Chemistry 222 **Name**_____
Spring 2011
Concentration units, etc.
20 Points, Due in class 1/10/11

Complete these problems on separate paper and staple your answers to this sheet. Identify your answers clearly and present them with the correct units and significant figures. Show all work.

1. Here's a warm-up. Define the following concentration units:
   a. Molarity: moles solute per liter of solution
   b. Parts per billion: grams solute per billion grams solution
   c. Volume percent (or % w/v): grams solute per hundred mL solution

2. One more warm-up: How many mL of 0.115 M sodium hydroxide is required to quantitatively neutralize 11.2 mL of 0.0978 M sulfuric acid?

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

$$11.2\ mL \times \frac{0.0978\ \cancel{mol\ H_2SO_4}}{1\ \cancel{L}} \times \frac{2\ \cancel{mol}\ \cancel{NaOH}}{1\ \cancel{mol\ H_2SO_4}} \times \frac{1\ \cancel{L}}{0.115\ \cancel{mol\ NaOH}} = 19.0_4\ mL$$

3. A household cleaner contains 0.030% (w/v) of a benzalkonium chloride salt (molecular formula: $C_{25}H_{46}NCl$) as a disinfectant. What is the concentration of the benzalkonium chloride salt in moles per liter? In ppm?

$$\frac{0.030\ \cancel{g\ C_{25}H_{46}NCl}}{100\ \cancel{mL\ sol'n}} \times \frac{1\ mol\ C_{25}H_{46}NCl}{396.08\ \cancel{g\ C_{25}H_{46}NCl}} \times \frac{1000\ \cancel{mL}}{1\ L} = 7.6x10^{-4}\ M$$

$$\frac{0.030\ \cancel{g\ C_{25}H_{46}NCl}}{100\ \cancel{mL\ sol'n}} \times \frac{1\ \cancel{mL\ sol'n}}{1\ \cancel{g\ sol'n}} \times 10^6 = 300\ ppm$$

*since the solution is dilute, assuming a density of 1 g/ml is reasonable

4. Starting with sodium sulfate, you need to prepare 4.0 L of solution that has a sodium concentration of 0.025 M. How many grams of sodium sulfate are needed to prepare this solution?

$$Na_2SO_4 \rightarrow 2Na^+ + SO_4^{2-}$$

$$4.0\ \cancel{L} \times \frac{0.025\ \cancel{mol\ Na^+}}{1\ \cancel{L}} \times \frac{1\ \cancel{mol}\ \cancel{Na_2SO_4}}{2\ \cancel{mol\ Na^+}} \times \frac{142.043\ g\ Na_2SO_4}{1\ \cancel{mol\ Cl^-}} = 7.1\ g$$

5. A 50% (w/w) sodium hydroxide solution has a density of 1.50 g/mL. How many mL of this solution will be required to prepare 0.750 L of 0.1000 M NaOH?

$$0.750\ \cancel{L} \times \frac{0.1000\ \cancel{\text{mol NaOH}}}{1\ \cancel{L}} \times \frac{39.997\ \text{g NaOH}}{1\ \text{mol}\ \cancel{\text{NaOH}}} = 2.9998\ \text{g NaOH needed}$$

$$2.9998\ \cancel{\text{g NaOH}} \times \frac{100\ \cancel{\text{g sol'n}}}{50\ \cancel{\text{g NaOH}}} \times \frac{1\ \text{mL sol'n}}{1.5\ \cancel{\text{g sol'n}}} = 3.9997\ \text{mL} = 4\ \text{mL needed}$$

6. After being used in a homicide, an iron pipe (725 g) was tossed into a 50,000.0 gallon (1 gal = 3629 g) wine vat and was dissolved over a period of time. If wine can contain no more than 0.40 ppm of Fe before excessive cloudiness occurs, is the vat of wine ruined?

$$50000\ \cancel{\text{gal.}} \times \frac{3629\ \text{g}}{1\ \cancel{\text{gal}}} = 181{,}450{,}000\ \text{g solution}$$

$$\frac{725\ \cancel{\text{g Fe}}}{181{,}450{,}000\ \cancel{\text{g sol'n}}} = \frac{x\ \cancel{\text{g Fe}}}{10^6\ \cancel{\text{g sol'n}}} \qquad x = 3.99\ \text{ppm, so the vat is ruined.}$$

7. Sulfate can be determined gravimetrically by precipitating sulfate ion with barium to form insoluble barium sulfate. A 200.00 mL sample of a solution containing an unknown sulfate ion concentration was reacted with an excess of barium nitrate. The resulting precipitate was filtered, dried, and weighed. If the mass of the precipitate was 0.0374 g, what was the concentration of sulfate ion in the original sample in ppm? Assume the density of the solution is 1.00 g/mL.

$$Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$$

$$0.0374\ \text{g}\ BaSO_4 \times \frac{1\ \cancel{\text{mol}\ BaSO_4}}{233.391\ \text{g}} \times \frac{1\ \cancel{\text{mol}\ SO_4^{2-}}}{1\ \cancel{\text{mol}\ BaSO_4}} \times \frac{96.064\ \text{g}\ SO_4^{2-}}{1\ \cancel{\text{mol}}\ SO_4^{2-}} = 0.01539\ \text{g}\ SO_4^{2-}$$

Since d = 1 g/mL, 200 mL sol'n = 200 g sol'n

$$\frac{0.01539\ \text{g}\ SO_4^{2-}}{200\ \text{g sol'n}} \times 10^6 = 77.0\ \text{ppm}\ SO_4^{2-}$$