CHM 1046 - JOENS WORKSHEET #2 Due date: Wednesday, September 6th

KEY

1) Which of the following liquids is miscible with water (circle all that apply)?

methanol (CH_3OH) **acetone (CH_3COCH_3)** cyclohexane (C_6H_{12})

Methanol has a polar O-H bond, and so can hydrogen bond with water molecules. Acetone has a polar C=O bond, and so is a polar molecule. Therefore acetone expected to be miscible with a polar liquid like water. Cyclohexane is a hydrocarbon, and so nonpolar, and so should not form a solution with water.

2) A solution is 14.8% by mass hexane (C_6H_{14}, MW = 86.2 g/mol) in carbon tetrachloride (CCl_4, MW = 153.8 g/mol). What are the molality and the mole fraction of hexane in the solution?

Assume 100.0 g of solution. Then there are 14.8 g hexane (H) and 85.2 g carbon tetrachloride (C).

$$\text{moles hexane} = 14.8 \text{ g} \; \frac{1 \text{ mol H}}{86.2 \text{ g H}} = 0.1717 \text{ mol H}$$

$$\text{moles carbon tetrachloride} = 85.2 \text{ g} \; \frac{1 \text{ mol C}}{153.8 \text{ g C}} = 0.5540 \text{ mol C}$$

$$m_H = \frac{\text{mol H}}{\text{kg C}} = \frac{0.1717 \text{ mol H}}{0.0852 \text{ kg C}} = 2.02 \text{ mol/kg}$$

$$X_H = \frac{\text{mol H}}{\text{mol H} + \text{mol C}} = \frac{0.1717 \text{ mol}}{0.1717 \text{ mol} + 0.5540 \text{ mol}} = 0.237$$

3) Because many chemical reactions in the atmosphere occur in cloud droplets, scientists are interested in the concentration of dissolved gases in these water droplets.

The Henry's law constant for sulfur dioxide (SO_2, MW = 64.1 g/mol) in water is k = 1.2 mol/L•atm at T =20. °C. What is the concentration of dissolved SO_2 in a cloud droplet when the partial pressure of SO_2 in the atmosphere is 30. x 10^{-6} atm (a typical value for an urban atmosphere)? Give your answer both in units of mol/L and g/L.

$[SO_2] = k\, p_{SO2}$ = (1.2 mol/L•atm) (30. x 10^{-6} atm) = 3.6 x 10^{-5} mol/L

In terms of g/L   concentration = 3.6 x 10^{-5} mol/L (64.1 g/mol) = 2.31 x 10^{-3} g/L

A partial pressure of 30. x 10^{-6} atm is actually much higher than one would find in an urban atmosphere (my bad), but that has no effect on how you do this problem.

4) The following question concerns ideal solutions formed by mixing two volatile liquids.

a) How do we define an ideal solution of two volatile liquids?

An ideal solution of two volatile liquids (A and B) is a solution where the partial pressure of each component is given by Raoult's law. So when

$$p_A = X_A\, p_A^\circ$$
$$p_B = X_B\, p_B^\circ$$

b) It is more common to observe ideal behavior in mixtures of gases than in mixtures of liquids. Explain this observation.

In gases the average distance between a molecule and its nearest neighbor is large compared to the size of a molecule. Because of this, even polar molecules do not strongly interact with one another in the gas phase because they are so far from each other.

Liquids are a condensed phase, and so in a liquid any particular molecule will be in contact with several other molecules of the liquid. Because of this, even weak interaction forces (such as dispersion forces) cannot be ignored. One only expects to see ideal behavior for mixtures of liquids if the liquids are nonpolar (so weak forces of interaction) and have a similar shape and size (so the interaction forces are about the same for all of the molecules in the liquid).