



MACHAKOS UNIVERSITY

University Examinations for 2020/2021 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:

TIME:

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

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

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

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

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

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

SECTION A

QUESTION ONE (30 MARKS)

- a) State three advantages of potentiometric titration. (3 marks)
- b) Differentiate between electrowinning and electrorefining as used in electrolysis. (2 marks)
- c) Calculate the reduction potential of Cu^{2+}/Cu electrode at 25°C when $[\text{Cu}^{2+}] = 0.010\text{M}$. (3 marks)
- d) State two differences between electronic conductance and electrolytic conductance. (4 marks)
- e) Explain the principle of the hydrogen-oxygen fuel cells and state two advantages over other ordinary cells. (4 marks)
- f) Calculate the equilibrium constant of the reaction. (3 marks)
- $$\text{Cu}_{(s)} + 2\text{Ag}_{(aq)}^+ \rightarrow \text{Cu}_{(aq)}^{2+} + 2\text{Ag}_{(s)} \quad E^0 = 0.46\text{V}$$
- g) State three disadvantages of standard hydrogen electrode (SHE) over the other secondary reference electrodes. (3 marks)
- h) The standard electrode potential for a Daniell cell is 1.1V . Calculate the standard Gibbs energy for the reaction. $\text{Zn}_{(s)} + \text{Cu}_{(aq)}^{2+} \rightarrow \text{Zn}_{(aq)}^{2+} + \text{Cu}_{(s)}$ $E^0 = 1.1\text{V}$ (3 marks)
- i) State three physical limitations of battery performance. (3 marks)
- j) Define junction potential as used in electrochemistry. (2 marks)

SECTION B

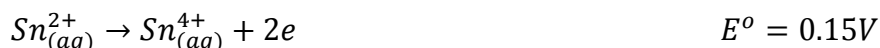
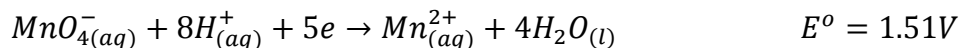
QUESTION TWO (20 MARKS)

- a) i) Define the term molar conductivity. (2 marks)
- ii) one half cell in a voltaic cell is constructed from a silver wire dipped in a silver nitrate solution of unknown concentration. Its other half cell consists of zinc electrode dipped in 1M solution of zinc nitrate. A voltage of 1.48V is measured for this cell. Use the information below to calculate the concentration of silver nitrate solution used.
- $$E_{\text{Zn}^{2+}/\text{Zn}}^0 = -0.76\text{V} \text{ and } E_{\text{Ag}^+/\text{Ag}}^0 = +0.80\text{V} \quad (8 \text{ marks})$$
- b) At 25°C the molar conductivities of Li^+ , Na^+ and K^+ are $3.87\text{ mSm}^2\text{mol}^{-1}$ and $5.01\text{ mSm}^2\text{mol}^{-1}$ and $7.35\text{ mSm}^2\text{mol}^{-1}$ respectively. Calculate the mobilities of Li^+ , Na^+ and K^+ . (4 marks)

- c) Calculate the amount of electric energy available from a dry cell with EMF of 1.5 V which consumes 10g of zinc. (Zn=63.5). (4 marks)
- d) Define a concentration cell. (2 marks)

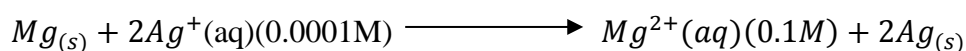
QUESTION THREE (20 MARKS)

- a) Two half-cell reactions of an electrochemical cell are given below



Construct a redox equation from the above half-cell reactions and predict if this reaction favours formation of reactants or products shown in the equations. (5 marks)

- b) The following chemical reaction is occurring in an electrochemical cell



The E^o electrode values for the half cells are given as;

$$Mg^{2+}(aq)/Mg(s) = -2.36 V$$

$$Ag^+(aq)/Ag(s) = 0.81 V$$

Using the above information calculate/write;

- E^o value for the electrode $2 Ag^+(aq)/2Ag(s)$. (1 mark)
 - Standard cell potential (E^o). (2 mark)
 - Cell potential (E_{cell}). (3 marks)
 - Symbolic representation of the above cell. (1 mark)
 - Will the cell reaction be spontaneous? (1 mark)
- c) The electrical resistance of a column of 0.05mol/L NaOH of diameter 1cm and length 50 cm is 5.55×10^3 ohm. Calculate:
- resistivity (ρ). (3 marks)
 - Conductivity. (2 marks)
 - Molar conductivity. (2 marks)

QUESTION FOUR (20 MARKS)

- a) Corrosion is essentially an electrochemical phenomenon. Explain the reactions occurring during corrosion of iron kept in an open atmosphere given that

$$E_{Fe^{2+}/Fe}^o = -0.44V \text{ and } E_{H^+/O_2/H_2O}^o = 1.23V \quad (5 \text{ marks})$$

- b) The conductivity of 0.001M acetic acid is $4.0 \times 10^{-5} S cm^{-1}$. Calculate the dissociation constant (k_a) if Λ_m^o for acetic acid is $390.5 S cm^2 mol^{-1}$. (5 marks)

- c) 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? (6 marks)
- d) The potential of a hydrogen electrode set up at 25°C in an aqueous solution is -0.295 V. Calculate the pH of the solution. (4 marks)

QUESTION FIVE (20 MARKS)

- a) Use the information given below to calculate the equilibrium constant (K_c) of the electrochemical reaction; $Fe(s) + Cd^{2+}(aq) \rightleftharpoons Fe^{2+}(aq) + Cd(s)$, given that $E_{Cd^{2+}/Cd}^{\circ} = -0.40V$ and $E_{Fe^{2+}/Fe}^{\circ} = -0.44V$. (5 marks)
- b) Use the information below to answer the questions that follow
- $$Cu^{2+}(aq) + 2e \rightarrow Cu(s) \quad E^{\circ} = +0.34V$$
- $$Ag^{+}(aq) + e \rightarrow Ag(s) \quad E^{\circ} = +0.80V$$
- 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? (5 marks)
- c) The Specific conductivity of a saturated solution of $Al(OH)_3$ at 298k is $8.5 \times 10^{-7} S \text{ cm}^{-1}$. If molar conductance at infinite dilution of $Al(OH)_3$ is $140.05 S \text{ cm}^2/\text{mol}$, calculate the solubility and K_{sp} of $Al(OH)_3$. (5 marks)
- d) State and explain three functions of a salt bridge. (3 marks)