Name _____ **Honors Chemistry** **___/___/___**

Solution Composition

- Because a mixture, unlike a chemical compound, has a variable composition, the relative amounts of substances in a solution must be specified.
- Some ways to calculate the composition of a solution are shown below. They include: molarity(M), molality(m), Mass percent (sometimes called weight percent), percent volume and mole fraction (symbolized by the Greek letter chi, X)

$$\text{Molarity(M)} = \frac{\text{moles of solute}}{\text{liters of solution}}$$

$$\text{Mole fraction of component A} = X_A = \frac{N_A}{N_A + N_B}$$

$$\text{Molality(m)} = \frac{\text{moles of solute}}{\text{kilograms of solvent}}$$

$$\text{Mass Percent} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 100\%$$

$$\%\ \text{volume} = \frac{\text{mL of solute}}{\text{mL of solution}} \times 100$$

- **Example:** A solution is prepared by mixing 12.00 g ethanol (C_2H_5OH) with 100.0 g water to give a final volume of 115 mL. The density of ethanol is 0.789 g/mL. Calculate the molarity, mass percent, percent volume, mole fraction and molality of ethanol in this solution.
  - **Molarity:**
    - Moles C_2H_5OH = 12.00 g C_2H_5OH ÷ 46.07 g/mol C_2H_5OH = 0.260 mol C_2H_5OH
    - Volume = 115 mL ÷ 1000 ml/L = 0.115 L
    - Molarity = 0.260 mol ÷ 0.115
    - **Molarity = 2.26 M**
  - **Mass Percent:**
    - Mass Percent = (12.00 g C_2H_5OH) ÷ (100.0 g H_2O + 12.00 g C_2H_5OH) x 100%
    - Mass Percent = (12.00 g C_2H_5OH) ÷ (112.0 g solution) x 100%
    - **Mass Percent = 10.71% C_2H_5OH**
  - **Percent Volume:**
    - Use density to convert mass of ethanol to volume of ethanol: 0.789 g/mL = 12.00/x = 15.2 mL
    - Percent volume = (15.2 mL C_2H_5OH) ÷ (115 mL solution) = **13.2% C_2H_5OH**
  - **Mole Fraction:**
    - Mole Fraction of C_2H_5OH = (moles C_2H_5OH) ÷ (moles C_2H_5OH + moles H_2O)
    - Moles H_2O = 100.0 g H_2O ÷ 18.0 grams/mol = 5.56 mol
    - Moles C_2H_5OH = 12.00 g C_2H_5OH ÷ 46.07 g/mol C_2H_5OH = 0.260 mol C_2H_5OH
    - Mole Fraction of C_2H_5OH = 0.260 ÷ (0.260 + 5.56)
    - Mole Fraction of C_2H_5OH = 0.260 ÷ 5.82
    - **Mole Fraction of C_2H_5OH = 0.0447**
  - **Molality:**
    - Molality of C_2H_5OH = (moles C_2H_5OH) ÷ (kilogram of H_2O)
    - Molality of C_2H_5OH = 0.260 ÷ 0.1000 kg
    - **Molality of C_2H_5OH = 2.6 m**

Dilutions

Many of the regularly used solutions are prepared as concentrated solutions. These concentrated solutions are referred to as stock solutions. Often times a lab or a demo calls for a less concentrated solution. The stock solutions are diluted (often with water) to make the desired solution. The process of adding more solvent to a solution is called a **dilution**. Acids are often purchased in their concentrated form. A bottle of concentrated sulfuric acid is 18.0 M. **For example:** a lab calls for 500. mL of a 6.00 M sulfuric acid solution, we must take from the stock solution and make a dilution. To do so we use the dilution formula ($\mathbf{M_1V_1 = M_2V_2}$). M_1 represents molarity of the stock solution. V_1 represents how much of the stock solution you need. Usually V_1 will be the value you are solving for, "x". M_2 is the desired molarity of the dilution. V_2 is the desired volume of the dilution. To make this dilution follow the steps below:

Remember: When diluting an acid, do as you otta and add acid to water

$M_1 = 18.0\ M \qquad V_1 = X \qquad M_2 = 6.00\ M \qquad V_2 = 500.\ mL$

$M_1V_1 = M_2V_2$

$18.0x = (6.00)(500.)$

$18.0x = 3000$

$x = 167\ mL$

To prepare 500. mL of a 6.00 M solution, you should obtain 167 mL of the stock solution and dilute it to 500. mL using a **volumetric flask**.

Dilution calculations are often accompanied by a sentence similar to the one above indicating how the dilution should be made. Solutions are always prepared in a volumetric flask.

Homework:

Percent Solutions

1. If 10.0 mL of acetic acid ($HC_2H_3O_2$) is diluted with water to a total solution volume of 200. mL, what is the percent by volume of acetic acid in solution?

2. A 75.0 gram sample of a solution contains 18.7 grams of potassium iodide. What is the mass percent of this solution?

3. A 900. mL solution is known to contain 150. mL of ethanol. Calculate the volume percent of this solution.

4. How many grams of magnesium sulfate are required to make 250. g of a 1.6% solution?

5. A solution contains 2.7 grams of $CuSO_4$ in 75 g of solution. What is the percent mass of the solution?

6. How many grams of glucose ($C_6H_{12}O_6$) would you need to prepare 2.0 kg of 2.0% solution?

Mole Fractions

1. If 42.0 grams of calcium chloride is dissolved in 600. grams of water, what is the mole fraction of calcium chloride in water?

2. If 600.0 grams of potassium iodide is dissolved in 1300. grams of water, what is the mole fraction of potassium iodide in water?

3. If 550.0 grams of potassium nitrate are dissolved in 750. grams of water, what is the mole fraction of potassium nitrate in water?

4. If 70.0 grams of HCl are added to 200. grams of water, what is the mole fraction of HCl in water?

Molality

1. A saline solution contains 12.0 moles of NaCl in 2.00 kg of water. What is its molality?

2. How many moles of calcium chloride are necessary to dissolve in 250. grams of water to make a 2.0m solution?

3. How many kilograms of solvent would be needed if you use 5.00 moles of sodium chloride to produce a 6.00 molal solution?

4. How many grams of table sugar (sucrose: $C_{12}H_{22}O_{11}$) should be dissolved in 3.50 kilograms of water to make a 1.15m solution?

Dilutions

1. How would you prepare 100. mL of 0.40 M $MgSO_4$ from a stock solution of 2.0 M $MgSO_4$?

2. Describe how to prepare 500. mL of 0.250 M NaOH solution starting from 6.00 M NaOH solution.

3. If 650 mL of water is added to 250. mL of 0.20 M KBr what is the new molarity?

4. How much water should be added to 400. mL of a 2.50 M sodium chloride solution to dilute it to a 1.00 M solution?

Mixed Problems

1. Calculate the molality of a 20.0 percent by weight aqueous solution of NH_4Cl.

2. What is the mole fraction of ethanol, C_2H_5OH, in an aqueous solution in which the ethanol concentration is 4.6 molal?

3. A solution of toluene (molecular weight 92.1) in benzene (molecular weight 78.1) is prepared. The mole fraction of toluene in the solution is 0.100. What is the molality of the solution?

4. A bottle of wine contains 12.5% ethanol by volume. The density of ethanol (C_2H_5OH) is 0.789 g/cm^3. Calculate the concentration of ethanol in wine in terms of molality, and mass percent.

5. An aqueous antifreeze solution is 40.0% ethylene glycol ($C_2H_6O_2$) by mass. The density of the solution is 1.05 g/cm^3. Calculate the molality, molarity and mole fraction of the ethylene glycol.

6. A solution is prepared by mixing 25.0 g ethanol (C_2H_5OH) with 100.0 g water to give a final volume of 120 mL. Calculate the molarity, mass percent, mole fraction and molality of ethanol in this solution