

INSTRUCTIONS/SUGGESTIONS.  
READ THIS CAREFULLY!

YOU MAY OMIT ANY TWO 15 POINT QUESTIONS AND ANY THREE 6 POINT QUESTIONS. YOU MUST DO QUESTION 4 (12 pts).

INDICATE ON THE NEXT PAGE WHICH **5** QUESTIONS ARE NOT TO BE GRADED BY WRITING DNG (DO NOT GRADE) NEXT TO THE PROBLEM NUMBER.

NO PARTIAL CREDIT on any question except where indicated by the statement SHOW WORK. When work is requested, set up equations (with numbers substituted in appropriate units) in space provided, but do the calculations on scrap sheet.

IF QUESTION STATES "SHOW WORK" AND YOU GUESS CORRECTLY WITHOUT SHOWING WORK - YOU GET 1/2 CREDIT.

CHECK FRONT BLACKBOARD FOR CORRECTIONS/CHANGES.

IF ANY QUESTION IS NOT CLEAR - ASK ERIC OR ME ABOUT IT!

CONSTANTS AND CONVERSION FACTORS ARE ON THE PAGE FOLLOWING THE LAST PROBLEM. PLEASE LOOK THERE!  
LAST THREE PAGES ARE FOR SCRAP WORK.  
FEEL FREE TO TEAR THESE PAGES OFF.

REMOVE THIS PAGE PRIOR TO STARTING EXAM.

CHEMISTRY F14O3  
PROFESSOR J. MORROW

SECOND EXAM

11/10/99

PRINT NAME, LAST: \_\_\_\_\_

FIRST: \_\_\_\_\_

I.D.#: \_\_\_\_\_

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MAXIMUM POINT VALUE IS IN PARENTHESES

- |               |                |                |
|---------------|----------------|----------------|
| 1. _____ (15) | 9. _____ (15)  | 17. _____ (6)  |
| 2. _____ (15) | 10. _____ (15) | 18. _____ (15) |
| 3. _____ (6)  | 11. _____ (6)  | 19. _____ (15) |
| 4. _____ (12) | 12. _____ (6)  | 20. _____ (15) |
| 5. _____ (15) | 13. _____ (6)  | 21. _____ (6)  |
| 6. _____ (6)  | 14. _____ (6)  | 22. _____ (6)  |
| 7. _____ (15) | 15. _____ (15) | 23. _____ (15) |
| 8. _____ (6)  | 16. _____ (6)  | 24. _____ (6)  |

COLUMN TOTALS (MAXIMUM):

\_\_\_\_\_ (90)                      \_\_\_\_\_ (75)                      \_\_\_\_\_ (84)

EXAM TOTAL (201 pts) \_\_\_\_\_

\_\_\_\_\_   
OUT OF 100

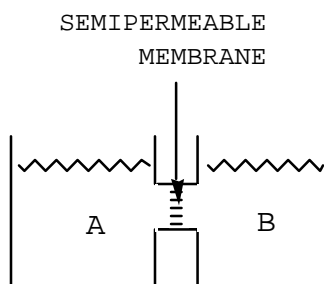
THE FOLLOWING INFORMATION IS FOR USE IN PROBLEMS 1, 2, AND 3.

You are given the following system of two beakers separated by a semipermeable membrane. Beaker A contains a 0.100 M solution of  $\text{Al}(\text{NO}_3)_3$ .

Beaker B contains a 0.120 M solution of  $\text{Ca}(\text{NO}_3)_2$ . The contents in both beakers are 100 % ionized.

The volume of each solution is 500 mL and their densities are 1.00 g/mL. As a result of these initial conditions there is an osmotic pressure difference between the two beakers which would require that water pass from one beaker to the other beaker to equalize their osmotic pressures. The density of

"pure" water is 1.00 g/mL.  $R = 0.0821 \frac{\text{L}\cdot\text{atm}}{\text{deg}\cdot\text{mol}}$



1) Calculate the direction of water flow and the volume of water required to equalize their osmotic pressures. (15 pts) SHOW WORK

- |                      |                      |                      |                      |                      |                      |
|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| a) A $\rightarrow$ B | b) B $\rightarrow$ A | c) A $\rightarrow$ B | d) B $\rightarrow$ A | e) A $\rightarrow$ B | f) B $\rightarrow$ A |
| 26.3 mL              | 26.3 mL              | 45.4 mL              | 45.4 mL              | 20.0 mL              | 20.0 mL              |

ANSWER IS: \_\_\_\_\_

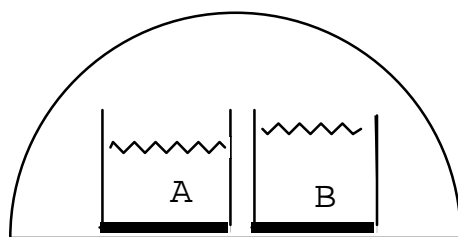
2) Referring back to the initial setup, what mass of  $\text{NaNO}_3$  would have to be added (and to which beaker) to equalize the osmotic pressures thereby preventing water from flowing from one beaker to the other beaker? Assume the  $\text{NaNO}_3$  (100 % ionized) is added without changing the solutions volume.

Molar mass of  $\text{NaNO}_3$  is  $85.0 \frac{\text{g}}{\text{mol}}$  . (15 pts) SHOW WORK

- a) beaker A    b) beaker B    c) beaker A    d) beaker B    e) beaker A    f) beaker B  
       3.40 g        3.40 g        1.70 g        1.70 g        0.85 g        0.85 g

ANSWER IS: \_\_\_\_\_

3) If the cell configuration was



but the contents were the same as originally described in question 1, in which direction does water pass, and what is its volume? HINT: The cells originally have different vapor pressures, therefore water will distill from the beaker of higher vapor pressure to the beaker of lower vapor pressure. (6 pts)

ANSWER IS: \_\_\_\_\_

4) Consider the the following equilibrium reaction at 25°C.



In which direction will the reaction (originally at equilibrium) shift (to the LEFT, to the RIGHT, or remain UNCHANGED), if (12 points)

a) A catalyst is added. ANSWER IS: \_\_\_\_\_

b) The volume is decreased. (Think of the container as a piston.)  
ANSWER IS: \_\_\_\_\_

c) The temperature is lowered. ANSWER IS: \_\_\_\_\_

d) The total pressure is increased by adding helium.  
ANSWER IS: \_\_\_\_\_

e) Some  $\text{N}_2$  is added. ANSWER IS: \_\_\_\_\_

f) Some HI is removed. ANSWER IS: \_\_\_\_\_

5) A 1.50 M ( $\frac{\text{mol}}{\text{L}}$ ) solution of glucose,  $\text{C}_6\text{H}_{12}\text{O}_6$  ( $F = 180 \frac{\text{g}}{\text{mol}}$ ), in water has a density of  $1.20 \frac{\text{g}}{\text{cm}^3}$ .

Glucose is a nonvolatile solute. At 25°C the vapor pressure of water is 23.8 torr. Calculate:  
(15 pts) SHOW WORK

a) The mole fraction of water. (5 pts)

ANSWER IS: \_\_\_\_\_

b) The molality (in terms of glucose) of this solution. (5 pts)

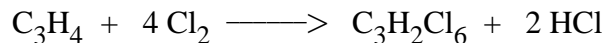
ANSWER IS: \_\_\_\_\_

c) The vapor pressure of this solution (in torr) if one (1) more mol of glucose was added to the above solution. (5 pts)

ANSWER IS: \_\_\_\_\_

THE FOLLOWING INFORMATION IS FOR PROBLEMS 6, 7, AND 8.

Given the following gaseous reaction:



The two reactants (1 mol of each) are each at STP in a volume of 22.4 L.

6) The reaction proceeds until the total pressure,  $P_T$ , is 1.60 atm. At this total equilibrium pressure all four compounds (both reactants and both products) are present. Calculate the density of the initial (starting) mixture.

Molar masses:  $\text{C}_3\text{H}_4$  (40.0) ;  $\text{Cl}_2$  (71.0) ;  $\text{C}_3\text{H}_2\text{Cl}_6$  (251.0) ;  $\text{HCl}$  (35.5)

(6 pts) ANSWER IS: \_\_\_\_\_

7) Calculate the partial pressures of  $\text{C}_3\text{H}_4$ ,  $\text{Cl}_2$ ,  $\text{C}_3\text{H}_2\text{Cl}_6$ , and  $\text{HCl}$  at

the total equilibrium pressure of 1.60 atm. SET UP THE EQUATIONS BELOW (7 pts) THAT WILL ALLOW YOU TO SOLVE FOR THE PRESSURES. DO THE CALCULATIONS ON SCRAP PAPER AND INSERT NUMERICAL ANSWERS WHERE INDICATED BELOW!

For  $\text{C}_3\text{H}_4$ ,  $P =$  \_\_\_\_\_ (2 pts)      For  $\text{Cl}_2$ ,  $P =$  \_\_\_\_\_ (2 pts)

For  $\text{C}_3\text{H}_2\text{Cl}_6$ ,  $P =$  \_\_\_\_\_ (2 pts)      For  $\text{HCl}$ ,  $P =$  \_\_\_\_\_ (2 pts)

8) The equilibrium expression for  $K_{P(\text{atm})}$  where  $P_T$  is the total pressure at equilibrium is; (6 pts)

a)  $\frac{(2-0.5P_T)(1-P_T)^2}{(0.5P_T)(2P_T-3)^4}$       b)  $\frac{(1-0.5P_T)(2-P_T)^2}{(0.5P_T)(2P_T-3)^4}$

$$c) \frac{(0.5P_T)(2-P_T)^2}{(1-0.5P_T)(2P_T-3)^4} \qquad d) \frac{(1-0.5P_T)(2-P_T)^4}{(0.5P_T)(2P_T-3)^2}$$

ANSWER IS: \_\_\_\_\_

9) What is the partial pressure of  $\text{SO}_2$  (in torr), if equal masses of  $\text{O}_2$  and  $\text{SO}_2$  are mixed and the total pressure is 600 torr?

Molar masses:  $\text{O}_2$  (32 g),  $\text{SO}_2$  (64 g)    SHOW WORK (15 pts)

- a) 500    b) 400    c) 300    d) 200    e) 100

ANSWER IS: \_\_\_\_\_

10) You have a container of gas X and a container of gas Y, and the following information: the two gases are ideal; they are at the same temperature; the molar mass of Y is twice that of X; the density of Y is half that of X. What is the ratio of the pressures of gas X to gas Y,  $(\frac{P_X}{P_Y})$ , in the two containers?

(15 pts)

- a)  $\frac{1}{4}$     b)  $\frac{1}{2}$     c) 1    d) 2    e) 4

ANSWER IS: \_\_\_\_\_

11) Calculate the universal gas constant, R, in the following units,  $\frac{\text{L}\cdot\text{Pa}}{\text{K}\cdot\text{mol}}$ .

(6 pts) ANSWER IS: \_\_\_\_\_

12) At room temperature mercury has a density of  $13.6 \frac{\text{g}}{\text{cm}^3}$  while liquid bromoform,  $\text{CHBr}_3$ , has a density of  $2.89 \frac{\text{g}}{\text{cm}^3}$ . How high a column of bromoform will be supported by a pressure that supports a column of mercury 200 mm high?    (6 pts)

- a) 94.1 mm    b) 272.0 mm    c) 42.5 cm    d) 94.1 cm    e) 272.0 cm

ANSWER IS: \_\_\_\_\_

13) Two 500.0 mL bulbs are connected by a stopcock.



Bulb B is evacuated. The other bulb, A, contains 100.0 g of liquid chloroform in equilibrium with its vapor. Both bulbs are maintained at 20.0°C. At this temperature the density of liquid chloroform is  $1.4925 \frac{\text{g}}{\text{cm}^3}$  and its vapor pressure is 159.6 torr. The valve between the two bulbs is now opened.

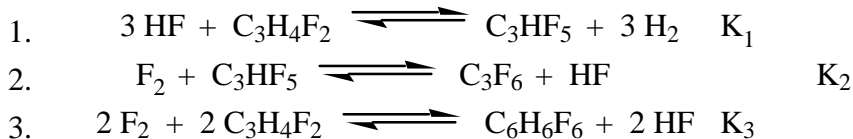
Estimate the volume of liquid (in  $\text{cm}^3$ ) remaining in bulb A, when equilibrium is established? Neglect the volume decrease of the liquid in calculating the volume of the gas after the stopcock is opened.  
(6 pts)

- a)  $100 \text{ cm}^3$       b)  $67 \text{ cm}^3$       c)  $50 \text{ cm}^3$       d)  $33 \text{ cm}^3$       e)  $0 \text{ cm}^3$

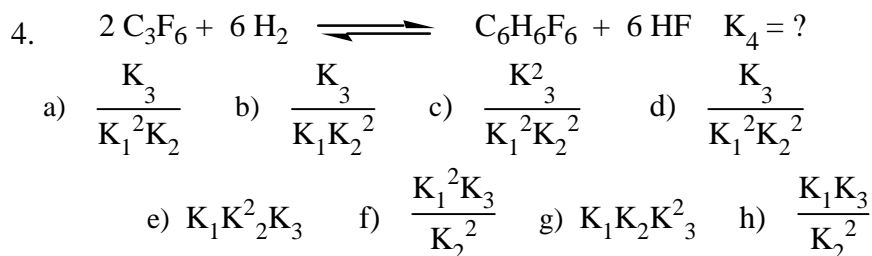
ANSWER IS: \_\_\_\_\_



14) Given the following gaseous reactions.

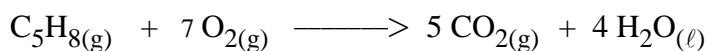


Calculate the equilibrium constant  $K_4$  (for reaction 4) in terms of  $K_1$ ,  $K_2$ , and  $K_3$ .

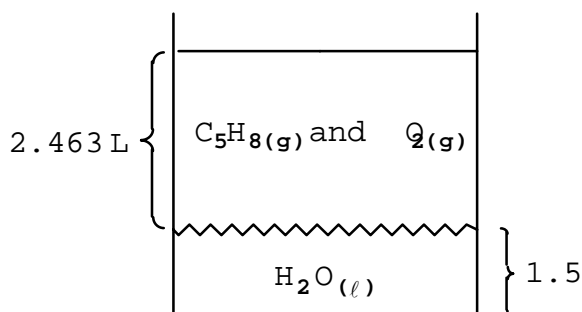


(6 pts) ANSWER IS: \_\_\_\_\_

15) The following reaction occurs in a vessel of 2.463 L volume at 27°C.



Initially, 1.00 atm of  $\text{C}_5\text{H}_8(\text{g})$  and 1.00 atm of  $\text{O}_2(\text{g})$  are mixed in the 2.463 L volume above the 1.5 L of liquid  $\text{H}_2\text{O}$ .



The reaction then goes to completion. The temperature remains constant at 27°C. The vapor pressure of water at 27°C is 27 torr. What is the total pressure (after reaction) in the 2.463 L volume above the 1.5 L of liquid  $\text{H}_2\text{O}$ ? SHOW WORK (15 pts)

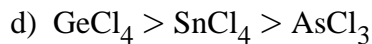
- a) 1194 torr    b) 651 torr    c) 1221 torr    d) 678 torr

ANSWER IS: \_\_\_\_\_

16) In the following group of three molecules, predict their relative

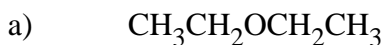
normal boiling points:  $\text{GeCl}_4$ ,  $\text{AsCl}_3$ , and  $\text{SnCl}_4$ .

Molar masses:  $\text{GeCl}_4$  (214);  $\text{AsCl}_3$  (181);  $\text{SnCl}_4$  (260)

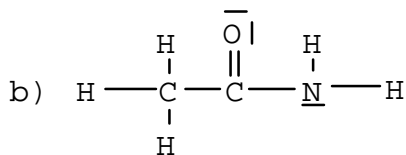
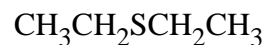


(6 pts) ANSWER IS: \_\_\_\_\_

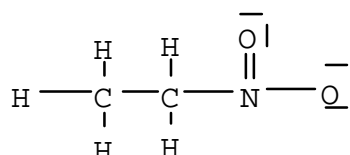
17) In each of the following pairs of covalent molecules, CIRCLE the one with the higher normal boiling point. (6 pts - 3 pts each)



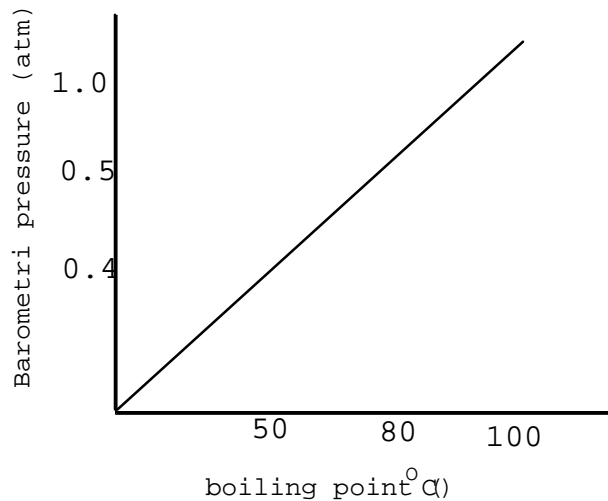
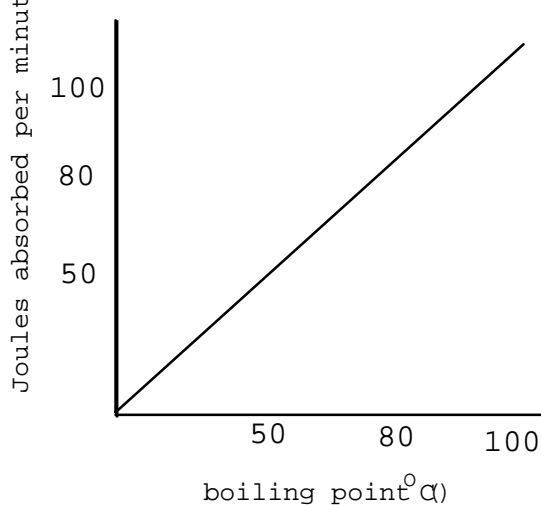
or



or



18) Given the following information,



How long (in min) would it take to cook the equivalent of a 3 minute "Earth Egg" (at a barometric pressure of 1 atm) on a planet where the barometric pressure is half that of earth? (15 pts)

SHOW WORK

ANSWER IS: \_\_\_\_\_

19) For a reaction of the type  $\text{A}_{(g)} + 2 \text{B}_{(g)} \rightleftharpoons 2 \text{C}_{(g)}$ , an equilibrium mixture consists of 3.0 mol of A, 0.80 mol of B, and 0.40 mol of C, in a 2.00 L flask. What is the value of  $K_p$  for this reaction at 300 K? (15 pts) SHOW WORK

- a) 0.020      b) 0.0134      c) 0.010      d) 0.0067      e) 0.0034

ANSWER IS: \_\_\_\_\_

20) Given pure ethylene glycol (EG), and pure water (W).

The molar masses are  $62.0 \frac{\text{g}}{\text{mol}}$  for EG, and  $18.0 \frac{\text{g}}{\text{mol}}$  for W.

The densities of EG and of W are  $0.800 \frac{\text{g}}{\text{mL}}$  and  $1.000 \frac{\text{g}}{\text{mL}}$  respectively.

You want to prepare 300 mL of a solution with a mass of 270 g. Assume the volumes are additive. The masses of pure EG and of pure W which will give you the desired solution are, (15 pts) SHOW WORK

- a) 120 g of EG and 150 g of W.                      b) 140 g of EG and 130 g of W.  
c) 150 g of EG and 120 g of W.                      d) 130 g of EG and 140 g of W.

ANSWER IS: \_\_\_\_\_

21) What is the mole fraction of EG in the above solution?

CREDIT FOR THIS PART IS BASED ON YOUR ANSWER FROM QUESTION 20. (6 pts)

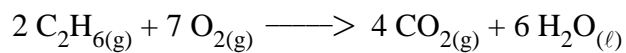
ANSWER IS: \_\_\_\_\_

22) Using water (W) as the solvent, what is the molality of the above solution?

CREDIT FOR THIS PART IS BASED ON YOUR ANSWER FROM QUESTION 20. (6 pts)

ANSWER IS: \_\_\_\_\_

23) What volume of  $\text{CO}_2$  (at STP) can be produced when 15.0 g of  $\text{C}_2\text{H}_6$  and 64.0 g of  $\text{O}_2$  are reacted according to; (15 pts) SHOW WORK



- a) 20.0 L      b) 22.4 L      c) 25.6 L      d) 33.6 L      e) 21.9 L

ANSWER IS: \_\_\_\_\_

24) What is the molar mass of a gas, 5.25 g of which occupy 1.25 L at 30.0°C and 0.915 atm pressure? (6 pts)

- a) 28.0 g/mol    b) 114 g/mol    c) 146 g/mol    d) 52 g/mol    e) 64 g/mol

ANSWER IS: \_\_\_\_\_

*CONVERSION FACTORS and POTENTIALLY USEFUL EQUATIONS*

1.  $R = 8.314 \frac{\text{J}}{\text{deg}\cdot\text{mol}} = 0.0821 \frac{\text{L}\cdot\text{atm}}{\text{deg}\cdot\text{mol}} = 82.1 \frac{\text{cm}^3\cdot\text{atm}}{\text{deg}\cdot\text{mol}}$
2.  $1 \text{ L}\cdot\text{atm} = 101.3 \text{ J}$  ( or, there are  $101.3 \frac{\text{J}}{\text{L}\cdot\text{atm}}$  )
3.  $1.00 \text{ atm} = 101.35 \text{ kPa}$
4.  $N_A = 6.022 \times 10^{23}$
5.  $P = dgh$  where  $d$  = density of the fluid,  $h$  = the height of the fluid, and  
 $g$  = the gravitational acceleration =  $980 \text{ cm/sec}^2 = 9.80 \text{ m/sec}^2$
6.  $K_p = K_c(RT)^{\Delta n}$

SCRAP WORK

## SCRAP WORK



## SCRAP WORK