



MACHAKOS UNIVERSITY

University Examinations 2022/2023 Academic year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR SECOND SEMESTER EXAMINATION FOR
BACHELOR OF SCIENCE (ANALYTICAL CHEMISTRY)

SAN 310: ELECTROCHEMISTRY

DATE: 18/4/2023

TIME: 2:00 – 4:00 PM

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks).

USEFUL FORMULARS

$$R = \rho \left(\frac{l}{A} \right), \pi = 3.142 \quad \kappa = \frac{1}{R} \times \text{Cell constant}$$

$$\Lambda_m = \frac{\kappa \times 1000}{c} \quad \alpha = \frac{\Lambda_m^c}{\Lambda_m^\infty} \quad K = \frac{c\alpha^2}{1-\alpha}$$

$$\log K_c = \frac{nE_{cell}^0}{0.0591} \quad E = E^0 - \frac{0.059v}{n} \log k$$

$$1C\Omega = 1As\Omega = 1Vs$$

$$\Delta G^0 = -nFE_{cell}^0 \text{ where } F=96500\text{C/mol}$$

$$\Delta G^0 = -2.303RT \log K_c$$

SECTION A

QUESTION ONE (30 MARKS)

- a) Define an electrochemical cell and give one example. (3 marks)
- b) Explain why it is not possible to measure single electrode potential. (2 marks)
- c) Calculate the electrode potential of copper wire dipped in 0.1 M copper sulphate solution at 25°C given that $\text{Cu}^{2+}/\text{Cu} = 0.34 \text{ V}$. (3 marks)
- d) i) What type of battery is lead storage cell? (1 mark)
ii) Using suitable chemical equations, explain the reactions at the anode and cathode and the overall reaction during discharging and recharging of the lead storage cell. (3 marks)
- e) List three merits of secondary reference electrodes. (3 marks)
- f) Define a fuel cell and state two materials beside hydrogen that can be used as fuels in a fuel cell. (3 marks)
- g) The overall reaction in a galvanic cell is $\text{Zn}_{(s)} + 2\text{Ag}_{(aq)}^+ \rightarrow \text{Zn}_{(aq)}^{2+} + 2\text{Ag}_{(s)}$
i) Write its cell representation. (1 mark)
ii) Identify the carriers of current in the cell. (1 mark)
iii) Identify the negatively charged electrode. (1 mark)
- h) The conductivity of 0.02 M solution of sodium chloride is $2.6 \times 10^{-2} \text{ scm}^{-1}$. Calculate its molar conductivity. (3 marks)
- i) The following reaction occurs in a cell.
 $2\text{Fe}_{(aq)}^{3+} + 2\text{I}_{(aq)}^- \rightarrow 2\text{Fe}_{(aq)}^{2+} + \text{I}_{2(s)}$ $E^{\circ}_{\text{cell}} = 0.236 \text{ V}$ (3 marks)
Calculate the equilibrium constant of the cell reaction.
- j) State three physical limitations of battery performance. (3 marks)

SECTION B

QUESTION TWO (20 MARKS)

- a) Calculate the change in Gibbs free energy (ΔG°) and equilibrium constant for the reaction below.
 $3\text{Cd}_{(aq)}^{2+} + 2\text{Cr}_{(s)} \rightarrow 2\text{Cr}_{(aq)}^{3+} + 3\text{Cd}_{(s)}$. Given $E^{\circ}_{\text{Cd}^{2+}/\text{Cd}} = -0.4 \text{ V}$ and $E^{\circ}_{\text{Cr}^{2+}/\text{Cr}} = -0.74 \text{ V}$. (7 marks)
- b) Explain the construction and working of calomel electrode. (7 marks)

- c) Conductivity of 0.00241 M acetic acid is $7.896 \times 10^{-5} \text{ S cm}^{-1}$. Calculate its molar conductivity and its dissociation constant if Λ_m° for acetic acid is $390.5 \text{ S cm}^2 \text{ mol}^{-1}$. (6 marks)

QUESTION THREE (20 MARKS)

- a) Explain how rusting of iron is considered as setting up an electrochemical cell. (6 marks)
- b) Conductivity of saturated solution of BaSO_4 at 315K is $3.648 \times 10^{-6} \text{ ohm cm}^{-1}$ and that of water is $1.25 \times 10^{-6} \text{ ohm cm}^{-1}$. Ionic conductance of Ba^{2+} and SO_4^{2-} are 110 and $136.6 \text{ ohm}^{-1} \text{ cm}^2 \text{ mol}^{-1}$ respectively. Calculate the solubility of BaSO_4 in g/L. (RMM of $\text{BaSO}_4 = 233$) (5 marks)
- c) Distinguish between chemical cell and concentration cell. (4 marks)
- d) Balance the reaction below in acidic conditions. (5 marks)
- $$\text{MnO}_4^{2-} + \text{C}_2\text{O}_4^{2-} \rightarrow \text{Mn}^{2+} + \text{CO}_2$$

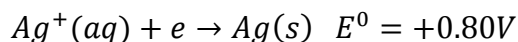
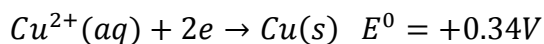
QUESTION FOUR (20 MARKS)

- a) i) Differentiate between weak and strong electrolytes. Give an example for each. (3 marks)
- ii) The E° values corresponding to the following electrode reduction process are $E_{\text{Cu}^+/\text{Cu}}^\circ = 0.52 \text{ V}$ and $E_{\text{Cu}^{2+}/\text{Cu}}^\circ = 0.16 \text{ V}$. Calculate cell potential and ΔG° for the cell. (5 marks)
- b) A constant current of 30.0A is passed through an aqueous solution of sodium chloride for a time of 1 hour. How many grams of sodium hydroxide and litres of chlorine gas at STP will be produced? (4 marks)
- c) The potential of a hydrogen electrode set up at 25°C in an aqueous solution was found to be -0.295 V. Calculate the pH of the solution. (4 marks)
- d) Define a biosensor and state its three main elements. (4 marks)

QUESTION FIVE (20 MARKS)

- a) Explain Kohlrausch's law of independent migration of ions. (2 marks)
- b) The Λ_m° for sodium acetate, HCl, NaCl are 91.0, 425.9 and $126.4 \text{ Scm}^2/\text{mol}$ respectively at 298K. Calculate Λ_m° for CH_3COOH . (4 marks)

- c) Use the information below to answer the questions that follow.



- i) Construct a galvanic cell using the above data. (2 marks)
- ii) For what concentration of Ag^+ ions will the EMF of the cell be zero at 25°C if the concentration of Cu^{2+} is 0.01M ? (4 marks)
- d) State and explain two functions of a salt bridge. (4 marks)
- e) Calculate the amount of electric energy available from a dry cell with EMF of 1.5 V which consumes 10 g of zinc. ($\text{Zn}=63.5$). (4 marks)