Titrations

- Stoichiometry with solutions
- A titration is a laboratory technique where the concentration (or other quantity) of a solution can be determined by adding it to a solution of known concentration in carefully measured amounts until the reaction is complete. Titrations are most commonly associated with acid-base reactions, but they can be used with other types of reactions as well.

Step 1 – write the complete balanced equation for the reaction that is occurring
Step 2 - calculate of the known substance
Step 3 – use the mole ratio (from the balanced chemical equation) to calculate moles of the unknown substance
Step 4 – convert from moles to the specified quantity

Example What is the molarity of a sodium hydroxide solution if 25.0 mL is required to neutralize 40.0 mL of a 1.50 M solution of sulfuric acid?

Step 1 $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

Step 2 $n = C \bullet V = (1.50\ mol/L)(0.0400\ L) = 0.0600\ mol\ H_2SO_4$

Step 3 $$(0.0600\ \text{mol}\ H_2SO_4)\left(\frac{2\ \text{mol NaOH}}{1\ \text{mol}\ H_2SO_4}\right) = 0.120\ \text{mol NaOH}$$

Step 4 $$C = \frac{n}{V} = \frac{0.120\ \text{mol}}{0.0250\ \text{L}} = 4.80\ \text{mol/L NaOH}$$

Titrations – alternate method

$$\frac{C_aV_a}{R_a} = \frac{C_bV_b}{R_b}$$

C_a = concentration of substance A
V_a = volume of substance A
R_a = ratio of substance A (from the balanced chemical equation)
C_b = concentration of substance B
V_b = volume of substance B
R_a = ratio of substance B (from the balanced chemical equation)

Example What is the molarity of a sodium hydroxide solution if 25.0 mL is required to neutralize 40.0 mL of a 1.50 M solution of sulfuric acid?

Step 1 $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

Step 2
C_a = 1.50 mol/L C_b = ?
V_a = 40.0 mL = 0.0400 L V_b = 25.0 mL = 0.0250 L
R_a = 1 R_a = 2

$$\frac{C_aV_a}{R_a} = \frac{C_bV_b}{R_b}$$

$$C_b = \frac{C_aV_aR_b}{V_bR_a} = \frac{(1.50\ \text{mol/L})(0.0400\ \text{L})(2)}{(0.0250\ \text{L})(1)} = 4.80\ \text{mol/L NaOH}$$