Chemistry 204: Quiz #7

1. Consider a solution made by mixing liquid A with liquid B at constant temperature in a closed container. Liquid A has a vapor pressure of 200.0 torr and the liquid mixture is 40% liquid A by moles. At equilibrium the vapor above the solution is about 70% B. Which of the following is the best estimate of the vapor pressure of liquid B?

   a) 100 torr b) 150 torr c) 200 torr d) 250 torr e) 300 torr

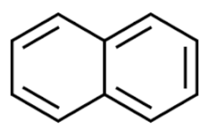
2. Consider a solution at a given temperature consisting of equal moles of benzene (vapor pressure = 745 torr) and toluene (vapor pressure = 290 torr). You distill this mixture in two steps; that is, you place the mixture in a closed container, allow the solution and vapor to come to equilibrium, collect and condense the vapor, and then allow that solution to come to equilibrium with its vapor. What is the mole fraction of benzene in the vapor in this second step?

   a) 0.28 b) 0.50 c) 0.72 d) 0.87 e) 0.93

3. When solid $MgCl_2$ dissolves in water, some of it remains un-ionized (that is, produces $MgCl_2(aq)$), some forms the ions $MgCl^+(aq)$ and $Cl^-(aq)$, and some forms a 1:2 ratio of $Mg^{2+}(aq)$ and $Cl^-(aq)$. Suppose you dissolve 1.000 mole of $MgCl_2(s)$ in 1.000 kg of water, and find that the freezing point is –4.557°C. If we know that all of the magnesium chloride dissolved in the water, and that 15.00% of it is un-ionized, determine the number of moles of $Mg^{2+}(aq)$ in the solution.

   a) 0.1500 mol b) 0.3000 mol c) 0.6000 mol d) 0.7000 mol e) 0.9000 mol

4. Naphthalene is the traditional ingredient in mothballs, which are used when storing clothing (to keep moths away). The structure can be represented as follows:

   Benzene has a freezing point of 5.51°C and a freezing point constant (K_f) of 5.12 K/m. What mass of naphthalene must be dissolved in 1.00 kg of benzene to give the solution the same freezing point as pure water?

   a) 111 g b) 119 g c) 127 g d) 138 g e) 147 g

5. Suppose you have a 1.00*M* aqueous solution of HF ($K_a = 7.2 \times 10^{-4}$). If we assume HF is a non-volatile solute, what is the *i* value we should use for colligative property calculations, rounded to the hundredths place?

   a) 1.00 b) 1.03 c) 1.05 d) 1.09 e) 1.50

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6. When discussing solutions, we talked about the colligative properties of freezing-point depression, boiling-point elevation, and osmotic pressure. Let's look at each of these.

   a. First, let's consider freezing-point depression. Suppose we have an ice cube at 0°C in a beaker of pure water at 0°C. We can melt the ice cube by either increasing the temperature of the water, or by adding salt to the water at 0°C. Even if we lower the temperature of this salt-ice-water system a bit, the water does not freeze. Answer the following questions:
   - Why does increasing the temperature of the pure water result in the melting of the ice?
   - Why does adding salt to the water (keeping the temperature at 0°C) result in the melting of the ice?
   - Why are we able to lower the temperature of the ice-cube/salt-water solution without additional water freezing, and why does it eventually freeze if we lower the temperature enough?

   Explain your answers using the concept of **vapor pressure**. Make sure to **describe what is meant** by the **freezing-point** of a liquid.

   b. Now let's consider boiling-point elevation. If you've ever made pasta by boiling it in water, you may have been told to add table salt (NaCl) to the water first. But why? If you look to the internet for answers, you will find many sites offer a reason that seems scientific – because adding salt to water increases the boiling point, we can boil the pasta at a higher temperature, therefore reducing the cooking time. But is this really the reason? That is, answer the following question: **is it reasonable to say that we add salt to water when cooking pasta because we will reduce the cooking time**? Here are our givens:
   - The K_{sp} value for NaCl is about 38.
   - The K_b value for water is 0.51 K/m.
   - The boiling point of pure water is 100°C at 1 atm.
   - It takes about 10 minutes to cook pasta at 100°C.

   Provide **quantitative support** for your answer, **list and explain any assumptions**, and **show all work**.

   c. Finally, let's look at osmotic pressure. Suppose that you predict (that is, determine by calculation) the osmotic pressure of an aqueous solution of NaCl from its concentration, but you failed to take into account that, in reality, 31.4% of the salt dissolves without dissociating into ions. Is your predicted (determined) osmotic pressure **higher or lower** than the actual value? **Why**?

   Calculate the percent error in your determination of osmotic pressure. **Show and explain all work.**

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KEY:
MC: 1. e, 2. d, 3. c, 4. d, 5. b

6. a. See lectures, videos, and textbook, b. It is not reasonable, c. 18.6% error