Chemistry 350 | Spring 2017
20 points | Due <u>In Class Wednesday January 24</u>

Problem Set 1 -- Stoichiometry and Concentration Review

Complete all problems on separate paper. Show all work for credit. Correct use of significant figures is required for full credit.

1. Describe how to prepare 2.00 L of a solution that has a potassium concentration of 0.0100 M starting with:
   a. solid potassium sulfate
   b. 0.200 M potassium sulfate solution.

a.

$$\frac{0.010\ \cancel{mol\ K^{+}}}{1\ \cancel{L}} \times 2.00\ \cancel{L} \times \frac{1\ \cancel{mol\ K_2(SO_4)}}{2\ \cancel{mol\ K^{+}}} \times \frac{174.259\ g\ K_2(SO_4)}{1\ \cancel{mol\ K_2(SO_4)}} = 1.74\ g\ K_2(SO_4)$$

So, weigh 1.74 g $K_2(SO_4)$and dilute it to 2.00 L.

b.

$$\frac{0.010\ \cancel{mol\ K^{+-}}}{1\ \cancel{L}} \times 2.00\ \cancel{L} \times \frac{1\ \cancel{mol\ K_2(SO_4)}}{2\ \cancel{mol\ K}} \times \frac{1\ L}{0.200\ \cancel{mol\ K_2(SO_4)}} = 0.050\ L$$

So, dilute 0.050 L (50 mL) of 0.200 M $K_2(SO_4)$ to 2.00 L.

2. Ammonia can be generated by heating together the solids $Ca(OH)_2$ and NH_4Cl. $CaCl_2$ and water are also formed. How many grams of NH_3 will form if 33.0 grams each of NH_4Cl and $Ca(OH)_2$ are heated? (molar masses (g/mol): NH_4Cl = 53.4912, NH_3 = 17.03056, $Ca(OH)_2$ = 74.093, $CaCl_2$ = 110.983, water = 18.0153)

$$2NH_4Cl + Ca(OH)_2 \rightarrow CaCl_2 + 2H_2O + 2NH_3$$

If NH_4Cl is the limiting reactant, how many grams of ammonium could be produced?

$$33.0\ \cancel{g\ NH_4Cl} \times \frac{1\ \cancel{mol\ NH_4Cl}}{53.4912\ \cancel{g\ NH_4Cl}} \times \frac{2\ \cancel{mol\ NH_3}}{2\ \cancel{mol\ NH_4Cl}} \times \frac{17.03056\ \cancel{g\ NH_3}}{1\ \cancel{mol\ NH_3}} = \mathbf{10.51\ g\ NH_3}$$

If $Ca(OH)_2$ is the limiting reactant, how many grams of ammonium could be produced?

$$33.0\ \cancel{g\ Ca(OH)_2} \times \frac{1\ \cancel{mol\ Ca(OH)_2}}{74.093\ \cancel{g\ Ca(OH)_2}} \times \frac{2\ \cancel{mol\ NH_3}}{1\ \cancel{mol\ Ca(OH)_2}} \times \frac{17.03056\ \cancel{g\ NH_3}}{1\ \cancel{mol\ NH_3}} = \mathbf{15.17\ g\ NH_3}$$

Therefore, ammonium chloride must be the limiting reagent, and a maximum of 10.5 grams of ammonia could be produced.

3. 22.5 grams of magnesium nitrate, 23.0 mL of 1.20 M nitric acid and 14.9 grams of aluminum nitrate are placed in a 500.0 mL volumetric flask, dissolved and diluted to a total volume of 500.0 mL. What is the nitrate concentration, in moles per liter, in the resulting solution?

$$22.5\ \cancel{g\ Mg(NO_3)_2} \times \frac{1\ \cancel{mol\ Mg(NO_3)_2}}{148.3\ \cancel{g\ Mg(NO_3)_2}} \times \frac{2\ \cancel{mol\ NO_3^-}}{1\ \cancel{mol\ Mg(NO_3)_2}} = 0.3034\ mol\ NO_3^-$$

$$\frac{1.20\ \cancel{mol\ HNO_3}}{1\ \cancel{L}} \times 0.0230\ \cancel{L} \times \frac{1\ \cancel{mol\ NO_3^-}}{1\ \cancel{mol\ HNO_3}} = 0.0276\ mol\ NO_3^-$$

$$14.9\ \cancel{g\ Al(NO_3)_3} \times \frac{1\ \cancel{mol\ Al(NO_3)_3}}{212.996\ \cancel{g\ Al(NO_3)_3}} \times \frac{3\ \cancel{mol\ NO_3^-}}{1\ \cancel{mol\ Al(NO_3)_3}} = 0.2099\ mol\ NO_3^-$$

Therefore, the nitrate concentration is:

$$\frac{(0.3034 + 0.0276 + 0.2099) \text{ mol } NO_3^-}{0.5000 \text{ L}} = \frac{0.5409 \text{ mol } NO_3^-}{0.5000 \text{ L}} = 1.08 \text{ M } NO_3^-$$

4. You dissolve 2.83 g of a copper-containing mixture in water in a 100.0 mL volumetric flask and dilute it to the mark to prepare solution A. You then pipet 5.00 mL of solution A into a 25.00 mL volumetric flask and dilute it to the mark to make solution B. Finally, you pipet 1.00 mL of solution B into a 25.00 mL flask and dilute it to the mark to make solution C. You then determine the copper concentration in solution C to be 6.62 x 10^{-4}M. What is the percent copper by mass in your original solid mixture?

For solution B:

$$M_B = \frac{M_C V_C}{V_B} = \frac{(6.62 \times 10^{-4} \text{M})(25.00 \,\cancel{\text{mL}})}{1.00 \,\cancel{\text{mL}}} = 0.01655 \text{ M} = [B]$$

For solution A:

$$M_A = \frac{M_B V_B}{V_A} = \frac{(0.01655 \text{ M})(25.00 \,\cancel{\text{mL}})}{5.00 \,\cancel{\text{mL}}} = 0.08275 \text{ M} = [A]$$

So, the molarity of copper in solution A is 0.08275 M, how many grams of copper must be in the solution?

$$0.1000 \,\cancel{\text{L sol'n}} \times \frac{0.08275 \,\cancel{\text{mol Cu}}}{1 \,\cancel{\text{L sol'n}}} \times \frac{63.546 \text{ g Cu}}{1 \,\cancel{\text{mol Cu}}} = 0.5258 \text{ g Cu}$$

So, the percent copper is:

$$\frac{0.5258 \text{ g Cu}}{2.83 \text{ g mixture}} \text{ X } 100\% = \mathbf{18.6 \% \text{ copper}}$$

5. In order for your car battery to function properly, the sulfuric acid in the battery must be between 4.8 and 5.3 M H_2SO_4. A 5.00 mL sample of acid from a battery requires 49.74 mL of 0.935 M NaOH to be completely neutralized in a titration. Does the concentration of this battery acid fall within the desired range? Justify your answer with a calculation.

$$2 \text{ NaOH} + H_2SO_4 \rightarrow Na_2SO_4 + 2 \text{ } H_2O$$

$$49.74 \,\cancel{\text{mL NaOH}} \times \frac{0.935 \,\cancel{\text{mol NaOH}}}{1 \,\cancel{\text{L NaOHl}}} \times \frac{1 \text{ mol } H_2SO_4}{2 \,\cancel{\text{mol NaOH}}} \times \frac{1}{5.00 \,\cancel{\text{mL}}} = \mathbf{4.65 \text{ M } H_2SO_4}$$

No, the concentration of acid is outside the desired range.