# UNIVERSITI TUN HUSSEIN ONN MALAYSIA

## FINAL EXAMINATION
## SEMESTER I
## SESSION 2010/2011

| | | |
|---|---|---|
| COURSE NAME | : | CHEMISTRY |
| COURSE CODE | : | DAS 12203/DSK 1913 |
| PROGRAMME | : | 1 DAA/DAC/DAI/DAM<br>2 DAA/DAC/ DAI/DAM |
| EXAMINATION DATE | : | NOVEMBER/DECEMBER 2010 |
| DURATION | : | 2½ HOURS |
| INSTRUCTION | : | ANSWER **ALL** QUESTIONS IN **PART A** AND **FOUR (4)** QUESTIONS IN **PART B** |

THIS QUESTION PAPER CONSISTS OF SIX (6) PAGES

## PART A

**Q1** (a) Given the reaction between oxide ion ($O^{2-}$) and water :

$$O^{2-}(aq) + H_2O(\ell) \rightleftharpoons OH^-(aq) + OH^-(aq)$$

Identify
(i) the Brønsted-Lowry acid and base
(ii) the conjugate acid-base pairs

(2 marks)

(b) The pH of a window-cleaning solution is 8.28. Find the $[H^+]$ and $[OH^-]$.
($K_w = 1.0 \times 10^{-14}$)

(4 marks)

(c) What is the pH of a 0.015 M $Ca(OH)_2$ solution?

(5 marks)

(d) Calculate the $[H^+]$, $[OH^-]$, $[NH_4^+]$ and pH of a 0.20 M aqueous ammonia, $NH_3$ solution.
($K_b = 1.8 \times 10^{-5}$)

(9 marks)

**Q2** (a) Determine the oxidation number of the underlined element.

(i) $\underline{Mn}O_4^-$
(ii) $\underline{Mn}O_2$
(iii) $\underline{C}_2O_4^{2-}$

(3 marks)

(b) A voltaic cell is set up based on the following standard half-reactions.

$$Cd^{2+}(aq) + 2e^- \rightarrow Cd(s), \quad E^\circ_{red} = -0.403\ V$$
$$Ag^+(aq) + e^- \rightarrow Ag(s), \quad E^\circ_{red} = 0.800\ V$$

(i) write the half-cell reactions at the anode and cathode as well as the cell diagram/notation
(ii) find the standard cell potential, $E^\circ_{cell}$.

(6 marks)

(c) For the following cell

$$Zn_{(s)} / Zn^{2+}_{(aq)} // Ni^{2+}_{(aq)} / Ni_{(s)} \text{ at } 25°C.$$

(i) Write the overall cell reaction.
(ii) Calculate $E^\circ_{cell}$ for the cell ( $E^\circ_{Zn^{2+}/Zn} = -0.763\ V$, $E^\circ_{Ni^{2+}/Ni} = -0.280\ V$ ).
(iii) Calculate $E_{cell}$ given $[Zn^{2+}] = 0.90$ M and $[Ni^{2+}] = 0.20$ M.

(7 marks)

(d) Calculate the mass of magnesium metal produced in 1 hour by the electrolysis of molten $MgCl_2$ if the current is 60.0 A.
(Molar mass of Mg = 24.3, 1 Faraday = 96 500 *C*)

(4 marks)

**PART B**

**Q3** (a) According to the equation below :

$$Cr_2O_7^{2-} + 6\,Fe^{2+} + 14\,H^+ \rightarrow 2\,Cr^{3+} + 6\,Fe^{3+}$$

The oxidation of 25.0 mL of a solution containing $Fe^{2+}$ requires 26.0 mL of 0.025*M* $K_2Cr_2O_7$ in acidic solution. Calculate the molar concentration of $Fe^{2+}$.

(4 marks)

(b) Compare quantitatively the rates of diffusion of methane, $CH_4$ and ammonia, $NH_3$.
(Relative atomic mass : C = 12, H = 1, N = 14)

(3 marks)

(c) A sample of $KClO_3$ is partially decomposed, producing $O_2$ gas that is collected over water. The volume of gas collected is 0.550 liter at 25°C and 657 torr total pressure.
(Partial pressure of water, $H_2O$ at 25°C = 23.76 torr, $R$ = 0.0821 L.atm/mol.K)

$$2\,KClO_3(s) \rightarrow 2\,KCl(s) + 3\,O_2(g)$$

(i) How many moles of $O_2$ are collected?
(ii) If the $O_2$ were dry, what volume would it occupy at the same temperature and pressure?

(8 marks)

**Q4** (a) A family of elements is characterized by an $ns^2np^2$ electron configuration in the outermost shell.

(i) give the possible values of $\ell$ and $m_\ell$ for the *s* and p orbital
(ii) draw the orbital diagram for all electrons in $ns^2np^2$
(iii) is the element diamagnetic or paramagnetic? Why?
(iv) identify the group of this family in the periodic table and state your reasons.

(7 marks)

(b) Arrange the following ions $K^+$, $Cl^-$, $S^{2-}$ and $Ca^{2+}$ in the order of decreasing ionic radii with suitable explanation.
(Atomic number, $Z$ : K = 19, Ca = 20, Cl = 17, S = 16)

(4 marks)

(c) (i) What is the difference between ionization energy and electron affinity?
(ii) Write equations to represent each process in (i) using the element sodium, Na as example.

(4 marks)

**Q5** (a) Use Lewis dot symbols to show the formation of aluminium oxide, $Al_2O_3$.
(Atomic number, $Z$ : Al = 13, O = 8)

(5 marks)

(b) Given 2 skeletal structures of formaldehyde, HCHO

(i) Complete the Lewis structure.
(ii) Calculate formal charges for all atoms in both structures.
(iii) Which structure is more stable? Give suitable reasons.
(Atomic number, $Z$ : O = 8, H = 1, C = 4)

(10 marks)

**Q6** (a) 455 grams of water is heated from 75 °C to 200 °C. Calculate the amount of heat that has been absorbed by the water.
Given the specific heat capacity of water is 4.18 $J.g^{-1}\ °C^{-1}$.

(3 marks)

(b) Calculate the standard entalphy of formation, $\Delta H°_f$ for methanol, $CH_3OH$.

$CH_3OH\ (\ell) + \frac{3}{2}\ O_2\ (g) \rightarrow CO_2\ (g) + 2H_2O\ (g),\ \Delta H°_c = -638.5\ kJ$

$\Delta H°_f$ [$CO_2$ = - 393.5 kJ $mol^{-1}$ , $H_2O$ = -241.8 kJ $mol^{-1}$]

(5 marks)

(c) Calculate the standard enthalpy change for the reaction

$BrCl\ (g) \rightarrow Br\ (g) + Cl(g)\ ,\ \Delta H°_{rxn} = ?$

Given the following data :

$Br_2(\ell) \rightarrow Br_2(g)$ $\Delta H°_{rxn} = +30.91$ kJ
$Br_2(g) \rightarrow 2Br(g)$ $\Delta H°_{rxn} = +192.90$ kJ
$Cl_2(g) \rightarrow 2Cl(g)$ $\Delta H°_{rxn} = +243.40$ kJ
$Br_2(\ell) + Cl_2(g) \rightarrow 2BrCl(g)$ $\Delta H°_{rxn} = +29.20$ kJ

(7 marks)

**Q7** (a) For the following reaction at 1100 °C :

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

From the data collected, determine:

(i) Rate law
(ii) Rate constant, *k*.

| Experiment | [NO] M | [$H_2$] M | Reaction rate (M/s) |
|---|---|---|---|
| 1 | $5.0 \times 10^{-3}$ | 0.32 | 0.012 |
| 2 | $1.0 \times 10^{-2}$ | 0.32 | 0.024 |
| 3 | $1.0 \times 10^{-2}$ | 0.64 | 0.096 |

(10 marks)

(b) The decomposition of $N_2O_5$ in solution in carbon tetrachloride is a first order reaction.

$$2\,N_2O_5 \rightarrow 4\,NO_2 + O_2$$

The rate constant, *k* is $5.25 \times 10^{-4}\ s^{-1}$. If the initial concentration of $N_2O_5$ is 0.200 M, find the concentration after 10 minutes.

(5 marks)

**Q8** (a) Write the equilibrium expression, $K_c$ for the following equations:

(i) $CO_2(g) + H_2(g) \rightleftharpoons CO(g) + H_2O(\ell)$
(ii) $SnO_2(s) + 2\,CO(g) \rightleftharpoons Sn(s) + 2\,CO_2(g)$
(iii) $3\,Fe(s) + 4\,H_2O(g) \rightleftharpoons Fe_3O_4(s) + 4\,H_2(g)$

(3 marks)

(b) Sulfur trioxide decomposes at a high temperature in a sealed container :

$$2\,SO_3(g) \rightleftharpoons 2\,SO_2\,(g) + O_2(g)$$

Initially, the vessel is charged at 1000 K with $SO_3(g)$ at a partial pressure of 0.500 atm. At equilibrium, the $SO_3$ partial pressure is 0.200 atm. Calculate the partial pressures of $SO_2$ and $O_2$ at equilibrium and the value of $K_p$.

(8 marks)

(c) Predict the shift on the equilibrium position for the following reactions :

(i) Ammonia (g) is removed from the following reaction

$4\ NH_3\ (g) + 5\ O_2\ (g) \rightleftharpoons 4\ NO(g) + 6\ H_2O(g)$

(ii) Catalyst is added to reaction below

$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3\ H_2(g)$

(iii) $CO_2$ (g) is added

$CaCO_3(s) + H_2O(\ell) + CO_2(g) \rightleftharpoons Ca(HCO_3)_2(aq)$

(iv) Heat is added to the system

$2\ NF_2(g) \rightleftharpoons N_2F_4\ (g), \quad \Delta H^o = -38.5\ kJ$

(4 marks)