Chapter 11
Properties of Solutions

11.1 Solution Composition

Solute is dissolved in the solvent to produce a homogeneous solution

1.) **Molarity**, ***M***, [ ]: moles of solute / Liter of solution
2.) **Mass Percent**: (mass of solute / mass of solution) x100
3.) **Mole fraction, χ**: moles of component A / total moles in the mixture
4.) **Molality, *m***: moles of solute / kg of solvent. Useful where temperature is a factor that will change the volume of solution, but not the mass. Colligative properties. In very dilute solutions, the magnitude of Molarity $\approx$ Molality
5.) **Normality, *N***: number of *equivalents/liter of solution. *Equivalent depends on the type of reaction taking place. Ex. in an acid base reaction with H_2SO_4 (98 g/mol), each mole of H_2SO_4 can furnish 2 moles of H^+ so the equivalent mass is 49 grams. Therefore a 1*M* H_2SO_4 is 2*N* (in an acid base reaction.).

In Class Examples:

1. 1.00g of ethanol (C_2H_5OH, D=0.789 g/ml) is dissolved into 100.0 g of H_2O to produce a solution with a final volume of 101.0 ml. Calculate:

Molarity: $\dfrac{\left(\dfrac{1.00\text{gEtOH}}{46.1\text{g/mol}}\right)}{0.101\text{L}} = 0.215M$

Mass Percent: $\left(\dfrac{1.00\text{gEtOH}}{101.0\text{gsoln}}\right)x100 = 0.990\%$

Mole Fraction: $\dfrac{\left(\dfrac{1.00gEtOH}{46.1g/mol}\right)}{\left(\dfrac{1.00gEtOH}{46.1g/mol}\right)+\left(\dfrac{100gH_2O}{18g/mol}\right)} = \dfrac{0.0217mol}{5.78} = 0.00376$

Density: $\dfrac{1.00gEtOH + 100.0gH_2O}{\left(1.00gEtOHx\dfrac{1ml}{0.789g}\right)+(100.0gH_2O)\dfrac{1ml}{1g}} = \dfrac{101g}{101.3} = 0.997\dfrac{g}{ml} \approx 1\dfrac{g}{ml}$

Molality: $\left(\dfrac{\dfrac{1.00gEtOH}{46.1g/mol}}{0.100kgsolvent}\right) = 0.217m$

2. A lead storage battery has a 3.75*M* solution of H_2SO_4 with a density of 1.230 g/ml. Calculate

Mass percent: $\frac{\left(\frac{3.75mol}{1}\frac{98g}{1mol}\right)}{\left(\frac{1000ml}{1}\frac{1.230g}{1ml}\right)} = \frac{367.5g}{1230g} x100 = 29.9\% H_2SO_4$

Molality: 1st, mass of solvent (from above): 1230g solution – 367.5g solute= 862g H_2O

$$\frac{3.75mol}{0.862kg\_solvent} = 4.35m$$

Mole fraction: moles of H_2O solvent, $\left(\frac{862gH_2O}{1}\frac{1mol}{18g}\right) = 47.9molH_2O$

$$\left(\frac{3.75molH_2SO_4}{3.75molH_2SO_4 + 47.9molH_2O}\right) = 0.0726 = \chi_{H2SO4}$$

Normality: 3.75*M* x2eguivalent/mol = 7.50 *N*

Homework Practice (Set 1): P.519 #10, 11, 12, 25, 26, 29, 30, 32, 80, 100