Chem 35 - Exam II **November 2, 1999** **Prof. W.R. Leenstra**

NAME: _____ **Please take a minute to read these instructions:**

This may be common sense, but I require that all answers be justified, i.e., show all your work and reasoning completely. Think about your presentation. For any answer involving writing, be complete but concise and precise, and write legibly, i.e., take your time and think about how to compose your answer in a coherent manner before writing. Point values for the problems are as follows (#-pts): 1-10, 2-5, 3-5, 4-15, 5-15, 6-5, 7-10, 8-15, 9-20.

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1. The van der Waals equation was derived by making two corrections to the ideal gas law.

   (a) What is the correction to the term V (volume) in the ideal gas law. Fully explain the entire correction.

   (b) Substitute this correction into the ideal gas law and obtain an expression in terms of pressure P. Next, make a correction to this expression and write down the adjusted P . Fully explain the entire correction.

   (c) Now rearrange the result from (b) above so that it resembles the ideal gas law (i.e., with nRT on the right-hand side of the equation). This is the conventional way of writing the van der Waals equation for gases.

2. Explain the relationship between the slope of the solid-liquid line in H_2O's phase diagram and the fact that ice floats on liquid water, rather than the other way around.

3. Gas laws can be cast in the form of a compressibility factor Z, which is defined as being equal to PV/nRT.

   (a) What is the value of Z for an ideal gas?

   (b) If you substitute the corrected pressure P from 1c, above, an expression for the compressibility factor Z can be derived. The result after some approximations is:

   $$Z \approx 1 + [b - a/RT]$$

   Within this framework, discuss the "Boyle temperature". Be sure to include in your discussion an analysis of the situation above and below this temperature.

4. Discuss the so-called hydrogen bonding.

(a) Explain why it exists. Your answer must include the two factors: (1) it only happens for hydrogen and (2) it can only occur if the H is bonded to O, N, or F.

(b) Present the experimental evidence for the conclusion that water is a substance that possesses hydrogen bonding in the liquid phase.

5. A perchloric acid solution is 60% $HClO_4$ by weight; this comes out to 9.20 M.

(a) Compute the density of this solution.

(b) Compute the molality of this solution.

(b) Compute the mole fraction of perchloric acid.

6. Suppose 15.0 g of solid NaOH is added to 1.75 L of an aqueous solution that is already 2.20 M in NaOH. Then water is added until the final volume is 3.80 L. Determine the concentration of NaOH in the resulting solution.

7. (a) State Raoult's law in words and with an equation.

(b) Draw a diagram that illustrates Raoult's law for the vapor pressure of a liquid in which a second component is a non-volatile additive. Label everything that is appropriate.

(c) Draw a diagram that illustrates Raoult's law for the vapor pressure of a mixture of two volatile liquids. Label everything that is appropriate.

8. At 40 °C, the vapor pressure of pure carbon tetrachloride (CCl_4) is 0.293 atm and the vapor pressure of pure dichloroethane ($C_2H_4Cl_2$) is 0.209 atm. A nearly ideal solution is prepared by mixing 30.0 g of carbon tetrachloride with 20.0 g of dichloroethane.

(a) Calculate the mole fraction of CCl_4 in the solution.

(b) Calculate the total vapor pressure of the solution at 40 °C.

(c) Calculate the mole fraction of CCl_4 in the vapor above the solution.

9. Short answers.

1. In the Maxwell-Boltzmann plots of the distribution of molecular speeds (number of molecules plotted as a function of speed), the most probable, the average and the rms values have the following relationships.

   Highest: Lowest:

2. The formula for the root-mean-square speed of molecules is given by $ì_{rms} = (3RT/M)^{2}$. In comparing oxygen gas at 350K with nitrogen gas at 300K, what is the relationship between their rms speeds (circle the correct answer).

   nitrogen=s is higher than oxygen=s oxygen=s is higher than nitrogen=s

3. The graphs that describe the non-ideality of molecules (and monatomic gases) plot the potential energy V(R) as a function of R. In just a few words, the depth of the potential energy curve depends on:

4. For the reaction $N_2O_4 + KCl \text{ ---> } NOCl + KNO_3$

   Atom _____ is oxidized and goes from oxidation state _____ to _____

   Atom _____ is reduced and goes from oxidation state _____ to _____

5. List the four colligative properties:

   a.

   b.

   c.

   d.