Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2015/2016

COURSE NAME	:	PHYSICAL CHEMISTRY
COURSE CODE	:	DAS 12303
PROGRAMME	:	1 DAU
EXAMINATION DATE	:	DECEMBER 2015/JANUARY 2016
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTION	:	SECTION A ANSWER **ALL** QUESTIONS SECTION B ANSWER **TWO (2)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **SIX (6)** PAGES

SECTION A

Q1 (a) The decomposition of N_2O_5 is as follows :

$$2\ N_2O_5(g) \rightarrow 4\ NO_2(g) + O_2(g)$$

(i) Write the rate expression for the above reaction.

(3 marks)

(ii) If the concentration of N_2O_5 is decreasing at a rate of 4.2×10^{-7} Ms^{-1}, determine the rate at which the concentration of NO_2 and O_2 is increasing.

(3 marks)

(b) The following data were collected for the reaction of nitric oxide with hydrogen.

$$2\ NO(g) + 2\ H_2(g) \rightarrow N_2(g) + 2\ H_2O(g)$$

Experiment	Initial concentration of NO (M)	Initial concentration of H_2 (M)	Initial rate (Ms^{-1})
1	0.10	0.10	1.23×10^{-3}
2	0.10	0.20	2.46×10^{-3}
3	0.20	0.10	4.92×10^{-3}

(i) Determine the order for the reactants NO, H_2 and the overall order.

(10 marks)

(ii) Calculate the rate constant, *k*.

(4 marks)

(iii) Calculate the rate when [NO] = 0.050 M and [H_2] =0.150 M.

(2 marks)

(c) Find the half-life for a first order reaction given the rate constant, *k* is 2.2×10^{-5} s^{-1}.

(3 marks)

Q2 (a) Determine the maximum number of electrons that can have the following quantum numbers

(i) $n = 5$

(1 mark)

(ii) $n = 4, \ell = 2$

(1 mark)

(iii) $n = 2, \ell = 1$

(1 mark)

(iv) $n = 0, \ell = 0, m_\ell = 0$

(1 mark)

(v) $n = 1, \ell = 0, m_\ell = 0$

(1 mark)

(b) (i) Write the electron configuration for the atoms Si and Ca.
(Atomic number, Z : Si = 14, Ca = 20)

(3 marks)

(ii) Select the atom that has diamagnetic properties.

(4 marks)

(c) Using NH_3 and MgO as examples,

(i) Discuss ionic and covalent bonds.

(4 marks)

(ii) Use Lewis dot symbols to show the formation of NH_3 and MgO.
(Atomic number, Z : H = 1, N = 7, O = 8, Mg = 12)

(4 marks)

(d) Write the Lewis structure of HOCl and calculate formal charges.
(Atomic number, Z : H = 1, O = 8, Cl = 17)

(5 marks)

SECTION B

Q3 (a) The gas pressure in an aerosol can is 1.5 atm at 25 °C. Find the pressure if the can is heated to 450 °C.

(5 marks)

(b) An inflated balloon has a volume of 6.0 L at sea level where the temperature is 22 °C and the pressure is 1.0 atm. Calculate the volume of the balloon when the temperature is – 21 °C and the pressure is 0.45 atm.

(5 marks)

(c) Tennis balls are usually filled with air or N_2 gas to a pressure above atmospheric pressure to increase their "bounce." If a tennis ball has a volume of 144 mL and contains 0.33 g of N_2 gas, calculate the pressure inside the ball at 24 °C.
(Relative atomic mass : N = 14, R = 0.0821 L.atm/mol.K)

(8 marks)

(d) Calculate the density of carbon tetrachloride vapour, CCl_4 at 714 torr and 125 °C.
(Relative atomic mass : C = 12, Cl = 35.5, R = 0.0821 L.atm/mol.K)

(7 marks)

Q4 (a) (i) Define entropy, S.

(2 marks)

(ii) Arrange $PCl_5(s)$, $PCl_5(g)$ and $PCl_3(g)$ in order of increasing S.

(1 mark)

(b) Consider the following reaction carried out at 25°C and 1 atm.

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$

Calculate $\Delta H°$, $\Delta S°$, and $\Delta G°$ using the following data:

Substance	ΔH_f^o (kJ/mol)	$S°$ (J $K^{-1}mol^{-1}$)
$SO_2(g)$	– 297	248
$O_2(g)$	0	205
$SO_3(g)$	– 396	257

(8 marks)

(c) 30.0 g of urea, $(NH_2)_2CO$ is dissolved in 200 g of H_2O at 25°C.

(i) Find the number of moles of $(NH_2)_2CO$ and H_2O.
(Relative atomic mass : H = 1, C = 12, N = 14, O = 16)

(4 marks)

(ii) Determine the mole fractions of H_3PO_4 and H_2O.

(4 marks)

(iii) Calculate the vapour pressure of the aqueous solution. The vapour pressure of pure H_2O at 25°C is 23.8 torr.

(3 marks)

(iv) Calculate the molarity of the solution.
(Assume density of solution is 1 g/mL)

(3 marks)

Q5 (a) At 1000 K, $K_p = 1.85$ for the reaction

$$SO_2(g) + \tfrac{1}{2}\ O_2(g) \rightleftharpoons SO_3(g)$$

(i) Find K_p for the reaction : $SO_3(g) \rightleftharpoons SO_2(g) + \tfrac{1}{2}\ O_2(g)$

(1 mark)

(ii) Find K_p for the reaction : $2\ SO_3(g) \rightleftharpoons 2\ SO_2(g) + O_2(g)$

(1 mark)

(iii) Determine K_c for the reaction in (ii).
(R = 0.0821 L.atm/mol.K)

(4 marks)

(b) A mixture of 0.10 mol of NO, 0.050 mol of H_2, and 0.10 mol of H_2O is placed in a 1.0-L vessel at 300 K. The following equilibrium is established:

$$2\ NO(g) + 2\ H_2(g) \rightleftharpoons N_2(g) + 2\ H_2O(g)$$

At equilibrium [NO] = 0.062 M.

(i) Calculate the equilibrium concentrations of H_2, N_2 and H_2O.

(4 marks)

(ii) Calculate K_c.

(3 marks)

(c) For a voltaic cell based on the reaction :

$$2\,Al(s) + 3\,I_2(s) \rightarrow 2\,Al^{3+}(aq) + 6\,I^-(aq)$$

(i) Identify the anode and cathode and write the half-cell reaction at the anode and cathode.

(2 marks)

(ii) Write the cell diagram for the voltaic cell.

(2 marks)

(iii) Calculate E°_{cell} and E_{cell} given $[Al^{3+}] = 1.0$ M and $[I^-] = 0.068$ M.
($E^\circ_{Al^{3+}/Al} = -1.66$ V, $E^\circ_{I_2/I^-} = 0.54$ V)

(8 marks)

Q6 (a) Identify the Brønsted-Lowry acid and base and their conjugate acid-base pairs for the reaction :

(i) $H_2O(\ell) + H_2CO_3(aq) \rightleftharpoons H_3O^+(aq) + HCO_3^-(aq)$

(2 marks)

(ii) $C_5H_5NH^+(aq) + H_2O(\ell) \rightleftharpoons C_5H_5N(aq) + H_3O^+(aq)$

(2 marks)

(b) A solution has $[OH^-] = 3.9 \times 10^{-6}$ M

(i) Calculate $[H^+]$, pH and pOH
($K_w = 1.0 \times 10^{-14}$)

(8 marks)

(ii) Classify the solution as acidic, basic or neutral giving suitable reasons.

(2 marks)

(c) Calculate the pH of 5.0×10^{-2} M $Ca(OH)_2$ solution.
($K_w = 1.0 \times 10^{-14}$)

(4 marks)

(d) The pH of a 1.00 X 10^{-2} M solution of cyanic acid (HOCN) is 2.77 at 25°C.

(i) Write an equation for the dissociation of cyanic acid.

(1 mark)

(ii) Find the concentration of H^+ ions.

(2 marks)

(iii) Calculate K_a for HOCN.

(4 marks)

- END OF QUESTION -