1999 Exam #1 – Chem 36 Exam Questions

1. In order to keep carbonated water carbonated, it is necessary to keep a high pressure of CO_2 over the solution. If the concentration of CO_2 in "sparkling water" is 0.147 mol/L, what must be the partial pressure (in atm) of the CO_2 above it? The Henry's law constant for CO_2 at 25 ^oC is 1.65×10^3 atm. (You may assume the density of the solution is 1.00 g/mL.)

2. Benzene (C_6H_6) shows up quite frequently in your text in a number of chapters and, besides being quite useful as an organic synthetic reagent, is a suspected carcinogen (oh boy!). The vaporization of benzene is represented by the expression below:

$$C_6H_6\ (l) \ \text{-->}\ C_6H_6\ (g)$$

   a. Using the thermodynamic data provided, calculate the standard molar enthalpy of vaporization (ΔH^o_{vap}) for benzene.

   b. Based on the enthalpy of vaporization that you calcuated above, is this process exothermic or endothermic?

   c. Calculate the change in standard molar free energy (ΔG^o) at 25 ^oC for this process.

   d. Based on the free energy calculated in part c, is the vaporization of benzene a spontaneous process at 25 ^oC?

   e. Would you expect an increase or decrease in the entropy of this system as a result of the vaporization of benzene? (Don't do any calculations! Base your answer only on inspection of the reaction equation.) Briefly explain.

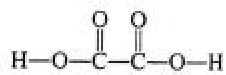
   f. Using the thermodynamic data provided, calculate the standard molar entropy change (ΔS^o) for the vaporization of benzene.

   g. Compare the value of ΔS^o you calculated with the value from Trouten's Rule. Explain whether you expect there to be significant deviations from the Trouten's Rule value.

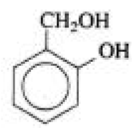
   h. Using data from your above answers, calculate the boiling point of benzene (i.e., at what temperature does the vaporization of benzene become spontaneous?).

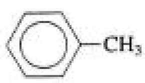
3. Calculate the partial pressure of benzene (in torr or mm Hg) above a solution obtained by mixing 45.8 grams of benzene (MW = 78.114 g/mol) with 25.5 grams of toluene (C_7H_8) - MW = 92.141 g/mol) at 25 ^oC.

4. a. Since we're on the subject of benzene, let's look at some solubility considerations. Circle the compound(s) below which you would expect to be moderately soluble in both benzene and water. Explain (briefly) why. (Note: "Like dissolves like" is NOT a suitable explanation!)

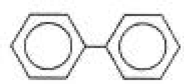
oxalic acid, 

salicyl alcohol (a local anesthetic)



toluene, 

diphenyl (a heat transfer agent)



   b. Would you expect the benzene solutions resulting from the dissolution of the compounds that you selected in part a (above) to be ideal solutions? Explain.

5. a. Suppose that an unknown compound is dissolved in 557.3 grams of benzene. How many moles of the compound must be dissolved in the solution in order to reduce benzene's freezing point from 5.53 ^oC to 3.10 ^oC?

   b. Would you expect the molality and the molarity of this solution to be very different? Explain. (Note: you don't need to calculate the molarity to answer this!)

   c. If the solution described in part a of this question was prepared by adding 11.734 grams of the solute to the benzene, calculate the molecular weight of the unknown compound.

6. a. NaCl(aq) isotonic with blood is 0.90% NaCl (mass/vol). For this solution, calculate the osmotic pressure (in torr or mm Hg) at 37. ^oC (normal body temperature).

   b. Briefly describe (and explain) what would happen to a red blood cell that was placed into distilled water.

EXTRA CREDIT! Although I have given you the vapor pressure of pure benzene at 25 ^oC on your formulae sheet, it is also possible to calculate it directly from the thermodynamic data that I've provided. For 5 big extra credit points (and a chance at what's behind door number 2 . . .), calculate the vapor pressure of benzene at 25 ^oC using the thermodynamic values given for benzene. How does this calculated value compare with the value that I've given you? NOTE: you will likely need to use some equilibrium and free energy relationships to solve this one . . .