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

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

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

$Log\ K_c = \frac{nE_{cell}^O}{0.0591} \qquad E = E^O - \frac{0.059v}{n} \log k$

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

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

$\Delta G^o = -2.303RT\ logK_C$

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 25^0C given that Cu^{2+} /Cu =0.34 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 $Zn_{(s)} + 2Ag^{+}_{(aq)} \rightarrow Zn^{2+}_{(aq)} + 2Ag_{(s)}$

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 $2.6 \times 10^{-2} scm^{-1}$. Calculate its molar conductivity. (3 marks)

i) The following reaction occurs in a cell.

$2Fe^{3+}{}_{(ag)} + 2I^{-}_{(aq)} \rightarrow 2Fe^{2+}_{(aq)} + I_2(s) \quad E^O cell = 0.236V$ (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 Gibb's free energy (ΔG^o) and equilibrium constant for the reaction below.

$3Cd^{2+}{}_{(aq)} + 2Cr_{(s)} \rightarrow 2Cr^{3+}_{(aq)} + 3Cd(s)$. Given $E^o_{Cd^{2+}/Cd} = -0.4\,V$ and $E^o_{Cr^{2+}/Cr} = -0.74\,V$. (7 marks)

b) Explain the construction and working of calomel electrode. (7 marks)

c) Conductivity of 0.00241 M acetic acid is 7.896×10^{-5} S cm^{-1}. Calculate its molar conductivity and its dissociation constant if Λ^o_m for acetic acid is 390.5 S cm^2 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 $3.648 \times 10^{-6} ohm\ cm^{-1}$ and that of water is $1.25 \times 10^{-6} ohm\ cm^{-1}$. Ionic conductance of Ba^{2+} and SO_4^{2-} are 110 and 136.6 $ohm^{-1}\ cm^2 mol^{-1}$ respectively. Calculate the solubility of $BaSO_4$ in g/L. (RMM of $BaS0_4 = 233$ (5 marks)

c) Distinguish between chemical cell and concentration cell. (4 marks)

d) Balance the reaction below in acidic conditions. (5 marks)

$MnO_4^{2-} + C_2O_4^{2-} \rightarrow Mn^{2+} + CO_2$

QUESTION FOUR (20 MARKS)

a) i) Differentiate between weak and strong electrolytes. Give an example for each. (3 marks)

ii) The E^o values corresponding to the following electrode reduction process are $E^O_{Cu^+/Cu} = 0.52\,V$ *and* $E^O_{Cu^{2+}/Cu} = 0.16\,V$. Calculate cell potential and ΔG^o 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^o_m for sodium acetate, HCl, NaCl are 91.0, 425.9 and 126.4 Scm^2/mol respectively at 298k. Calculate Λ^o_m for CH_3COOH. (4 marks)

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

$$Cu^{2+}(aq) + 2e \rightarrow Cu(s) \quad E^0 = +0.34V$$

$$Ag^{+}(aq) + e \rightarrow Ag(s) \quad E^0 = +0.80V$$

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^{o}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. (Zn=63.5). (4 marks)