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KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2022/2023 ACADEMIC YEAR

FOURTH YEAR FIRST SEMESTER
MAIN EXAMINATIONS

FOR THE DEGREE OF B.SC (SCIENCE)

COURSE CODE: SCH 412

COURSE TITLE: ELECTROCHEMISTRY

DURATION: 2 HOURS

DATE: 18/04/2023 **TIME: 2:00-4:00PM**

INSTRUCTIONS TO CANDIDATES

- Answer **QUESTION ONE** (Compulsory) and any other two (2) Questions.
- Indicate **answered questions** on the front cover.
- Start every question on a new page and make sure question's number is written on each page.

This paper consists of **6** printed pages. Please Turn Over

Question One (30 Marks)

a) State and explain Faraday's law of electrolysis. **[02]**

b) What are fuel cells ? Write the reaction of an oxygen hydrogen fuel cell. **[02]**

c) What is mercury cell ? Give the electrode reactions. **[02]**

d) Define the terms equivalent and molar conductivity. What are their physical significance? **[02]**

e) (i) What is corrosion ? What are the factors which affect corrosion ? **[02]**

(ii) CO_2 is always present in natural water. Explain its effect (increases, stops or no effect) on rusting of iron. **[02]**

(iii) Rusting of iron is quicker in saline water than in ordinary water. Explain. **[02]**

(iv) We can use aluminium in place of zinc for cathodic protection of rusting, Comment. **[02]**

(v) How is cathodic protection of iron different from its galvanisation? **[02]**

f) Why does conductivity of a solution decrease with dilution ? **[02]**

g) Define Kohlrausch's law. How does it help in

(i) calculating of Δ^{∞} for a weak electrolyte. **[02]**

(ii) degree of dissociation of a weak electroyte. **[02]**

h) Distinguish between;

i. Electrolytic cell and Electrochemical cell. **[02]**

ii. E.M.F. and Potential difference. **[02]**

iii. Metallic conduction and Electrolytic conduce conduction. **[02]**

Question two (20 Marks)

a) The table below shows limiting molar conductivies of common anions and cations at 298K;

Cation	**Limiting molar conductivity** $(\wedge^{\circ}_{m})$**Scm^{2}mol$^-$**	**Anion**	**Limiting molar conductivity** $(\wedge^{\circ}_{m})$**Scm^{2}mol$^-$**
H^+	349.6	OH^-	199.1
Na^+	50.1	Cl^-	76.3
K^+	73.5	Br^-	78.1
Ca^{2+}	119.0	Ac^-	40.0
Mg^{2+}	106.0	SO_4^{2-}	160.0

Use it to answer the questions (a) and (b) that follow.

Explain the difference in conductivity between;

i. H^+ ion and Na^+ ion

ii. Na^+ and Ca^{2+}

iii. SO_4^{2-} and OH^- **[03]**

iv. Calculate the value of ($\wedge^\circ_m$) for $CaCl_2$ and $MgSO_4$ solutions. **[02]**

c) The limiting molar conductivity ($\wedge^\circ_m$) values for NaCl, HCl and NaAc are 126.4 Scm^2mol^-, 425.9 Scm^2mol^-, and 91.05 Scm^2mol^-,respectively. Use these values to calculate the value of ($\wedge^\circ_m$) for HAc. **[02]**

d) The conductivity of 0.001028mol.L^- acetic acid is $4.95 \times 10^{-5} scm^{-1}$. Calculate its dissociation constant if $(\wedge^\circ_m)_{acetic\ acid}$ is 390.05 Scm^2mol^- **[02]**

e) The conductivity of sodium chloride at 298K was determined at different concentrations and the results tabulated as below.

Concentration ($mol.m^{-3}$)	**Conductivity k x 10^2 ($Sm^{2)}$**	**Molar conductivity ($\wedge_m$)Scm^2mol^-**	**$C^{1/2}$**
0.001	1.237		
0.010	11.85		
0.020	23.15		
0.050	55.58		
0.100	106.7		

Calculate ($\wedge_m$) for all values of concentration given, and draw a graph between ($\wedge_m$) and $C^{1/2}$. Use the graph to find the value of $\wedge^\circ_m$. **[04]**

f) Explain how using Kohlraush law one cam determine $\wedge^\circ_m$ for distilled water. **[02]**

g) Calculate the molar conductivity of the KCl solution? Given: Molarity (M) = 0.30M ;Conductivity at 298 K (k) = 0.023 S cm– **[02]**

h) Conductivity of 0.02 M solution of KCl at 298 K is 0.0248 Scm^- . Calculate the molar conductivity?Given: Molarity (M) = 0.20M, Conductivity at 298 K (k) = 0.0248 Scm^- **[02]**

i) Molar conductance values at infinite dilution of Na^+ and Cl^- ions are 51.12×10^{-4} Sm2mol-1 and 73.54×10^{-4} Sm^2mol^{-1} respectively. Calculate the total molar conductance of NaCl? **[02]**

Question three (20 Marks)

i. The Lead-acid cell, also called an acid accumlator has the overall spontaneous reaction below.

$Pb_{(s)} + PbO_{2(s)} \rightarrow PbSO_{4(s)}$

i. Write the equation of the reaction at the **anode**. **[01]**

ii. Write the equation of the reaction at the **Cathode.** **[01]**

b) An element X has r.a.m of 88. When a current of 0.5A was passed through the fused chloride of X for 32minutes and 10 seconds, 0.44g of X was deposited at the cathode. (Use 1 Farad = 96,500 coulombs)

i. Calculate the quantity of electicity needed to liberate one mole of X. **[03]**
ii. Write the formular for the cation of X. **[01]**
iii. Write formular for the chloride of X. **[01]**

c)

i) For a galvanic cell combining Zn and Cu, calculate the standard cell potential E° (given standard reduction potential for Zn^{2+} is -0.76V and that for Cu^{2+} is +0.34V) **[03]**

ii) Calculate the cell potential for the Zn//Cu cell at $[Zn^{2+}_{(aq)}] = 10M$ and $[Cu^{2+}_{(aq)}] = 0.1M$ **[03]**

d) The oxidation and reduction half cell reactions of the following overall process exist in separate half cells.

$$Cr_2O_7^{2-}{}_{(aq)} + I^-_{(aq)} \rightarrow Cr^{3+}_{(aq)} + I_{2(s)} \quad E° = 0.8254V.$$

Given the stoichiometric equation is,

$Cr_2O_7^{2-}{}_{(aq)} + 6\,I^-_{(aq)}\ 14H^+_{(aq)} \rightarrow Cr^{3+}_{(aq)} + 3\,I_{2(s)} + 7H_2O_{(l)}$ and the different concentrations are tabulated

Species	Concentration
$Cr^{3+}_{(aq)}$	2.0×10^{-5}
$Cr_2O_7^{2-}{}_{(aq)}$	2.0
$H^+_{(aq)}$	1.0
$I^-_{(aq)}$	1.0

e)

i. Calculate the instantenoius cell potential for the cell. **[04]**
ii. Dichromate (VI) ions are powerful oxidising agents and are reduced to chromium III ions. This colour change was once used in 'breath test' apparatus to determine if a driver had consumed excessive alcohol. Explain the term 'redox reaction' **[01]**

f) Explain how rusting of iron is envisaged as setting up of an electrochemical cell. **[02]**

Question four (20 Marks)

a) Calculate the Gibb's free energy in Joules for a Zn/Cu cell whose standard cell potiential is +1.10V. Explain this cell is spontaneous? **[01]**

b) Use the standard reduction potentials below to calculate the equilibrium constant for the following reaction at 25°C. **[02]**

$3I_{2(s)} + 2Al_{(s)} \rightarrow \quad 6I^-_{(aq)} + 2Al^{3+}_{(aq)}$

$I_{2(s)} + 2e^- \rightarrow \quad 2I_{-(aq)} \quad Eo = +0.54V$.....(i)

$Al^{3+}_{(aq)} + 3e^- \rightarrow \quad Al_{-(s)} \quad Eo = -1.66V$.....(ii)

c) A concentration cell is made using two Zn half cells, one with $[Zn^{2+}_{(aq)}] = 0.1M$ and the other $[Zn^{2+}_{(aq)}] = 1.0M$. if

$Zn^{2+}_{(aq)} + 2e^- \rightarrow Zn_{(s)} \quad Eo = -0.76V$,

Calculate the potential developed across the terminals of this cell.

Comment on the cell potential when the two half cells have the same concentration. **[03]**

d)

i. Differentiate the following terms;Resistivity and Conductivity **[02]**

ii. Calculate the resistance of a 12m copper wire whose diiametre is 0.01m ($\varrho_{cu} = 1.68 \times 10^{-8} m$) **[02]**

e) The resistance of a conductivity cell filled with $0.1 mol.L^{-1}$ KCl is 100Ω. If the resistance of the same cell when filled with $0.02 mol.L^{-1}$ solution is 520Ω. Calculate conductivity and molar conductivity of the $0.02 mol.L^{-1}$ KCl solution. The resistivity (ϱ) of $0.1 mol.L^{-1}$ KCl solution is $1.29 sm^{-1}$. **[02]**

f) How would you determine the standard electrode potential of the system Mg^{2+}/Mg? **[01]**

g) Depict the galvanic cell in which the reaction $Zn(s) + 2^+ Ag\ (aq) \rightarrow Zn^{2+}\ (aq) + 2Ag\ (s)$ takes place. **[03]**

Further show;

(i) Which of the electrode is negatively charged ? **[01]**

(ii) The carriers of the current in the cell. **[01]**

(iii) Individual reaction at each electrode. **[02]**

Question five (20 Marks)

a) What is Potentiometric Titration? **[02]**

b) Explain the principle in Potentiometric titration. **[02]**

c) Describe the method of Potentiometric titration. **[04]**

d) Name FOUR types of Potentiometric titrations. Give a brief description of each of these types of titration. **[04]**

e) What is the main advantage of potentiometric titration? **[02]**

f) How do you determine the endpoint of this titration? **[02]**

g) Mention one use of quinhydrone? **[02]**

h) Which electrode is used as a reference electrode? **[02]**