ANSWER KEY

CHEMISTRY S14O3 SECOND EXAM 6/17/99
PROFESSOR J. MORROW

PRINT NAME, LAST: ___________________________

FIRST: ___________________________

I.D.# : ___________________________

MAXIMUM POINT VALUE IS IN PARENTHESES

1. ________ (1O)
2. ________ (12)
3. ________ (2O)
4. ________ (1O)
5. ________ (1O)
6. ________ (1O)
7. ________ (1O)
8. ________ (1O)
9. ________ (5)
10. ________ (1O)
11. ________ (1O)
12. ________ (8)
13. ________ (14)
14. ________ (1O)
15. ________ (4)
16. ________ (4)
17. ________ (1O)

COLUMN TOTALS (MAXIMUM):

________(72) ________(53) ________(42)

EXAM TOTAL (147 pts) ___________ ___________
OUT OF 1OO

<u>NO PARTIAL CREDIT</u> on any question except where indicated
by the statement <u>SHOW WORK.</u>
CHECK FRONT BLACKBOARD FOR CORRECTIONS/CHANGES.
SUGGESTION: DO THE SIMPLER PROBLEMS FIRST.
IF ANY PART OF EXAM IS NOT CLEAR - ASK PROCTORS ABOUT IT!

EQUATIONS, CONSTANTS AND CONVERSION FACTORS ARE ON THE PAGES FOLLOWING THE SCRAP WORK SHEETS. FEEL FREE TO TEAR THESE PAGES OFF.

1) Given the following thermochemical reactions and their H_f^o values;
(10 pts)

1. $3\,C_G + 3\,F_{2(g)} \longrightarrow C_3F_{6(g)}$ $\qquad H_1^o = -1080$ kJ

2. $6\,C_G + \frac{5}{2}\,H_{2(g)} + \frac{1}{2}\,F_{2(g)} \longrightarrow C_6H_5F_{(g)}$ $\qquad H_2^o = -150$ kJ

3) $\frac{1}{2}\,H_{2(g)} + \frac{1}{2}\,F_{2(g)} \longrightarrow HF$ $\qquad H_3^o = -274$ kJ

Calculate H_{rxn} for, (SHOW WORK)

$$2\,C_3F_6 + 8\,H_2 \rightleftharpoons C_6H_5F + 11\,HF$$

i) -2078 kJ ii) -1004 kJ iii) -4028 kJ iv) -1148 kJ

2(-1) $\quad 2\,C_3F_{6(g)} \longrightarrow 6\,C_G + 6\,F_{2(g)}$ $\qquad 2(\ H_1^o = 1080$ kJ)

11(3) $\quad \frac{11}{2}\,H_{2(g)} + \frac{11}{2}\,F_{2(g)} \longrightarrow 11\,HF$ $\qquad 11(\ H_3^o = -274$ kJ)

(2) $\quad 6\,C_G + \frac{5}{2}\,H_{2(g)} + \frac{1}{2}\,F_{2(g)} \longrightarrow C_6H_5F_{(g)}$ $\qquad H_2^o = -150$ kJ

$$H_{rxn} = 2160 - 3014 - 150 = -1004 \text{ kJ}$$

ANSWER IS: -1004 kJ

2) Consider the the following equilibrium reaction at 25°C. (12 points)

$$3\,HI_{(\lambda)} + N_{2(g)} \rightleftharpoons NH_{3(g)} + NI_{3(s)} \qquad H = +20.0 \text{ kJ}$$

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

a) A catalyst is added. ANSWER IS: UNCHANGED

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

c) The temperature is lowered. ANSWER IS: LEFT

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

e) Some N_2 is added. ANSWER IS: RIGHT

f) Some HI is removed. ANSWER IS: UNCHANGED

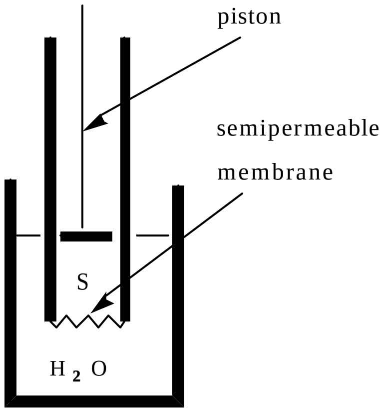
3) A balloon filled with helium has a volume of 875 L at STP. The temperature of the balloon is increased to 38^{o}C, and it expands to a volume of 998 L with the pressure remaining constant. Calculate (in kJ) q, w, E, and H for the helium in the balloon. ($C_{v,m} = 12.5 \frac{J}{K \cdot mol}$)

SHOW WORK

E = (39.04)(12.5)(38-O) = 18544 J	(5 pts)	For q, ANSWER IS: 31.O kJ
W = -(1)(998-875)(1O1.3) = -1246O J	(5 pts)	For W, ANSWER IS: -12.5 kJ
q = E - W = 18544 + 1246O = 31004 J	(5 pts)	For E, ANSWER IS: 18.5 kJ
H= E + P V = 18544 + 1246O = 31004 J	(5 pts)	For H, ANSWER IS: 31.O kJ

THE FOLLOWING IN FORMATION IS FOR USE IN PROBLEMS 4, 5, AND 6.

Given the following setup:



You have a tube with a semipermeable membrane. It is inserted into a beaker containing pure water. The tube contains a solution, S, which has 18.O g/L of an unknown solute which does not dissociate. The osmotic pressure of this solution is 1871 torr at 3OO K . The volume of this solution is 1OO.O mL and its density is 1.OO $\frac{g}{mL}$.

4) Calculate the molar mass of this unknown solute. 1O pts

$$ð = cRT = \frac{nRT}{V} = \frac{wRT}{FV} \quad \backslash \quad F = \frac{wRT}{ðV} = \frac{(18)(O.O821)(3OO)}{(1871/76O)(1)} = 18O \frac{g}{mol}$$

ANSWER IS: 18O $\frac{g}{mol}$

5) The piston (shown in the drawing) now exerts a downward pressure of 3742 torr on the solution. What is the final molarity of this solution when equilibrium is established (with ð = 3742 torr)? This process is called REVERSE OSMOLYSIS SINCE WATER GOES THROUGH THE MEMBRANE BACK INTO THE BEAKER. 1O pts

$$\text{ð} = \frac{3742}{76O}\ \text{atm} = 4.924\ \text{atm}$$

\ $c = \dfrac{\text{ð}}{RT} = \dfrac{4.924}{(O.O821)(3OO)}$ = O.2OO M

ANSWER IS: O.2OO M

6) Assume that after the process of reverse osmolysis the solution density was 1.1O $\frac{g}{mL}$. Calculate the weight of water forced back into the beaker of pure water. SHOW WORK 1O pts

i) 5O.O g ii) 45.O g iii) 48.2 g iv) 47.O g

INITIALLY WE HAVE 1.8 g SOLUTE IN 98.2 g H_2O

AT THE END, $c = \frac{n}{V}$ \ $V = \frac{n}{c} = \frac{w}{Fc} = \frac{1.8\text{ g solute}}{(18O)(O.2OO)}$ = O.O5OO L = 5O.O mL

\ WEIGHT OF SOLUTION = 55.O g (= 1.8 g solute + 53.2 g H_2O)

\ 45.O g OF H_2O WERE FORCED BACK INTO BEAKER

ANSWER IS: 45.O g

THE FOLLOWING INFORMATION IS FOR PROBLEMS 7, 8 AND 9. Two moles of argon (an ideal gas) are confined in a container of volume 11.2O L at 3OO K. The piston then undergoes an adiabatic expansion against a constant external pressure of one (1) atmosphere. After reaching the final volume, the temperature in the piston is T_2 (=?) and the work done by the piston is, W = -2494 J.

$$(C_{v,m} = 12.47\ \frac{J}{K\cdot mol})$$

7) The final volume of the gas (in liters) is: 1O pts (SHOW WORK)

i) 35.8 ii) 23.5 iii) 22.4 iv) 31.7

W = -2494 = -P V(1O1.3) = (-1)(V_2 - 11.2)(1O1.3)

V_2 = 35.8 L

ANSWER IS: i

8) Determine the final temperature, T_2 , for this process. 1O pts

$nC_V\ \ T = (2)(12.47)(T_2 - 3OO) = W = -2494\ J$

$T_2 = 2OO\ K$

ANSWER IS: <u>2OO K</u>

9) Calculate H (in Joules) for this process. $R = 8.31 \frac{J}{K\cdot mol}$. 5 pts

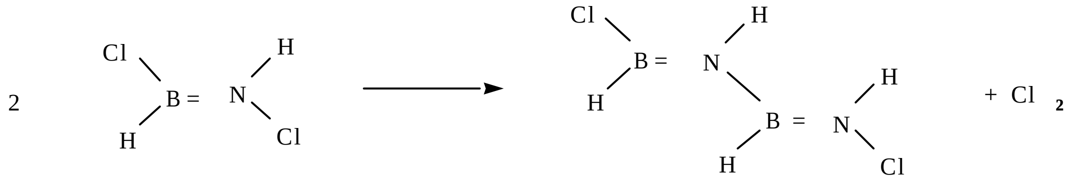
$H = \ \ E + \ \ (PV) = \ \ E + nR\ \ T = nC_p\ \ T$

$H = nC_p\ \ T = (2)(12.47 + 8.31)(-1OO) = -4156\ J$

ANSWER IS: - <u>4156 J</u>

1O) GIVEN: Bond enthalpies (kJ/mol): B=N (511); N-N (163); N-B (212);
N-H (388); N-Cl (381); B-H (551); Cl-Cl (243); B-Cl (349)

Using the above table of bond enthalpies, calculate the heat of reaction, H_{rxn}, for the <u>gaseous</u> reaction, (SHOW WORK) 1O pts



<u>BONDS BROKEN</u> (+)	<u>BONDS FORMED</u> (-)
N-Cl (381)	1 N-B (-212)
B-Cl (349)	1 Cl-Cl (-243)

$H_{rxn} = 73O + (-455) = 275\ kJ$

ANSWER IS: <u>275 kJ</u>

11) Given the following <u>gaseous</u> reactions.

1. $3\ HF + C_3H_4F_2 \rightleftharpoons C_3HF_5 + 3\ H_2$ K_1

2. $F_2 + C_3HF_5 \rightleftharpoons C_3F_6 + HF$ $\quad K_2$

3. $2\ C_3F_6 + 6\ H_2 \rightleftharpoons C_6H_6F_6 + 6\ HF$ $\quad K_3$

Calculate the equilibrium constant K_4 (for reaction 4) in terms of K_1, K_2, and K_3. 1O pts

4. $2\ F_2 + 2\ C_3H_4F_2 \rightleftharpoons C_6H_6F_6 + 2\ HF$ $\quad K_4$

a) $\dfrac{K_3}{K_1^2K_2}$ b) $\dfrac{K_3}{K_1K_2^2}$ c) $\dfrac{K_3}{K_1^2K_2^2}$ d) $\dfrac{K_3}{K_1^2K_2^2}$

e) $K_1^2K_2^2K_3$ f) $\dfrac{K_1^2K_3}{K_2^2}$ g) $K_1K_2K^2_3$ h) $\dfrac{K_1K_3}{K_2^2}$

ANSWER IS: _e_

THE FOLLOWING INFORMATION IS FOR PROBLEMS 12, 13, AND 14.

Given the following gaseous reaction:

$$C_3H_4 + 6\ Cl_2 \longrightarrow C_3Cl_8 + 4\ HCl$$

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

12) The reaction proceeds until the total pressure, P_T, is 1.8O atm. At this total equilibrium pressure all four compounds (both reactants and both products) are present.
Molar masses: C_3H_4 (4O.O) ; Cl_2 (71.O) ; C_3Cl_8 (32O.O) ; HCl (36.5)
Calculate the density ($\frac{g}{L}$) of the initial (starting) mixture. 8 pts

$$d = \frac{\text{TOTAL WEIGHT}}{\text{VOLUME}} = \frac{4O.O + 71.O}{22.4} = 4.96\,\frac{g}{L}$$

ANSWER IS: $4.96\,\frac{g}{L}$

13) Calculate the partial pressures of C_3H_4, Cl_2, C_3Cl_8, and HCl at the total equilibrium pressure of 1.8O atm. 14 pts
SET UP THE EQUATIONS BELOW (6 pts) THAT WILL ALLOW YOU TO SOLVE FOR THE
PRESSURES. DO THE CALCULATIONS ON SCRAP PAPER AND INSERT NUMERICAL

ANSWERS WHERE INDICATED BELOW!

$$P_T = 1.8O = P_{C3H4} + P_{Cl2} + P_{C3Cl8} + P_{HCl} \qquad (6\text{ pts})$$

$$1.8O = (1-x) + (1-6x) + x + 4x = 2-2x$$

$$\therefore \qquad x = O.1O\text{ atm}$$

For C_3H_4, P = O.9O atm(2 pts) For Cl_2, P = O.1O atm(2 pts)

For C_3Cl_8, P = O.4O atm(2 pts) For HCl, P = O.4O atm(2 pts)

14) The equilibrium expression for $K_{P(atm)}$ where P_T is the total pressure at equilibrium is; 1O pts

i) $\dfrac{(1-O.5P_T)(4-2P_T)^4}{(O.5P_T)(3P_T-5)^6}$ ii) $\dfrac{(1-O.5P_T)(2-P_T)^4}{(O.5P_T)(3P_T-5)^6}$

iii) $\dfrac{(2-O.5P_T)(4-2P_T)^4}{(O.5P_T)(3P_T-5)^6}$ iv) $\dfrac{(1-O.5P_T)(4-2P_T)^4}{(P_T)(2P_T-5)^6}$

ANSWER IS: i

15) In the following group of three molecules, predict their relative normal boiling points: $GeCl_4$, $AsCl_3$, and $SnCl_4$.

Molar masses: $GeCl_4$ (214) ; $AsCl_3$ (181) ; $SnCl_4$ (26O)

i) $GeCl_4 > AsCl_3 > SnCl_4$ ii) $AsCl_3 > SnCl_4 > GeCl_4$

iii) $AsCl_3 > GeCl_4 > SnCl_4$ iv) $GeCl_4 > SnCl_4 > AsCl_3$

$AsCl_3 > SnCl_4 > GeCl_4$ actual values: 4O3 K > 384 K > 357 K

(4 pts) ANSWER IS: ii

16) In each of the following pairs of covalent molecules, CIRCLE the one with the higher normal boiling point. (2 pts each)

i) $CH_3CH_2CH_2CH_2SH$ or *$(CH_3)_2CHCH_2CH_2SH$*

ii) $HOCH_2CH_2CN$ or *$HOCH_2CH_2OH$*

17) 4O.O g of ice at O°C are mixed with 4O.O g of liquid (water) at O°C and an unknown mass of liquid (water) at 75°C. At equilibrium the final temperature of the entire system is 1O°C. Calculate the starting mass of liquid at 75°C. 1O pts (SHOW EQUATIONS USED WITH NUMBERS SUBSTITUTED BUT DO THE CALCULATIONS ON SCRAP PAPER)

GIVEN: specific heat of liquid = $4.18 \frac{J}{g \cdot deg}$; heat of fusion = $333 \frac{J}{g}$.

i) 15.O g   ii) 75.1 g   iii) 25.5 g   iv) 61.3 g   v) 3O.2 g

$$\underset{4Og,\ O^{o}C}{H_2O_{(s)}} \xrightarrow{q_1} \underset{4Og,\ O^{o}C}{H_2O_{(\lambda)}} \xrightarrow{q_2} \underset{4Og,\ 1O^{o}C}{H_2O_{(\lambda)}}$$

$$\underset{4Og,\ O^{o}C}{H_2O_{(\lambda)}} \xrightarrow{q_3} \underset{4Og,\ 1O^{o}C}{H_2O_{(\lambda)}} \qquad \underset{m\ g,\ 75^{o}C}{H_2O_{(\lambda)}} \xrightarrow{q_4} \underset{m\ g,\ 1O^{o}C}{H_2O_{(\lambda)}}$$

$$q_1 \quad + \quad q_2 \quad + \quad q_3 \quad + \quad q_4 \quad = \quad O$$

$$(4O.O)(333) + (4O.O)(4.18)(1O) + (4O.O)(4.18)(1O) + m(4.18)(-65) = O$$

ANSWER IS: <u>iv</u>