Chemistry 1210 Exam 3- Jordan. Fall 1999. Form A

Name____________________

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You must show all work for credit

Useful information: $\Delta G = \Delta H - T\Delta S$, $C = q/\Delta T$, $\Delta H = \Delta E + P\Delta V$, $\Delta E = q + w = q - P\Delta V$, $w = -P\Delta V$, 1L•atm = 101 J, PV=nRT, R = 0.0821 (Latm)/(molK) = 8.314 J/(molK), $J = kgm^2/s^2$, $Rate_1/Rate_2 = (MW_2/MW_1)^{1/2}$, $u^2 = (3RT)/MW$

(1) The heat capacity of Al is 0.902 J/(g°C), how much energy does it take to heat a 1.20 kg aluminum frying pan from 20.0 °C to 150.0°C? $\Delta T = 150.0 - 20.0 = 130.0°C$ $1.20 kg = 1.20 \times 10^3 g$

+4

$\frac{0.902 J}{g °C} \times 130.0°C \times 1.20 \times 10^3 g = 1.41 \times 10^5 J$

(2) Define the following in terms of ΔH and also without using ΔH.

+2 (a) exothermic $\Delta H < 0$, heat leaves the system

+2 (b) endothermic $\Delta H > 0$ heat enters the system

(3) In the reaction below, the change in volume of the reaction of 2 moles of H_2 with 1 mole of O_2 is -67.2 L.

(a) If the atmospheric pressure is 1.00 atm, how much PV work is done (in J, the sign counts).

$$2H_{2(g)} + O_{2(g)} \text{ -----> } 2H_2O_{(l)} \quad \Delta H = -571.6 \text{ kJ}$$

$\Delta V = -67.2L$ $P = 1.00 atm$ $P\Delta V = (-67.2L)(1.00 atm) = -67.2 L\cdot atm$

$W = -P\Delta V = 67.2 L\cdot atm$

$67.2 L\cdot atm \times \frac{101 J}{L\cdot atm} = 6.79 \times 10^3 J = 6.79 kJ$

(b) What is ΔE for the reaction above?

$\Delta H = \Delta E + P\Delta V$ $-571.6 kJ = \Delta E - 6.79 kJ$ $\Delta E = -564.8 kJ$

(4) Use Hesse's Law and the following equations to find ΔH for the formation of $C_6H_{6(g)}$ (equation 1)

$$6\,C_{(S)} + 3\,H_{2(g)} \text{ ------> } C_6H_{6(g)} \qquad (1)$$

Use the following equations

$$6\,C_{(s)} + 3\,H_{2(g)} \text{ ------> } C_6H_{6(l)} \qquad \Delta H = 49.0 \text{ kJ} \quad (2)$$

$$C_6H_{6(g)} \text{ --------> } C_6H_{6(l)} \qquad \Delta H = -30.8 \text{ kJ} \quad (3)$$

$6C_{(s)} + 3H_{2(g)} \rightarrow C_6H_6(g)$

$6C_{(s)} + 3H_{2(g)} \rightarrow C_6H_6(l)$ $\Delta H = 49.0 kJ$

$C_6H_6(l) \longrightarrow C_6H_6(g)$ $\Delta H = 30.8 kJ$

$\Delta H = 79.8 kJ$

$6C_{(s)} + 3H_{2(g)} + C_6H_6(l) \rightarrow C_6H_6(l) + C_6H_6(g)$ $\Delta H = 49.0 kJ + 30.8 kJ$

(5) Given the following reaction (equation1), (a) is heat given off or absorbed when 10.2 g of NO_2 is formed and (b) How much energy is given off of absorbed?

$$N_{2\,(g)} + 2O_{2\,(g)} \text{ ------> } 2NO_{2\,(g)} \qquad \Delta H = 66.4 \text{ kJ}$$

NO_2 MW = 46.0 g/mol

(a) absorbs heat

10.2g ÷ 46.0 g/mol = 0.222 moles

(b) $\Delta H = \frac{66.4 kJ}{2 moles\ NO_{2(g)}} = \frac{33.2 kJ}{1 mole\ NO_2}$

$\frac{33.2 kJ}{mole} \times 0.222 moles = 7.36 kJ$

(6) What is the heat of combustion for acetic acid (CH_3COOH)? The heat of formation for acetic acid is -484.5 kJ.

$CH_3COOH + O_2 \longrightarrow 2CO_2 + 2H_2O$

$\Delta H = (2\Delta H_{f\,CO_2} + 2\Delta H_{f\,H_2O}) - (\Delta H_{f\,CH_3COOH} + 0) =$

$[2(-393.5 kJ) + 2(-241 kJ)] - (-484.5 kJ)$

$\Delta H = -784.5 kJ$

(7) Given the reaction and the information below, aswer the following questions

$CaCO_3$ -------> $CaO + CO_2$ $\Delta H = 178.3$ kJ, $\Delta S = 160.5$ J/K $\Delta S = 0.1605 \frac{kJ}{K}$

(a) Will the reaction be spontaneous at 400 K? Why?

$\Delta G = \Delta H - T\Delta S = 178.3 kJ - (400 K)(0.1605 \frac{kJ}{K})$

$\Delta G = 114.1$ kJ

no, it will not be spontaneous

(b) Above what temperature will this reaction be spontaneous (and why)?

$\Delta G = 0$ for equilibrium

$0 = \Delta H - T\Delta S = 178.3 kJ - T(0.1605 \frac{kJ}{K})$

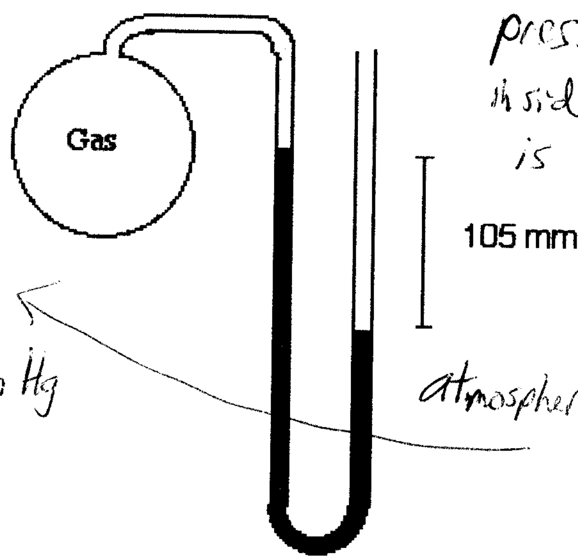
$178.3 kJ = T(0.1605 \frac{kJ}{K})$

$1.11 \times 10^3 K = T$

above 1.11×10^3 K it will be spontaneous

✓

(8) Given the mercury manometer shown below, if the atmospheric pressure is 605 mm of Hg, what is the pressure inside the bulb?



inside bulb

605 mm Hg − 105 mm Hg

bulb pressure = 500 mm Hg

pressure inside the bulb is 105 mm Hg less than atmospheric pressure

atmosphere = 605 mm Hg

assume 1.00L of gas PV=nRT MW AsH_3 = 77.95 g/mol
25°C = 298K

$(1.00 atm)(1.00L) = n(0.0821 \frac{L\,atm}{mol\,K})(298K)$

4.09×10^{-2} moles = n in 1.00L

4.09×10^{-2} moles $\times \frac{77.95 g}{mole}$ = 3.19g $\frac{3.19g}{1.00L}$ = **3.19 g/L**

✓(9) State 4 points of the Kinetic-Molecular Theory of Gases.

(1) A gas consists of tiny particles (atoms or molecules)

(2) The volume of the gas particles is negligible +1 each any 4

(3) Attractive and repulsive forces between particles are negligible

(4) Collisions of gas particles are perfectly elastic

(5) Temperature (K) is a measure (is proportional to) the average kinetic energy of the gas particles.

✓ (+2) (10) If you have Ar at 1.70 atm of pressure in a 2.00 L container at 273 K, what will the pressure be if you ~~increase~~ decrease the temperature to 268 K?

initial PV=nRT

$(1.70 atm)(2.00L) = n(0.0821 \frac{L\,atm}{mol\,K})(273K)$

0.152 moles = n

final

$P(2.00L) = 0.152$ moles $(0.0821 \frac{L\,atm}{mol\,K})$ 268K

P = 1.67 atm

(11) What is the density of AsH_3 at 25 °C and 1.00 atm pressure? AsH_3 MW = 77.95 g/mol

PV=nRT assume 1.00L 25°C = 298K $n = 4.09 \times 10^{-2}$ moles AsH_3

$(1.00 atm)(1.00L) = n(0.0821 \frac{L\,atm}{mol\,K})(298K)$ 4.09×10^{-2} moles $\times$ 77.95 g/mole = 3.19g

$\frac{3.19g}{1.00L}$ = **3.19 g/L**

(12) How much faster would you expect He to effuse through a porous media than $SiCl_4$?

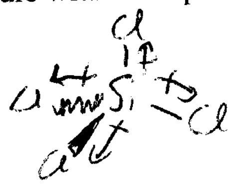
$$\frac{Rate_1}{Rate_2} = \frac{\sqrt{MW_2}}{\sqrt{MW_1}}$$

He AW 4.00 g/mol
$SiCl_4$ MW = 169.9 g/mole

$$\frac{Rate_{He}}{Rate_{SiCl_4}} = \frac{\sqrt{MW_{SiCl_4}}}{\sqrt{MW_{He}}} = \frac{\sqrt{169.9 \, g/mol}}{\sqrt{4.00 \, g/mol}} = 6.52 \times \text{faster}$$

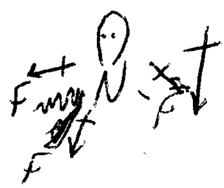
(13) Specify if each of the following molecules has a permanent dipole moment. If they do, draw in the structure with the dipole moment specified

(a) $SiCl_4$



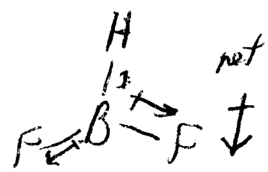
dipoles cancel no dipole moment

(b) NF_3



net dipole moment

(c) BF_2H



net dipole moment

(14) Specify the type of intermolecular forces that will be important for the following compounds in the liquid or solid state.

+1 each

(a) CH_3OH dispersion forces, hydrogen bonding

(b) N_2 dispersion forces

(c) CH_2Cl_2 dispersion forces dipole-dipole forces

(d) CH_4 dispersion forces

(15) Which process will have a larger ΔH, melting or boiling? Why? What will the sign of ΔH be? (and why)

boiling Only a small # of bonds or interatomic or intermolecular forces need to be broken to melt a solid. To boil a liquid, you must break all the remaining interatomic or intermolecular forces. So ΔH will be positive. Energy needed to break those attractive forces.

✓ (+1)

Extra Credit: What is the average velocity of a He atom at 400 K?

$u^2 = \frac{3RT}{Mw}$ $T = 400K$ $Mw = 4.00 \frac{g}{mol}$

$u^2 = \frac{3(8.314 \frac{kg\,m^2}{s^2\,mol\,K})(400K)}{4.00 \frac{g}{mol}}$ $u^2 = \frac{3(8.314 \frac{kg\,m^2}{s^2\,mol\,K})(400K)}{0.00400 \frac{kg}{mol}}$

Note: The extra credit problem was changed just prior to the exam. Look up Dalton's Law of Partial Pressure

$u^2 = 2.494 \times 10^6 \frac{m^2}{s^2}$

$u = 1.58 \times 10^3 \frac{m}{s}$