Question	1	2	3	4	5	6	7	8	Total
Mark	/3	/5	/9	/4	/9	/6	/9	/5	/50

CHEM 121 TEST A

Tuesday, 22 January 2008

Name (Print clearly): ....

Signature: ....

Instructions:

Attempt **all** questions. Enter answers in the spaces provided (continue on the back of the **opposite** sheet if necessary).

Total marks: 50 Time allowed: 60 minutes

Note:

At the end of this paper are:

1. A Periodic Table

2. A sheet containing physical chemistry formulae and some data

[Please check that both of these pages are attached before starting to answer the test paper!]

1. [3 marks]

Americium, the radioactive element used in smoke alarms, decays by alpha decay:

$$^{243}_{95}Am \rightarrow {}^{4}_{2}He + X$$

What is the isotope X formed? Use the standard symbol for an isotope including the atomic symbol.

2. [5 marks]

The enthalpy changes for the following reactions can be measured:

$Cu(s) + \frac{1}{2}O_2(g) \rightarrow CuO(s)$	$\Delta H° = -155$ kJ
$Cu(s) + S(s) \rightarrow CuS(s)$	$\Delta H° = -53.1$ kJ
$S(s) + O_2(g) \rightarrow SO_2(g)$	$\Delta H° = -297$kJ
$4CuS(s) + 2CuO(s) \rightarrow 3Cu_2S(s) + SO_2(g)$	$\Delta H° = -13.1$kJ

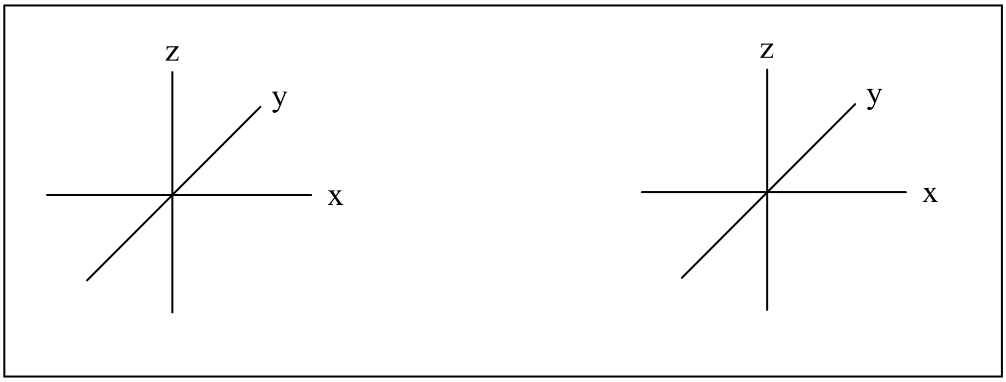
Use these values to calculate ΔH° for the reaction:

$CuS(s) + Cu(s) \rightarrow Cu_2S(s)$

3 [9 marks]

(a) On the axes given below, sketch the shapes (or "boundary surface" diagrams) of:

(i) the 2s orbital (ii) the $3p_x$ orbital



(b) Give the full electron configuration for the following atoms or ions:

[Use C ($1s^2 2s^2 2p^2$) for C (Z=6) as a model for the notation to be used in your answer.]

i) P (Z = 15)

ii) Cu (Z=29)

Question 3 continued

(c) Draw the Lewis structure for chlorite anion ion ClO_2^-. Calculate the formal charge on each atom.

4. [4 marks]

Explain the following terms used in thermodynamics:

(a) State function

(b) First law of thermodynamics (Explain **all** terms in any equation stated)

5.. [9 marks]

(a) In an analysis of Mn in steel, a sample of steel is first dissolved in concentrated nitric acid to form Mn^{2+} and $NO_2(g)$.

(i) What is the oxidation number of N in

(A) NO_2

(B) HNO_3

(ii) By using ion-electron half equations, write a balanced equation for the reaction of Mn and HNO_3.

(b) The Mn^{2+} ion is then treated with an acidic solution containing the periodate ion (IO_4^-) to give the MnO_4^- and IO_3^- ions. Finally, the concentration of the permanganate solution is determined by reacting with a standard $FeSO_4$ solution in an acidic medium. The balanced equations for these two steps are:

$$2Mn^{2+} + 5IO_4^- + 3H_2O \rightarrow 2MnO_4^- + 6H^+ + 5IO_3^- \quad (1)$$

$$MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O \quad (2)$$

Determine the relationship between the amount of Mn in a sample and the amount of $FeSO_4$ reacted in the final step (2). **Explain** your answer.

6. [6 marks]

(a) For a meteorological study, a hot-air balloon is launched at standard atmospheric pressure. A hot-air burner keeps the temperature of the air within the balloon at 55°C. If the volume of the balloon is 100,000 L, how many moles of air does it contain?

$R = 8.314\ J\ k^{-1}\ mol^{-1}$; 0°C = 273.15 K; 1 atm = 101.3 kPa

(b) The balloon ascends to an altitude at which the pressure is 90% of standard atmospheric pressure. Assuming that the hot-air burner maintains the air in the balloon at the same temperature (55°C) and that the amount of air within the balloon is unchanged, what will be the new volume of the balloon?

7. [9 marks]

A sample of propane gas, $C_3H_8(g)$ of mass 4.41 g was mixed with excess oxygen and burned in a **constant-volume** calorimeter at 25°C and 1 atmosphere pressure. It was observed that after the combustion was complete the temperature of the calorimeter and its contents had **increased** by 1.84 degrees. In a separate experiment (using electrical heating) the heat capacity of the calorimeter was found to be 120 kJ K^{-1}.

(a) Write a balanced equation for the combustion of propane given that the products are $CO_2(g)$ and $H_2O(l)$.

(b) Calculate the standard internal energy change ($\Delta U°$) for the combustion of **one mole** of propane. [$M(C_3H_8) = 44.1$ g mol^{-1}]

(c) Calculate the standard enthalpy change ($\Delta H°$) for the combustion of **one mole** of propane

8. [5 marks]

For the reduction of iron ore, $Fe_2O_3(s)$, by carbon monoxide to form iron metal and carbon dioxide.

Data:

Molecule	ΔH_f^o (kJ mol^{-1})
$Fe_2O_3(s)$	-822.3
$CO(g)$	-110.5
$CO_2(g)$	-393.5

(a) Write down a balanced equation for the reduction of $Fe_2O_3(s)$ by $CO(g)$ to form $Fe(s)$ and $CO_2(g)$.

(b) Calculate ΔH^o for the reduction of $Fe_2O_3(s)$ by $CO(g)$ to form $Fe(s)$ and $CO_2(g)$.

END OF PAPER

Periodic Table

1 H 1.008																	2 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.8	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.0	10 Ne 20.2
11 Na 23.0	12 Mg 24.3											13 Al 27.0	14 Si 28.1	15 P 31.0	16 S 32.1	17 Cl 35.5	18 Ar 39.9
19 K 39.1	20 Ca 40.1	21 Sc 45.0	22 Ti 47.9	23 V 50.9	24 Cr 52.0	25 Mn 54.9	26 Fe 55.9	27 Co 58.9	28 Ni 58.7	29 Cu 63.5	30 Zn 65.4	31 Ga 69.7	32 Ge 72.6	33 As 74.9	34 Se 79.0	35 Br 79.9	36 Kr 83.8
37 Rb 85.5	38 Sr 87.6	39 Y 88.9	40 Zr 91.2	41 Nb 92.9	42 Mo 95.9	43 Tc (99)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57-71 see below	72 Hf 178.5	73 Ta 181.0	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (210)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89-103 see below	104 Rf (257)	105 Db (260)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110	111	112						

57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (147)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0

89 Ac (227)	90 Th 232.0	91 Pa (231)	92 U 238.1	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (245)	98 Cf (251)	99 Es (254)	100 Fm (253)	101 Md (256)	102 No (254)	103 Lr (257)

Physical Chemistry Formulae

$PV = nRT$

$P_A = x_A P_{total}$ where $P_{total} = P_A + P_B$ and $x_i = \frac{n_i}{\sum_i n_i}$

$P_A = X_A P_A^\circ$

$P_B = (k_H)_B X_B$

$\Delta U = q + w$

$w_P = -P\Delta V$

$H = U + PV$

$\Delta H = \Delta U + RT\Delta n_{gas}$ when $\Delta T = 0$

$\Delta H(T_2) = \Delta H(T_1) + \Delta C_P(T_2 - T_1)$

$C_P = dH/dT$ (when $\Delta P = 0$)

$C_V = dU/dT$ (when $\Delta V = 0$)

$\Delta H_{reaction} = \sum_{prods} \nu_{prod} \Delta H_f(prod) - \sum_{reacts} \nu_{react} \Delta H_f(react)$

For $aA + bB \rightarrow cC + dD$, Rate $= \frac{-1}{a}\frac{d[A]}{dt} = \frac{-1}{b}\frac{d[B]}{dt} = \frac{1}{c}\frac{d[C]}{dt} = \frac{1}{d}\frac{d[D]}{dt}$

For Rate $= \frac{-d[A]}{dt} = k$, $[A] = [A]_0 - kt$

For Rate $= \frac{-d[A]}{dt} = k[A]$, $[A] = [A]_0 e^{-kt}$ and $t_{1/2} = (1/k)\log_e(2)$

$k = Ae^{-E_a/RT}$

$\log_e(k_2/k_1) = E_a/R(1/T_1 - 1/T_2)$

$K_a = \frac{[H^+][A^-]}{[HA]}$

$K_b = \frac{[BH^+][OH^-]}{[B]}$

$pH = -\log_{10}[H^+]$

$pH = pK_a + \log_{10}\left(\frac{[A^-]}{[HA]}\right) = pK_a + \log_{10}(n(A^-)/n(HA))$

$\Delta S = \sum_{prods} \nu_{prod} S(prod) - \sum_{reacts} \nu_{react} S(react)$

$\Delta S_{phase\ change} = \frac{\Delta H_{phase\ change}}{T_{critical}}$

$\Delta S_{surr} = \frac{-\Delta H_{sys}}{T}$

$\Delta G = \Delta H - T\Delta S$

$\Delta G = \sum_{prods} \nu_{prod} \Delta G_f(prod) - \sum_{reacts} \nu_{react} \Delta G_f(react)$

$\Delta G = \Delta G^\circ + RT\log_e Q$

$\Delta G^\circ = -RT\log_e K$

$\log_e K = \frac{-\Delta H^\circ}{RT} + \frac{\Delta S^\circ}{R}$

$\log_e\left(\frac{K_2}{K_1}\right) = \frac{\Delta H^\circ}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$

$E_{cell} = E_{RHS} - E_{LHS} = E_{cathode} - E_{anode}$

$w_{elect} = \Delta G = -nFE$

$\Delta G^\circ = -RT\log_e K = -nFE^\circ$

$E^\circ = \frac{RT}{nF}\log_e K = \frac{2.303RT}{nF}\log_{10} K$

At 25°C: $E^\circ = \frac{0.0591\ V}{n}\log_{10} K$

$E = E^\circ - \frac{RT}{nF}\log_e Q = E^\circ - \frac{2.303RT}{nF}\log_{10} Q$

At 25°C: $E = E^\circ - \frac{0.0591\ V}{n}\log_{10} Q$

R Gas constant (8.314 J mol^{-1} K^{-1} or 0.082 L atm mol^{-1} K^{-1})

F Faraday Constant (96489 C mol^{-1})