Study Guide – Properties of Solutions (Chapters 20 & 21) Name: _____
Chemistry II
2 points DUE AT TEST Date: _____

Topics to be covered on the February 3, 2010 test:

solution	solute	solvent
dilute	concentrated	molarity (M)
mass percent (%)	mole fraction (χ)	molality (m)
normality (N)	steps involved in forming a solution	"like dissolves like"
vapor pressure	changes of state and energy involved	equilibrium
volatile	vapor pressure of solutions	Raoult's Law
freezing point depression	boiling point elevation	molar mass from f. pt.
colligative properties		

Practice problems (do any 10 for full credit–may attach additional pages of work–must show work on math for credit):

1) The four most common ways to describe a solution's concentration are mass percent, mole fraction, molarity, and molality. Define each of these methods. Compare and contrast them. Why is molarity temperature dependent, while the other three do not depend on temperature?

2) What does the phrase "like dissolves like" mean? There are four possible solute-solvent combinations: polar solute in polar solvent, polar solute in nonpolar solvent, nonpolar solute in nonpolar solvent, and nonpolar solute in polar solvent. For each combination, discuss what would occur during the three steps of the solution process, the ΔH for each step (endothermic, exothermic, large, small), the overall ΔH for the process, and whether a solution would be likely to form.

3) Describe what is meant by the concepts of equilibrium and vapor pressure of a pure solvent. Is the vapor pressure higher or lower for volatile solvents vs. nonvolatile solvents? What makes a solvent volatile? Is the vapor pressure higher or lower for a solution containing a nonvolatile solute? Why?

4) List the six changes of state. Indicate what process is occurring during each. Indicate whether each is endothermic or exothermic. Choose one exothermic and one endothermic, and explain how you know which is which.

5) Common commercial acids and bases are aqueous solutions with the following properties:

	Density (g/mL)	Mass Percent of Solute
hydrochloric acid	1.19	38%
nitric acid	1.42	70.%
sulfuric acid	1.84	95%
acetic acid	1.05	99%
ammonia	0.90	28%

Calculate the molarity, molality, and mole fraction of each of the solutes.
[hydrochloric: 12 M, 16 m, 0.23; nitric: 16 M, 37 m, 0.39; sulfuric: 18 M, 200 m, 0.76; acetic: 17 M, 2000 m, 0.96; ammonia: 15 M, 23 m, 0.29]

6) A solution is made by mixing 25 mL of pentane (density of 0.63 g/mL) with 45 mL of hexane (density of 0.66 g/cm^3). Assuming that the volumes add on mixing, calculate the mass percent, mole fraction, molality, and molarity of the pentane. [35%, 0.39, 7.3 m, 3.1 M]

7) Which solvent, water or carbon tetrachloride, would you choose to dissolve each of the following?

a) KrF_2
b) SF_2
c) SO_2
d) CO_2
e) MgF_2
f) CH_2O
g) ethene

8) Glycerin, C_3H_8O, is a nonvolatile liquid. What is the vapor pressure of a solution made by adding 164 g of glycerin to 338 mL of water at 39.8 °C? (The vapor pressure of pure water at 39.8 °C is 54.74 torr, and its density is 0.992 g/mL.) [47.7 torr]

9) At a certain temperature, the vapor pressure of pure benzene is 0.930 atm. A solution was prepared by dissolving 10.0 g of a non-dissociating, nonvolatile solute in 78.11 g of benzene at the temperature. The vapor pressure of the solution was found to be 0.900 atm. Assuming the solution behaves ideally, determine the molar mass of the solute. [300 g/mol]

10) What mass of glycerin (C_3H_8O) must be dissolved in 200.0 g of water to give a solution with a freezing point of -1.50 °C? [9.69 g]

11) Calculate the freezing point and boiling point of an antifreeze solution that is 50.0% by mass of ethylene glycol ($HOCH_2CH_2OH$) is water. [T_f = -30.0 °C, T_b = 108.2 °C]

12) Thyroxine, an important hormone that controls the rate of metabolism in the body, can be isolated from the thyroid gland. When 0.455 g of thyroxine are dissolved in 10.0 g of benzene (K_f = 5.12, f. pt = 5.5 °C), the freezing point of the solution is depressed by 0.300 °C. What is the molar mass of thyroxine? [776 g/mol]

13) An unknown compound contains only carbon, hydrogen, and oxygen. Combustion analysis of the compound gives mass percents of 31.57% C and 5.30% H. The molar mass is determined by measuring the freezing point depression of an aqueous solution of the compound. A freezing point of -5.20 °C was recorded for the solution made by dissolving 10.56 g of the compound in 25.0 g of water. Determine the empirical formula, molar mass, and molecular formula of the compound.

[$C_2H_4O_3$, 151 g/mol (experimental), 152.10 g/mol (theoretical), $C_4H_8O_6$]

14) The vapor pressure of pure water at 110.0 °C is 1070 torr. A solution of ethylene glycol and water has a vapor pressure of 1.00 atm at 110.0 °C. Assuming that Raoult's Law is obeyed, what is the mole fraction of ethylene glycol in the solution? [0.29]

15) Camphor ($C_{10}H_{16}O$) melts at 179.8 °C and has a particularly large freezing-point depression constant, $K_f = 30.0$ °C·kg/mol. When 0.186 g of an organic substance of unknown molar mass is dissolved in 22.01 g of liquid camphor, the freezing point of the mixture is found to be 176.7 °C. What is the molar mass of the unknown solute? [85 g/mol]

16) Calculate the molarity of the following aqueous solutions [choose at least one to do]:

(a) 0.540 g magnesium nitrate in 250.0 mL of solution [1.46×10^{-2} M]

(b) 22.4 g of lithium perchlorate trihydrate in 125 mL of solution [1.12 M]

(c) 25.0 mL of 3.50 M nitric acid diluted to 250.0 mL [0.350 M]

17) Describe how you would prepare each of the following solutions, starting with solid KBr [choose one to do]:

(a) 0.75 L of 1.5×10^{-2} M KBr [1.3 g KBr in 750 mL volumetric flask]

(b) 125 g of 0.180 m KBr [2.68 g KBr in 122.32 g water]

(c) 1.85 L of 12% KBr by mass (density of the solution is 1.10 g/mL)
[244 g KBr; dilute until 1.85 L of total solution]

(d) 0.150 M solution of KBr that contains just enough KBr to precipitate 16.0 g of AgBr from a solution containing 0.480 mol of $AgNO_3$ [10.1 g KBr in 0.568 L of solution]