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KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2021/2022 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: 25/05/2022 **TIME: 2:00PM-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

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Question One (30 Marks)

a) Differentiate between Galvanic cells and electrolytic cells **[02]**

b) Explain **FOUR** factors that affect electrolytic conduction **[02]**

c) An electrochemical cell is created using gold and magnesium half-cells. Given

i. $Mg^{2+} + 2e^- \rightarrow Mg_{(s)}$ **E° (Volts)** -2.37 and

ii. $Au^{3+} + 3e^- \rightarrow Au_{(s)}$ **E° (Volts)** +1.50

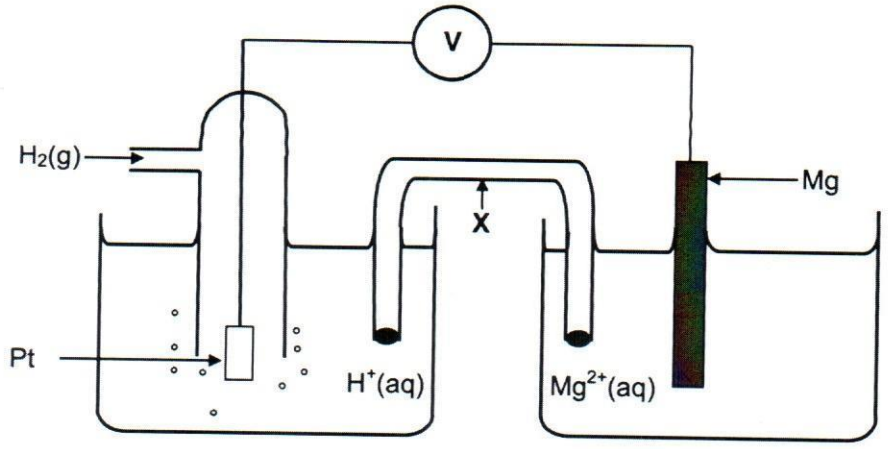
Determine which half-cell will undergo oxidation and which will undergo reduction, identify anode and cathode, and calculate the voltage for the cell. **[03]**

If the mass of the magnesium electrode changes by 5.0 g, what will be the change in mass of the gold electrode? (Take molar mass of Mg: 24.3 g $\cdot mol^{-1}$ molar mass of Au: 197.0 g $\cdot mol^{-1}$) **[03]**

d) State Faraday's **First and Second laws** of electrolysis **[02]**

Calculate the Gibb's free energy in Joules for a Zn/Cu cell whose standard cell potential is +1.10V. Explain this cell is spontaneous? **[02]**

e) The galvanic cell represented below consists of a hydrogen half-cell and a magnesium half-cell at standard conditions. The reading on the voltmeter is 2.36 V.



i. Apart from concentration, write down **TWO** other conditions needed for the hydrogen half-cell to function at standard conditions. **[02]**

ii. Write down the name of the item of apparatus labelled X. State any two functions of this apparatus. How is it prepared in the laboratory? **[03]**

iii. Is magnesium the ANODE or CATHODE in the cell above? Refer to the relative strengths of reducing agents to explain the answer. **[02]**

iv. Write down the cell notation for this cell. **[02]**

v. Calculate the standard reduction potential of the magnesium half-cell. Show ALL your working. **[02]**

vi. Write down the balanced NET (overall) cell reaction that takes place in this cell. No spectator ions are required. **[02]**

vii. A learner adds a few drops of Universal indicator to the hydrogen half cell. She notices that while the cell is working the colour of the indicator changes regularly at first but then remains constant. What would you expect to happen to the pH of the solution from the time the cell starts work till there is no change in the indicator colour. Explain why the indicator colour stops changing. **[02]**

Question Two (20 Marks)

a) Write all the **THREE** forms of Nernst equation. **[02]**

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

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

- $I_{2(s)} + 2e^- \rightarrow 2I_{-(aq)}$ Eo = +0.54V.....(i)
- $Al^{3+}_{(aq)} + 3e^- \rightarrow Al_{-(s)}$ 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

$Zn^{2+}_{(aq)} + 2e^- \rightarrow Zn_{(s)}$ 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) Define the following terms;

i. Resistivity

ii. Conductivity

iii. Molar conductance **[02]**

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

e) Using a suitable sketch, on the same axes describe variation of Molar conductance with concentration for

i) $HCl_{(aq)}$

ii) $CH_3COOH_{(aq)}$ **[03]**

f) The resistance of a conductivity cell filled with $0.1mol.L^{-1}$ KCl is 100Ω. If the resistance of the same cell when filled with $0.02mol.L^{-1}$ solution is 520Ω. Calculate conductivity and molar conductivity of the $0.02mol.L^{-1}$ KCl solution. The resistivity (ϱ) of $0.1mol.L^{-1}$ KCl solution is $1.29sm^{-1}$. **[04]**

Question Three (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 $(\wedge^\circ_m)Scm^2mol^-$	Anion	Limiting molar conductivity $(\wedge^\circ_m)Scm^2mol^-$
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. K^+ and Ca^{2+}

iii. Cl^- 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. **\03**

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^-. **[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 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 $\wedge^\circ_m$. **[05]**

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

Question four (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]**