Name: ___________________________ **Score:** __________ / 40 points possible

Chemistry 1A Quiz #7

May 11, 2010

1) **(3 points)** For each substance below, write whether it would be soluble in "H_2O" (a polar solvent), "CCl_4" (a nonpolar solvent), or "neither".

   a) Glucose ($C_6H_{12}O_6$) (polar) would be soluble in __________H_2O____________.

   b) Sodium phosphate (Na_3PO_4) (ionic) would be soluble in ______H_2O_______.

   c) Iodine (I_2) (nonpolar) would be soluble in____________CCl_4______________.

2) **(4 points)** Fill in each blank with the phrase "does not change much" or "increases" or "decreases"

   a) As temperature increases, the solubility of a gas solute in a liquid solvent decreases

   b) As temperature increases, the solubility of a solid solute in a liquid solvent increases

   c) As pressure increases, the solubility of a gas solute in a liquid solvent decreases___

   d) As pressure increases, the solubility of a solid solute in a liquid solvent does not change much

3) **(4 points)** Scuba divers can get the "bends" when nitrogen dissolves in their blood while they are diving, and then forms bubbles in the blood vessels when they return to the surface. The Henry's law constant for nitrogen gas (N_2) in blood at human body temperature (309.8 K) is 6.1 x 10^{-4} M / atm. While diving, a scuba diver may breathe air from a tank at a pressure of 4.9 atm. If the mole fraction of nitrogen in the air is 0.78, and a human body contains roughly 5.6 L of blood, how many grams of nitrogen will dissolve in the scuba diver's blood?

Henry's Law:

$$C_{N_2} = k_{\text{Henry's law}} P_{N_2}$$

Dalton's Law of Partial Pressures:

$$P_{N_2} = \chi_{N_2} P_T$$

Combine These Laws:

$$C_{N_2} = k_{\text{Henry's law}} \chi_{N_2} P_T$$

$$C_{N_2} = (6.1 \text{ x } 10^{-4} \text{ M / atm})(0.78)(4.9 \text{ atm}) = 0.00233 \text{ M}$$

$$?\,\text{g}\,N_2 = 5.6\,\text{L blood}\left(\frac{0.00233\,\text{mol}\,N_2}{1\,\text{L blood}}\right)\left(\frac{28.014\,\text{g}\,N_2}{1\,\text{mol}\,N_2}\right) = \boxed{0.366\,\text{g}\,N_2}$$

4) The vinegar that you purchase at the grocery store is a 5.00 % by mass aqueous solution of acetic acid ($C_2H_4O_2$). The density of this solution is 1.01 g / mL. Assume that acetic acid is a nonvolatile nonelectrolyte.

For parts (a), (c), and (e), let's assume that we have 100 g of solution!!!

a) **(3 points)** Calculate the mole fraction of WATER in vinegar.

$$? \text{ mol } C_2H_4O_2 = 5.00 \text{ g } C_2H_4O_2 \left(\frac{1 \text{ mol } C_2H_4O_2}{60.052 \text{ g } C_2H_4O_2} \right) = 0.08326 \text{ mol } C_2H_4O_2$$

$$100 \text{ g sol'n} - 5.00 \text{ g } C_2H_4O_2 = 95.00 \text{ g } H_2O \left(\frac{1 \text{ mol } H_2O}{18.015 \text{ g } H_2O} \right) = 5.273 \text{ mol } H_2O$$

$$\chi_{H_2O} = \frac{\text{mol } H_2O}{\text{total moles}} = \frac{5.273 \text{ mol } H_2O}{5.273 \text{ mol} + 0.08326 \text{ mol}} = \boxed{0.985}$$

b) **(3 points)** If you were to repeat Experiment 12, collecting oxygen gas over vinegar instead of water, you would need to know the vapor pressure of the water in vinegar. Using your answer from part (a), determine this vapor pressure (in torr), assuming that the temperature of the vinegar is 22 °C and that the vapor pressure of pure water at this temperature is 19.8 torr. If (and only if) you are unable to calculate the mole fraction in part (a), you may assume that it is 0.500 for this calculation.

$$P_{H_2O} = \chi_{H_2O} P_T = (0.985)(19.8 \text{ torr}) = \boxed{19.5 \text{ torr}}$$

c) **(3 points)** Calculate the molality of acetic acid in vinegar.

$$? \text{ kg } H_2O = 95.00 \text{ g } H_2O \left(\frac{1 \text{ kg } H_2O}{10^3 \text{ g } H_2O} \right) = 0.09500 \text{ kg } H_2O$$

$$\text{molality} = \frac{\text{mol glucose}}{\text{kg water}} = \frac{0.08326 \text{ mol}}{0.09500 \text{ kg } H_2O} = \boxed{0.876 \text{ m}}$$

d) **(3 points)** When cucumbers are pickled in jars, the jars must be boiled. Using the molality that you calculated in part (c), calculate the boiling point of vinegar (in °C). If (and only if) you are unable to calculate the molality in part (c), you may assume that it is 0.500 m for this calculation.

$$\Delta T_b = imK_b = (1)(0.876\ m)(0.512\ °C / m) = 0.449\ °C$$
$$100\ °C + 0.449\ °C = \boxed{100.449\ °C}$$

e) **(3 points)** Calculate the molarity of acetic acid in vinegar.

$$? \text{ L sol'n} = 100 \text{ g sol'n} \left(\frac{1 \text{ mL sol'n}}{1.01 \text{ g sol'n}} \right) \left(\frac{10^{-3} \text{ L sol'n}}{1 \text{ mL sol'n}} \right) = 0.099 \text{ L sol'n}$$

$$\text{molality} = \frac{\text{mol glucose}}{\text{L solution}} = \frac{0.08236 \text{ mol}}{0.099 \text{ L sol'n}} = \boxed{0.841 \text{ M}}$$

f) **(3 points)** Vinegar can be used as a standard to calibrate osmometers. Using the molarity that you calculated in part (e), calculate the osmotic pressure of vinegar (in torr) at 22 °C. If (and only if) you are unable to calculate the molarity in part (e), you may assume that it is 0.500 M for this calculation.

$$T = 22\ °C + 273.15 = 295.15 \text{ K}$$
$$\pi = iMRT = (1)(0.841 \text{ M})(0.08206 \text{ L atm / mol K})(295.15 \text{ K}) = \boxed{20.4 \text{ atm}}$$

5) **(6 points)** When 0.500 g of a certain vitamin is dissolved in 0.0100 kg of camphor, the freezing point of the solution if 4.43 °C lower than that of pure camphor. Assuming that the vitamin is a nonelectrolyte, determine its molar mass. (Note K_f for camphor = 40.0 °C / *m*).

$$\Delta T_f = imK_f \quad \text{...REARRANGE...} \quad m = \frac{\Delta T_f}{iK_f} = \frac{(4.43\,°C)}{(1)(40.0\,°C/m)} = 0.11075\ m$$

$$?\,\text{mol unknown} = 0.0100\,\text{kg solvent}\left(\frac{0.11075\,\text{mol unknown}}{1\,\text{kg solvent}}\right) = 0.00111\,\text{mol unknown}$$

$$\text{Molar Mass} = \frac{m}{n} = \frac{0.500\,g}{0.00111\,\text{mol}} = \boxed{451\,g/\text{mol}}$$

6) **(5 points)** When 1.00 mole of a nonvolatile weak electrolyte is dissolved in 1.00 kg of benzene, A solution with a volume of 1.21 L is formed. If the solution freezes at a temperature that is 2.6 °C colder than pure benzene, determine the osmotic pressure at 298 K of this solution in atm. *Note: K_f for benzene is 5.10 °C/m* . (Hint: the van't Hoff factor is NOT an integer).

$$m = \frac{\text{mol solute}}{\text{kg solvent}} = \frac{1.00\,\text{mol}}{1.00\,\text{kg}} = 1.00\ m$$

$$\Delta T_f = imK_f \quad \text{...REARRANGE...} \quad i = \frac{\Delta T_f}{mK_f} = \frac{(2.6\,°C)}{(1.00\,m)(5.10\,°C/m)} = 0.51$$

$$M = \frac{\text{mol solute}}{\text{L solvent}} = \frac{1.00\,\text{mol}}{1.21\,L} = 0.826\ M$$

$$\pi = iMRT = (0.51)(0.826\ M)(0.08206\ L\ atm\ /\ mol\ K)(298\ K) = \boxed{10.3\ atm}$$