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Name Key  
(Please print family name last; e.g., Robert Boyle)

Student Number \_\_\_\_\_

Chem 116 - Section 1  
Hour Examination I  
March 9, 2007

This test consists of five (5) pages, including this cover page. Be sure your copy is complete before beginning your work. If this test packet is defective, ask for another one. A separate copy of the periodic table will be distributed with this test.

☛ **You must show work in the spaces provided that leads to your answers to problems 2 and 3. Answers without such work receive no credit.**

Ideal Gas Law Constant =  $R = 0.08206 \text{ L}\cdot\text{atm}/\text{K}\cdot\text{mol} = 8.314 \text{ J}/\text{K}\cdot\text{mol}$ Molar volume of an ideal gas at STP =  $22.4 \text{ L}/\text{mol}$  $K = ^\circ\text{C} + 273.15$        $1.00 \text{ atm} = 760 \text{ mm Hg}$        $N_A = 6.022 \times 10^{23}$ 

DO NOT WRITE BELOW THIS LINE

1.

2.

3.

TOTAL

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1. (68 points; 4 points each) Circle the best answer to each of the following.

a. "Equal volumes of gases at the same temperature and pressure contain equal numbers of molecules" is a statement of the relationship discovered by

Avogadro

Charles

Boyle

Amonton

Dalton

b. How high in meters must a column of ethanol be to exert a pressure equal to that of a column of mercury 772 mm high? The density of mercury is 13.6 g/mL, and that of ethanol is 0.791 g/mL.

0.0449 m

0.772 m

0.611 m

10.5 m

13.3 m

c. A gas sample is contained in a 6.00-L vessel at 48 °C and 3.00 atm. What is the pressure if the temperature is increased to 155 °C?

49.0 atm

2.25 atm

3.00 atm

4.00 atm

9.69 atm

d. A sample of gas in a steel tank with a volume of 836 mL at 23 °C has a pressure of 1150 torr. How many moles of gas does the tank contain?

0.0521 mol

0.670 mol

1.49 mol

19.2 mol

39.6 mol

e. Consider one mole samples of each of the following gasses under the conditions specified. Which one has the highest root-mean-squared velocity?

CO<sub>2</sub>(g) at 300 K

He(g) at 300 K

SF<sub>6</sub>(g) at 300 KH<sub>2</sub>(g) at 400 KCH<sub>4</sub>(g) at STPf. A 0.132-mol sample of O<sub>2</sub>(g) (m.w. = 32.0 u) effuses from a certain apparatus in 15.0 s. How many moles of He(g) (at. wt. = 4.00 u) would effuse in the same time from the same apparatus under identical conditions?

0.0165 mol

0.0467 mol

0.132 mol

0.373 mol

1.06 mol

g. Which one of the following is most volatile?

CCl<sub>4</sub>CH<sub>2</sub>Cl<sub>2</sub>CH<sub>3</sub>ClCHCl<sub>3</sub>CBr<sub>4</sub>

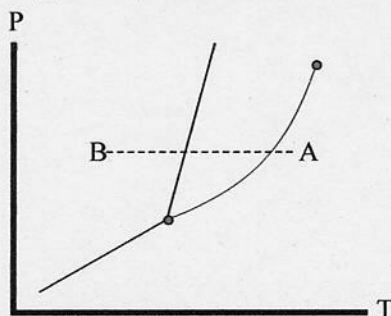
h. Which one of the following is capable of hydrogen bonding between its molecules?

CH<sub>3</sub>OCH<sub>3</sub>(CH<sub>3</sub>)<sub>3</sub>NH<sub>2</sub>SHOCH<sub>2</sub>CH<sub>2</sub>OHCH<sub>3</sub>F

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- i. Consider the following phase diagram for a certain substance.



If the temperature is decreased as indicated by the dotted line A-B, which of the following describes the sequence of phases that will be observed?

solid → liquid → gas      gas → liquid → solid      liquid → solid → gas

solid → gas → liquid      gas → solid → liquid

- j. A gas mixture contains 0.120 mol  $N_2(g)$  and 0.360 mol  $O_2(g)$  and has a total pressure of 1.64 atm. What is the partial pressure of  $N_2(g)$  in the mixture?

0.197 atm      0.410 atm      0.590 atm      1.23 atm      1.64 atm

- k. Based on the nature of the solid, which of the following has the lowest melting point?

$C_2H_5OH$       Fe       $C_6H_{12}$        $SiO_2$       CaO

- l. Which one of the following gasses might be expected to show the most significant deviation from ideal-gas behavior at low temperature?

$H_2$        $CO_2$        $CH_4$       HF       $N_2$

- m. Which one of the following is probably most soluble in hexane,  $C_6H_{12}(l)$ ?

$CH_3OH$        $CH_3CO_2H$        $CH_3(CH_2)_{16}CO_2H$        $H_2O$       NaCl

- n. Which one of the following would have the highest osmotic pressure at 25° C?

0.120 M glucose      0.070 M NaCl      0.120 M  $CH_3CO_2H$       0.050 M  $CaCl_2$       0.035 M  $Na_3PO_4$

- o. A temperature and pressure at which gas and solid phases are in equilibrium is a

sublimation point      boiling point      critical point      triple point      melting point

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- p. For a 0.0100 *m* solution of NaCl(aq), the measured value of the van't Hoff *i* factor is 1.94. If this solution behaved ideally, what would the expected value of *i* be?

1.00

1.01

1.94

2.00

3.00

- q. At 20 °C, the vapor pressure of pure benzene is 75 torr and that of toluene is 22 torr. If equal moles of benzene and toluene are mixed, which of the following statements would describe the composition of the *vapor* in equilibrium with this solution?

The mole fraction of both benzene and toluene would be 0.50.

The mole fraction of benzene would be greater than 0.50.

The mole fraction of toluene would be greater than 0.50.

2. (12 points) The freezing point of a solution prepared by mixing 3.16 g of an unknown molecular compound with 50.0 g of carbon tetrachloride is -37.0 °C. The freezing point of pure carbon tetrachloride is -22.3 °C, and its freezing point depression constant,  $K_f$ , is 29.8 °C/m. Given these data, what is the molecular weight of the unknown solute?

$$\Delta T = (-37.0 + 22.3)^\circ\text{C} = -14.7^\circ\text{C}$$

$$m = \frac{\Delta T}{K_f} = \frac{14.7^\circ\text{C}}{29.8^\circ\text{C/m}} = 0.493\text{ m}$$

$$m.w. = \left( \frac{3.16\text{ g X}}{50.0\text{ g CCl}_4} \right) \left( \frac{10^3\text{ g CCl}_4}{0.493\text{ mol X}} \right) = 128\text{ g/mol}$$

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3. (20 points + 5 point bonus) Hexachlorobenzene ( $C_6Cl_6$ , m.w. = 284.79 u) is a non-volatile solid that dissolves in chloroform ( $CHCl_3$ , m.w. = 119.38 u). Consider a solution prepared by mixing 26.0 g of hexachlorobenzene in 154 g of chloroform.

- a. (6 points) What is the molality of the solution?

$$m = \left( \frac{26.0 \text{ g } C_6Cl_6}{154 \text{ g } CHCl_3} \right) \left( \frac{\text{mol } C_6Cl_6}{284.79 \text{ g } C_6Cl_6} \right) \left( \frac{10^3 \text{ g } CHCl_3}{\text{kg } CHCl_3} \right) = 0.593 \text{ m}$$

- b. (9 points) What is the mole fraction of *chloroform* (not hexachlorobenzene) in this solution?

$$\text{mol } C_6Cl_6 = (26.0 \text{ g } C_6Cl_6) \left( \frac{\text{mol } C_6Cl_6}{284.79 \text{ g } C_6Cl_6} \right) = 0.0912_{15} \text{ mol}$$

$$\text{mol } CHCl_3 = (154 \text{ g } CHCl_3) \left( \frac{\text{mol } CHCl_3}{119.38 \text{ g } CHCl_3} \right) = 1.29 \text{ mol}$$

$$X_{CHCl_3} = \frac{1.29}{1.29 + 0.0913} = 0.934$$

- c. (5 points) The vapor pressure of pure chloroform at 25°C is 172 torr. Assuming ideal behavior, what is the expected vapor pressure above the solution at 25°C?

$$P_{CHCl_3} = (0.934)(172 \text{ torr}) = 161 \text{ torr}$$

Extra Credit (5 points) At what temperature in °C will the solution boil?  $K_b = 3.63 \text{ }^\circ\text{C}/m$  for  $CHCl_3$ . The boiling point of pure  $CHCl_3$  is 61.2°C.

$$\Delta T = (0.593 \text{ m})(3.63 \text{ }^\circ\text{C}/m) = 2.15 \text{ }^\circ\text{C}$$

$$T'_b = (61.2 + 2.15) \text{ }^\circ\text{C} = 63.35 \text{ }^\circ\text{C} = 63.4 \text{ }^\circ\text{C}$$