Name _____**Chem 162, Section**: _____**Group Number:** _____

ALE 25. Units of Concentration

(Reference: 13.5 *Silberberg 5th edition*)

How do you convert from one unit of concentration to another?

Your Goal: to be able to convert from one unit of concentration in the model below to any other unit of concentration in the model using dimensional analysis (factor-label method) to show your work.

1. The first step in achieving this goal is to *memorize* each unit of concentration in the model below…

The Model: Units of Concentration

Unit of Concentration	Ratio	Major Uses
Molarity (*M*)	$\frac{\text{(mol) of solute}}{\text{volume (L) of solution}}$	Stoichiometric calculations involving solutions since V(L) x M = mol solute
Molality (*m*)	$\frac{\text{(mol) of solute}}{\text{mass (kg) of solvent}}$	Does not change with temp. ∴ used in BP elevation and FP depression calculations
Parts by mass (mass fraction)	$\frac{\text{mass of solute}}{\text{mass of solution}}$ = mass fraction	Commly used in the biological, medical and environmental sciences. ppm and ppb are used when solute concentration is very low.
Parts per million (ppm)	= (mass fraction) x 10^6	
Parts per billion (ppb)	= (mass fraction) x 10^9	
Mass % (% w/w or % m/m)	(mass fraction) x 100	
Volume % (% v/v)	$\left(\frac{\text{volume of solute}}{\text{volume of solution}}\right)$ x 100	
Mass/Volume % (% m/v)	$\left(\frac{\text{mass of solute}}{\text{volume of solution}}\right)$ x 100	
Mole fraction (*X*)	$\frac{\text{(mol) of solute}}{\text{(mol) of solute + (mol) of solvent}}$	Used in Raolt's Law Calculations when finding the vapor pressure of a solution

2. Your task now is to practice applying using these units of concentration. Consider the following questions when solving problems involving conversion of one unit of concentration to another:
   a. What are the units of concentration given in the problem?
   b. What are the units you are converting to?
   c. What is (are) the conversion factor(s) needed to get the desired unit of concentration?
   d. Set up the problems using dimensional analysis. Units should cancel to give the units desired.

3. **Useful Conversion Factors**

To convert between…	Conversion factor	Units of conversion factor
moles of a substance and its *mass*	molar mass or molecular weight	g / 1 mol
mass of a substance and its *volume*	density, d	g / 1 mL or g / 1 L (for gases)
moles of solute to *volume of solution*	Molarity, M	mol solute / 1 L solution
moles of solute to *kg solvent*	molality, m	mol solute / 1 kg solvent

Exercises

Use dimensional analysis (factor-label method) and correct significant figures to solve the following problems. Circle you answer for each question.

1. Calculate the molarity of a solution made by diluting 25.0 mL of 6.15 *M* HCl to a volume of 0.500 L with water. *Circle your answer.*

2. How would you prepare 3.5 L of 0.55 *M* NaCl from solid NaCl? *Circle your answer.*

3. Calculate ***molality*** of a solution containing 164 g of HCl in 753g of water. *Circle your answer.*

4. Calculate the ***molality*** of a solution consisting of 2.77 mL of carbon tetrachloride (CCl_4, d = 1.59 g/mL) in 79.5 mL of methylene chloride (CH_2Cl_2, d = 1.33 g/mL) *Circle your answer.*

5. A 28.8 mass % aqueous solution of iron (III) chloride has a density of 1.280 g/mL.
   a.) Calculate the ***molality*** of the solution. ***Circle your answer.***

   b.) Calculate the ***molarity*** of the solution. ***Circle your answer.***

   c.) Calculate the mole fraction of $FeCl_3$. ***Circle your answer.***

6.a. How many grams of solid NaOH are needed to prepare 250.0g of 1.00% (w/w) NaOH in water? ***Circle your answer.***

   b.) How many grams of water are needed? ***Circle your answer.***

   c.) How many mL of water at 20.0 ^oC are needed? (d_{water} at 20.0 ^oC = 0.9882 g/mL) ***Circle your answer.***

   d.) What is the molality of the solution? ***Circle your answer.***

6e.) What is the approximate freezing point of the solution? (K_f for water = 1.86 $^oC/m$) *Circle your answer.*

7a. Concentrated hydrochloric acid purchased from chemical supply houses is 37% HCl by mass. What mass in grams of conc. HCl is needed to make 1.0 liter of 0.10 M HCl? *Circle your answer.*

b.) How would you make the 0.1 M HCl solution? *Circle your answer.*

8. Calculate the molality 2.00 % NaCl (w/w). (NaCl = 58.4425 g/mol) *Circle your answer.*

9. Conc. hydrobromic acid can be purchased as 40.0% HBr by mass. The density of the solution is 1.38 g/mL. What is the molar concentration of 40.0% HBr? (HBr = 80.912 g/mol) *Circle your answer.*

Recall Raoult's Law from the last ALE…

Raoult's Law

$$\mathbf{P_{soln} = (X_{solvent})(P^{o}_{solvent})}$$

Where…

P_{soln} = Vapor Pressure of Solution
$X_{solvent}$ = mole fraction of solvent
$P_{osolvent}$ = Vapor pressure of the pure solvent

10. Dibutyl phthalate, $C_{16}H_{22}O_4$ (mw = 278 g/mol), is an oil sometimes worked into plastic articles to give them softness. It has a negligible vapor pressure (P = 1 torr @ 148 ^{o}C). What is the vapor pressure at 20.0 ^{o}C of a solution of 20.0 g dibutyl phthalate in 50.0 g of octane, C_8H_{18} (mw = 114 g/mol)? The vapor pressure of pure octane at 20.0 ^{o}C is 10.5 torr. *Circle your answer.*