reactant determines the amount of products that can be produced
- Other reactants will be in excess (more than enough)
- The easiest way to determine the limiting reactant is:
    - Calculate the theoretical yield of a product for EACH reactant
    - The reactant that can produce the least amount of product is the L.R.
- Also, the Limiting Reactant should be used to determine the amount of the other reactants that are used
    - Subtract this from the initial amount to find the amount in excess

EXAMPLE #3: 50.0g of Al react with 50.0g of O_2. (a) What mass of Al_2O_3 will be formed? (b) How much of which reactant is left over?

$$4\ Al + 3O_2 \rightarrow 2Al_2O_3$$

$$50.0g\ Al \times \frac{1mol\ Al}{26.987g\ Al} \times \frac{2mol\ Al2O3}{4mol\ Al} \times \frac{101.96g\ Al2O3}{1\ mol\ Al2O3} = 94.5g\ Al_2O_3$$

$$50.0g\ O_2 \times \frac{1mol\ O2}{32.00g\ O2} \times \frac{2mol\ Al2O3}{3mol\ O3} \times \frac{101.96g\ Al2O3}{1\ mol\ Al2O3} = 106g\ Al_2O_3$$

** ALUMINUM is the LIMITING REACTANT, so only 94.5g of product will be made.*

$$50.0g\ Al \times \frac{1mol\ Al}{26.987g\ Al} \times \frac{3mol\ O2}{4mol\ Al} \times \frac{32.00g\ O2}{1\ mol\ O2} = 44.5g\ O_2\ are\ USED$$

** SInce we STARTED with 50.0g of O_2 and 44.5g of O_2 are used in the reaction, there will be 5.5g EXCESS*

Yield

- The calculated maximum amount of product determined by stoichiometry is the THEORETICAL YIELD
- Due to error, the EXPERIMENTAL or ACTUAL YIELD will be less than the theoretical yield
- Percent Yield is a measure of the efficiency of a reaction
    - $\%\ Yield = \frac{Experimental\ Yield}{Theoretical\ Yeild} x\ 100$

Molarity

- Describes the concentration of a solution
- Molarity = moles of solute per liter of solution
- M = mol/L