Question	1	2	3	4	5	6	Total
Mark	/9	/8	/8	/10	/5	/10	/50

CHEM 121 TEST B

Wednesday, 7 February 2007

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 (9 marks)

For the reaction

$$2NO_2(g) \rightleftharpoons N_2O_4(g) \qquad (1)$$

the following data are obtained at 275ºC.

$\Delta H^o = -58.1$ kJ mol^{-1}

$K = 1.9 \times 10^{-4}$

(a) Write an expression for the equilibrium constant (K).

(b) Explain the difference between the reaction quotient (Q) and for the equilibrium constant (K).

(c) Explain Le Chatelier's principle.

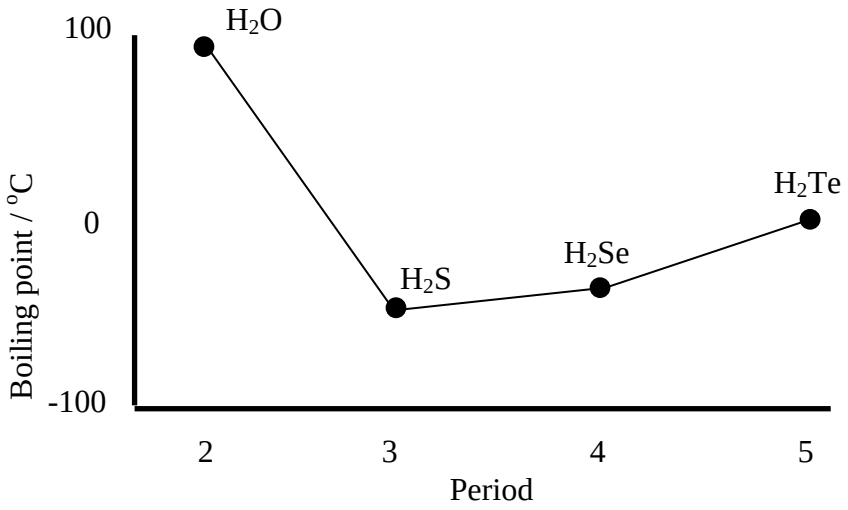
(d) In what way would the value for K for reaction (1) be changed by applying the following changes to this system at equilibrium? Explain your answers.

(i) The volume is decreased at constant temperature.

(ii) The temperature is increased at constant volume

2. (8 marks)

(a)



(i) Explain why water has the highest boiling point?

ii) Why do the boiling points from H_2S through to H_2Te increase?

(b). Explain, using equations, why $AlCl_3$ dissolves in water to produce a weakly acidic solution.

(3) (8 marks)

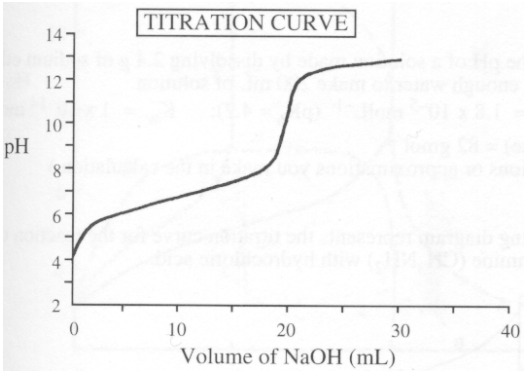
6.75g of SO_2Cl_2 was placed in a 2L flask. At 648K the equilibrium amount of SO_2 was 0.0345 moles. Calculate K for the reaction:

$$SO_2Cl_2(g) \rightleftharpoons SO_2(g) + Cl_2(g)$$

$Mr(SO_2Cl_2) = 135\ g\ mol^{-1}$

4. (10 marks)

An acid with the general formula HA has a yellow colour. The colour of its conjugate base, A^-, is blue. When equal concentrations of HA and A^- are present a green colour is observed. When a 15 mL sample of HA is titrated with 0.1 mol L^{-1} sodium hydroxide solution the pH changes as shown below.



(a) Is HA a strong or weak acid? Give a reason for your answer.

(b) What is the conjugate acid of base A^-.

(c) What is the colour of the solution at pH = 10?

(d) What is the concentration of the HA in the initial solution?

(e) What is the pH when the colour of the solution is green?

(f) Estimate the pKa of the acid HA. Justify your answer.

5 (5 marks)

(a) Propionic acid is a weak acid. Write an equation for the equilibrium that exists for propionic acid in water.

(b) Ka for propionic acid is 1.4×10^{-5}. Calculate the pH of a 0.1 mol L^{-1} solution of propionic acid. Explain any assumptions that you make.

6. (10 marks)

(a) Calculate the molar solubility (i.e. in mol L^{-1}) of $BaSO_4$ in pure water.

[Data: $K_{sp}(BaSO_4) = 1.1 \times 10^{-10}$]

(b) Calculate the molar solubility of Mg^{2+} in a buffered solution with pH = 12.00.

(Hint: first calculate the concentration of OH^- ions in the buffered solution.)

[Data: $K_{sp}(Mg(OH)_2) = 1.0 \times 10^{-11}$].

(c) 50 mL of 1.00×10^{-3} mol L^{-1} sodium sulfate solution is mixed with 50 mL of 2.00×10^{-3} mol L^{-1} barium chloride solution.

Will a precipitate of barium sulfate occur under these conditions?

(K_{sp} of $BaSO_4 = 1.0 \times 10^{-10}$)

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

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

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