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

Student Number _____

Chem 104 - Section 1
Hour Examination I
March 3, 2006

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 L·atm/K·mol = 8.314 J/K·mol
Molar volume of an ideal gas at STP = 22.4 L/mol
K = °C + 273.15 1.00 atm = 760 mm Hg $N_A = 6.022 \times 10^{23}$

DO NOT WRITE BELOW THIS LINE

1.

2.

3.

TOTAL

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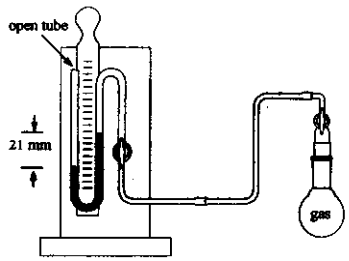
1. (64 points; 4 points each) Circle the best answer to each of the following.

a. "For a sample of gas with a fixed volume, the pressure is proportional to the absolute temperature" is a statement of the law named for

Avogadro Charles Boyle (Amonton) Dalton

b. A gas sample is connected to an open-ended manometer, as shown below.



The mercury height in the outer arm is lower than that of the inner arm by 21 mm. The barometric pressure in the laboratory is 752 mm Hg. What is the pressure of the sample gas in atmospheres?

1.02 atm 0.989 atm (0.962 atm) 0.0276 atm –0.0276 atm

c. A sample of gas in a piston chamber occupies 6.0 L at a pressure of 3.0 atm and a temperature of 500 K. What is its volume at 2.0 atm and 250 K?

2.0 L (4.5 L) 6.0 L 8.0 L 18.0 L

d. A 13.0-g sample of gas at 0 °C and 1.00 atm occupies 11.2 L. What is the molar mass of the gas?

6.50 g 8.00 g (26.0 g) 13.0 g 11.2 g

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

$N_2O(g)$ at 300 K $He(g)$ at 300 K $SF_6(g)$ at 250 K

($H_2(g)$ at 400 K) $CH_4(g)$ at STP

f. A 0.132-mol sample of SF_6 (m.w. 146 u) effuses from a certain apparatus in 13.6 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?

0.00363 mol 0.0218 mol 0.132 mol 0.482 mol (0.797 mol)

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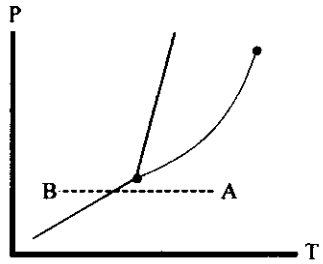
g. Which one of the following has the highest boiling point?

CCl_4 C_2Cl_6 C_2H_2 CH_4 C_6H_6

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

CH_3NH_2 CH_3OCH_3 CH_3F H_2S $(CH_3)_3N$

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



If the temperature were decreased as indicated by the dotted line A-B, which one of the following sequences of phase transitions would be observed?

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

j. A tank is filled with a mixture of $N_2(g)$ and $O_2(g)$ to a pressure of 4.65 atm. If the mixture is 18.0 % $N_2(g)$ by volume, what is the partial pressure of $O_2(g)$ in the tank?

0.180 atm 0.820 atm 0.837 atm 3.81 atm 4.65 atm

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

C_6H_5OH Cu C_6H_6 SiO_2 MgO

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

H_2 Ne CH_4 CH_3CO_2H Cl_2

m. Which one of the following is probably miscible with hexane, $C_6H_{12}(l)$?

$C_6H_5CH_3$ CH_3CO_2H C_2H_5OH H_2O H_2SO_4

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n. Which one of the following would result in a lower average kinetic energy for a gas sample?

decreased pressure higher molecular weight (lower temperature)

both higher molecular weight and lower temperature increased volume

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

critical point sublimation point (triple point) boiling point melting point

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

2. (10 points) An aqueous solution of 10.0 g of sugar with a volume of exactly 100 mL has an osmotic pressure of 16.3 atm at 25 °C. What is the molecular weight of the sugar?

$\pi = MRT \Rightarrow M = \pi/RT = \frac{16.3 \text{ atm}}{(0.08206 \text{ L·atm/K·mol})(298 \text{ K})}$

$= 0.667 \text{ mol/L}$

$\text{m.w.} = \left(\frac{10.0 \text{ g sugar}}{0.100 \text{ L soln}}\right)\left(\frac{\text{L soln}}{0.667 \text{ mol sugar}}\right)$

$= 150. \text{ g/mol}$

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3. (26 points + 5 point bonus) Ferrocene, $Fe(C_5H_5)_2$ (m.w. = 186.04 u) is a non-volatile solid that dissolves without dissociating in carbon tetrachloride, CCl_4 (m.w. = 153.82 u). Consider a solution prepared by dissolving 4.93 g of ferrocene in 125 g of carbon tetrachloride.

a. (10 points) What is the molality of the solution?

$$m = \left(\frac{4.93\ g\ Fe(C_5H_5)_2}{125\ g\ CCl_4}\right)\left(\frac{mol\ Fe(C_5H_5)_2}{186.04\ g\ Fe(C_5H_5)_2}\right)\left(\frac{10^3\ g\ CCl_4}{kg\ CCl_4}\right)$$

$$= 0.212\ m$$

b. (10 points) What is the mole fraction of *carbon tetrachloride* (not ferrocene) in this solution?

$$mol\ CCl_4 = (1.00 \times 10^3\ g\ CCl_4)\left(\frac{mol\ CCl_4}{153.82\ g\ CCl_4}\right) = 6.50\ mol$$

$$\chi_{CCl_4} = \frac{6.50}{6.50 + 0.212} = 0.968$$

c. (6 points) The vapor pressure of pure carbon tetrachloride at 65 °C is 504 torr. Assuming ideal behavior, what is the expected vapor pressure above the ferrocene solution at 65 °C?

$$P_{soln} = \chi_{CCl_4} P^\circ_{CCl_4} = (0.968)(504\ torr) = 488\ torr$$

Extra Credit (5 points) At what temperature in °C will the solution freeze? $K_f = 29.8$ °C/*m* for CCl_4. The freezing point of pure $CCl_4(l)$ is –22.8 °C.

$$\Delta T = (0.212\ m)(29.8\ °C/m) = 6.32\ °C$$

$$T' = T - \Delta T = (-22.8 - 6.32)\ °C = -29.1\ °C$$