Problems - Chapter 13 (with solutions)

1) Define the following terms: a) solution, b) miscible, c) hydration, d) percent by mass (solute), e) colligative property, f) hypotonic.

2) The following question concerns mixing of liquids.

a) Consider mixing two liquids where mixing is exothermic ($\Delta H_{soln} < 0$). Would you expect a solution to form (yes/maybe/no)? Justify your answer.

b) Consider mixing two liquids where mixing is endothermic ($\Delta H_{soln} > 0$). Would you expect a solution to form (yes/maybe/no)? Justify your answer.

3) (13.12) Explain the variation in the solubility in water of the listed alcohols:

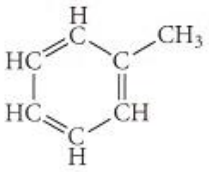
Compound	Solubility (g/100 g H_2O) at T = 20. °C
CH_3OH	∞
CH_3CH_2OH	∞
$CH_3CH_2CH_2OH$	∞
$CH_3CH_2CH_2CH_2OH$	9.0
$CH_3CH_2CH_2CH_2CH_2OH$	2.7

∞ means the alcohol and water are completely miscible

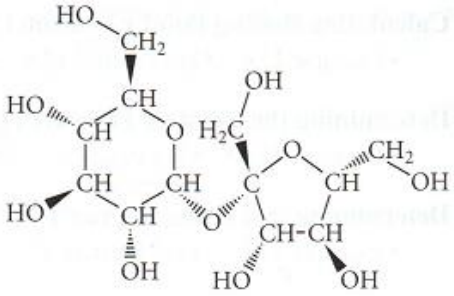
4) What does the statement like dissolves like mean with respect to solution formation?

5) For each compound would you expect greater solubility in water (H_2O) or in hexane (C_6H_{14})? Indicate the kinds of intermolecular forces that would occur between the solute and the solvent in which the molecule is more soluble.

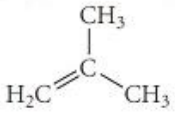
a. toluene



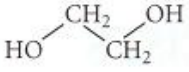
b. sucrose (table sugar)



c. isobutene



d. ethylene glycol



6) (13.18) Calculate the molality of each of the following aqueous solutions.

a) 2.55 M NaCl solution, density = D = 1.08 g/mL.

b) 45.2 percent by mass KBr.

7) (13.24) The density of an aqueous solution containing 15.0 percent ethyl alcohol (EtOH = CH_3CH_2OH) by mass is D = 0.984 g/mL.

a) Calculate the molality of this solution.

b) Calculate the molarity of the solution

8) An aqueous KNO_3 solution is made using 72.5 g of KNO_3 dissolved to a total solution volume of 2.00 L. Calculate the molarity, molality, and mass percent KNO_3 in the solution. Assume a density of 1.050 g/mL for the solution.

9) A stock solution is prepared by dissolving 18.21 g of sodium acetate ($NaC_2H_3O_2$) in water. The final volume of the solution is V = 250.0 mL.

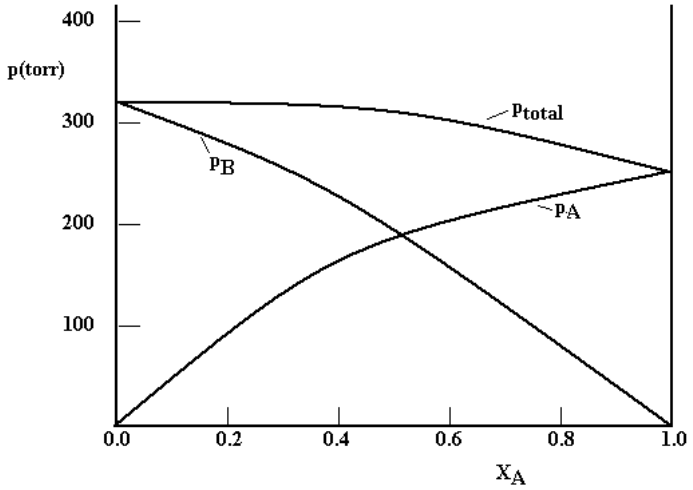
a) What is the molarity of sodium acetate in the solution?

b) How many mL of the stock solution of sodium acetate are needed to prepare 100.0 mL of a 0.1000 mol/L sodium acetate solution?

10) The Henry's law constant for methyl bromide (CH_3Br) in water is 0.159 mol/L•atm at T = 25. °C. How many grams of methyl bromide will dissolve in 1.000 L of water at this temperature when the pressure of methyl bromide above the water is p = 320. torr?

11) A solution contains a mixture of pentane and hexane at room temperature. The solution has a vapor pressure of 258. torr. Pure pentane and hexane have vapor pressures of 425 torr and 151 torr, respectively, at room temperature. What is the mole fraction composition of the mixture? Assume ideal behavior.

12) The diagram below is for a solution of two volatile liquids A and B, and shows the



partial pressure of A, the partial pressure of B, and the total pressure above a solution as a function of X_A, the mole fraction of A in the solution.

a) Do A and B form an ideal solution? Justify your answer.

b) If A and B do not form an ideal solution, are the A--B interactions <u>stronger than</u>, <u>approximately equal to</u>, or <u>weaker than</u> the average of the A---A and B---B interactions? Justify your answer.

13) How many grams of glucose ($C_6H_{12}O_6$) must be added to 552. g of water to give a solution with a vapor pressure 0.20 torr less than that of pure water at 20.0 °C? The vapor pressure of pure water at this temperature is $p°_{H2O}$ = 17.5 torr.

14) An ethylene glycol solution contains 21.2 g of ethylene glycol ($C_2H_6O_2$) in 85.4 mL of water. Determine the freezing point and boiling point of the solution. Assume a density of 1.000 g/mL for water. Note that for water K_f = 1.86 °C•kg/mol and K_b = 0.512 °C•kg/mol, and that ethylene glycol is a nonvolatile and nonionizing solute.

15) An aqueous solution containing 35.9 g of an unknown nonvolatile and nonionizing molecular compound in 150.0 g of water was found to have a freezing point of – 1.30 °C. Calculate the molar mass of the unknown compound. For water, K_f = 1.86 °C•kg/mol.

16) **(**13.66) What is the osmotic pressure, in atmospheres, of a 1.57 M aqueous solution of urea ($(NH_2)_2CO$), a nonvolatile and nonionizing solute, at T = 27. °C.

17) (13.78) Arrange the following aqueous solutions in order of decreasing freezing point, and explain your reasoning: 0.50 m HCl, 0.50 m glucose, 0.50 m CH_3COOH.

18) (13.86) A quantity of 7.480 g of an organic compound is dissolved in water to make 300.0 mL of solution. The solution has an osmotic pressure of 1.43 atm at T = 27. °C. The analysis of this compound shows that it contains 41.8 percent C, 4.7 percent H, 37.3 percent O, and 16.3 percent N. Find the molecular formula for the compound.

19) A solution is prepared by dissolving 2.18 g of potassium nitrate (KNO_3, MW = 101.1 g/mol) in water. The final volume of the solution is V = 400.0 mL. What is the osmotic pressure of the solution at T = 20.0 °C?

20) Consider 0.0100 mol/kg aqueous solutions of iron III chloride ($FeCl_3$), calcium nitrate ($Ca(NO_3)_2$), and copper II sulfate ($CuSO_4$). Which of these solutions will have the highest freezing point, and which of these solutions will have the highest melting point? Justify your answer.