Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2014/2015

COURSE NAME	:	PHYSICAL CHEMISTRY
COURSE CODE	:	DAS 12303
PROGRAMME	:	1 DAU
EXAMINATION DATE	:	DECEMBER 2014/JANUARY 2015
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTION	:	A) ANSWER **ALL** QUESTIONS
		B) ANSWER **TWO (2)** QUESTIONS ONLY

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

SECTION A

Q1 (a) The rate law for the reaction : $Cl_2(g) + CHCl_3(g) \rightarrow HCl(g) + CCl_4(g)$

is Rate = $k[C1_2]^{½}[CHC1_3]$

(i) Write the rate law expression.

(2 marks)

(ii) Find the order with respect to $[C1_2]$, $[CHC1_3]$ and the overall order of the reaction.

(3 marks)

(iii) Determine the units for k assuming time in seconds.

(3 marks)

(b) Theophylline is a pharmaceutical drug that is sometimes used to help with lung function. You observe a case where the initial lab results indicate that the concentration of theophylline in a patient's body decreased from 2.0×10^{-3} M to 1.0×10^{-3} M in 24 hours. In another 12 hours, the drug concentration was found to be 5.0×10^{-4} M. Calculate the value of the rate constant for the metabolism of this drug in the body.

(5 marks)

(c) A certain reaction has the following general form:

$$a\text{A} \rightarrow b\text{B}$$

At a particular temperature and initial concentration $[A]_o = 2.00 \times 10^{-2}$ M, concentration versus time data were collected for this reaction, and a plot of ln[A] versus time resulted in a straight line with a slope value of -2.97×10^{-2} min^{-1}.

(i) Determine the rate law, the integrated rate law, and the value of the rate constant, k for this reaction.

(3 marks)

(ii) Calculate the half-life for this reaction.

(2 marks)

(iii) Calculate the time required for the concentration of A to decrease to 2.50×10^{-3} M.

(3 marks)

(iv) Calculate the concentration of A after 1 hour.

(4 marks)

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

(i) $n = 4$
(ii) $n = 3, \ell = 2$
(iii) $n = 2, \ell = 1$
(iv) $n = 0, \ell = 0, m_\ell = 0$
(v) $n = 1, \ell = 0, m_\ell = 0$

(5 marks)

(b) (i) Write the electron configuration for the atoms Sc and P.
(Atomic number, Z : P = 15, Sc = 21)

(3 marks)

(ii) Determine the number of unpaired electrons in the above atoms.

(4 marks)

(c) Using HCl and KCl as examples,

(i) Discuss ionic and covalent bonds.

(4 marks)

(ii) Use Lewis dot symbols to show the formation of HCl and KCl.
(Atomic number, Z : H = 1, Cl = 17, K = 19)

(4 marks)

(d) Write the Lewis structures of ClF_3 and calculate formal charges.
(Atomic number, Z : F = 9, Cl = 17)

(5 marks)

SECTION B

Q3 (a) A sample of sulphur dioxide occupies a volume of 652 mL at 40 °C and 720 mm Hg. Calculate the volume the gas will occupy at standard temperature and pressure (STP).

(7 marks)

(b) In a mixture of two gases, the partial pressures of $CH_4(g)$ and $O_2(g)$ are 0.175 atm and 0.250 atm, respectively.

(i) Find the total pressure.

(1 mark)

(ii) Calculate the mole fraction of each gas in the mixture.

(6 marks)

(iii) If the mixture occupies a volume of 10.5 L at 65°C, calculate the total number of moles of gas in the mixture.
(R = 0.0821 L.atm/mol.K)

(3 marks)

(iv) Calculate the mass of each gas in the mixture.
(Relative atomic mass : H = 1, C = 12, O = 16)

(8 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) A solution of phosphoric acid was made by dissolving 10.0 g of H_3PO_4 in 100.00 mL of water. The resulting volume was 104 mL. Assuming water has a density of 1.00 g/mL, calculate

(i) the density of the solution

(2 marks)

(ii) the number of moles of H_3PO_4 and H_2O and their respective mole fractions
(Relative atomic mass : H = 1, P = 31, O = 16)

(8 marks)

(iii) molarity of the solution

(2 marks)

(iv) molality of the solution.

(2 marks)

Q5 (a) The balanced equation for the Haber process at 127 °C is

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(i) Calculate K_c given $[N_2] = 8.5 \times 10^{-1}$ M, $[H_2] = 3.1 \times 10^{-3}$ M, $[NH_3] = 3.1 \times 10^{-2}$ M

(3 marks)

(ii) Calculate K_c for the reaction $2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g)$

(2 marks)

(iii) Calculate K_c for the reaction $\frac{1}{2}N_2(g) + \frac{3}{2}H_2(g) \rightleftharpoons NH_3(g)$

(2 marks)

(iv) Calculate K_p. (R = 0.0821 L.atm/mol.K)

(4 marks)

(b) Arsenic can be extracted from its ores by first reacting the ore, with oxygen (a process called *roasting)* to form solid As_4O_6 which is then reduced with carbon

$$As_4O_6(s) + 6C(s) \rightleftharpoons As_4(g) + 6CO(g)$$

Predict the direction of the shift of the equilibrium position for this reaction in response to each of the following changes in conditions.

(i) Addition of CO
(ii) Addition or removal of C or As_4O_6
(iii) Removal of As_4

(3 marks)

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

$$Au^{3+}(aq) + 3\,Tl(s) \rightarrow Au(s) + 3Tl^{+}(aq)$$

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

(4 marks)

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

(1 mark)

(iii) Calculate E°_{cell}.
($E^{\circ}_{Au^{3+}/Au} = 1.50$ V, $E^{\circ}_{Tl^{+}/Tl} = -0.34$ V)

(2 marks)

(iv) Calculate E_{cell} given $[Au^{3+}] = 1.0 \times 10^{-2}$ M and $[Tl^{+}] = 1.0 \times 10^{-4}$ M.

(4 marks)

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

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

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

(4 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 $Ba(OH)_2$ 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 -