KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2020/2021 ACADEMIC YEAR

FOURTH YEAR SECOND SEMESTER
SPECIAL/SUPPLEMENTARY EXAMINATIONS

FOR THE DEGREE OF B.SC (SCIENCE)

COURSE CODE: SCH 440:

COURSE TITLE: ELECTROCHEMISTRY

DURATION: 2 HOURS

DATE: 11/1/2022 **TIME: 11-1PM**

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

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Question One (30 Marks)

a)

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**. **[02]**

ii. Write the equation of the reaction at the **Cathode.** **[02]**

iii. Differentiate between a galvanic cell and an electrolytic cell. **[02]**

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. **[04]**

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 **[05]**

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

e) 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) Aluminium metal is extracted from molten bauxite ($Al_2O_3.2H_2O$) using electrolysis. Cryolite (AlF_3) added to the ore in order to lower the melting point required and thus the energy required by the process.

i. Write an half equation to show how aluminium metal is produced from the ore. **[01]**

iv. What mass of aluminium metal would be produced if a current of 30,000A is applied to a cell for 1 hour. **[04]**

v. In the molten mixture there is a mixture of anions which mostly consists of O_2^- and F^-. Write an equation to show which of these anions will be oxidised in the cell? **[01]**

Question two (20 Marks)

a) State Kohlrausch's law. **[01]**

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

Cation	**Limiting molar conductivity (Λ°_m)Scm^2mol^-**	**Anion**	**Limiting molar conductivity (Λ°_m)Scm^2mol^-**
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 (Λ°_m) for $CaCl_2$ and $MgSO_4$ solutions. **[02]**

c) The limiting molar conductivity (Λ°_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 (Λ°_m) for HAc. **[03]**

d) The conductivity of 0.001028mol.L^- acetic acid is $4.95 \times 10^{-5} scm^{-1}$. Calculate its dissociation constant if $(\Lambda^\circ_m)_{\text{acetic acid}}$ is 390.05 Scm^2mol^- **[03]**

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

Concentration ($mol.m^{-3}$)	**Conductivity $k \times 10^2$ ($Sm^{2)}$**	**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 ($\wedge_m$) forall values of concentration given, and draw a graph between ($\wedge_m$) and $C^{1/2}$. Use the graph to find the value of $\wedge^\circ_m$. **[05]**

f) Explain how using Kohlraush law one cam determine $\wedge^\circ_m$ for distilled water. **[03]**

Question three (20 Marks)

b) The Nickel Cadimium cell, also called an alkaline cell has the overall spontaneous reaction

$Cd_{(s)} + NiO(OH)_{(s)} \rightarrow Cd(OH)_{2(s)} + Ni(OH)_{2(s)}$

iv. Write the equation of the reaction at the **anode**. **[02]**

v. Write the equation of the reaction at the **Cathode.** **[02]**

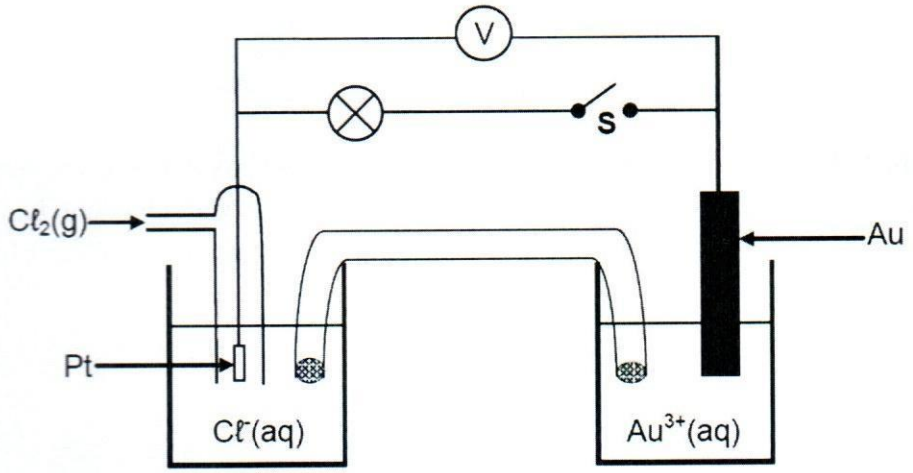
vi. Explain how the alkaline cell recharges itself. **[01]**

vii. State **three** disadvantages and **two** disadvantages of the alkaline accumulator over the Lead-acid cell. **[05]**

c) The diagram below shows a galvanic cell operating under standard conditions. The cell reaction taking place when the cell is functioning is:

$6C\ell^-(aq) + 2Au^{3+}(aq) \rightarrow 3C\ell_2(g) + 2Au(s)$

With switch is open, the initial reading on the voltmeter is 0.14 V.



Write down the:

i. NAME or FORMULA of the oxidising agent **[01]**

ii. Half-reaction which takes place at the anode **[02]**

iii. Cell notation for this cell **[02]**

iv. Calculate the standard reduction potential of Au. **[03]**

v. Switch S is now closed and the bulb lights up. How will the reading on the voltmeter now compare to the INITIAL reading of 0,14 V?. Give a reason for the answer. **[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? **[02]**

b) Use the standard reduction potentials below to calculate the equilibrium constant for the following reaction at 25°C. **[03]**

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

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

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

Calculate the potential developed across the terminals of this cell.

Comment on the cell potential when the two half cells have the same concentration. **[04]**

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) Differentiate between metallic conduction and electrolytic conduction. **[03]**

f) 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 $1.29 sm^{-1}$. **[04]**

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]**