MACHAKOS UNIVERSITY

University Examinations for 2021/2022 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FOURTH YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF EDUCATION (SPECIAL NEEDS EDUCATION)

BACHELOR OF EDUCATION (SCIENCE)

SCH 401: ELECTROCHEMISTRY

DATE: 25/8/2022 **TIME: 2.00-4.00 PM**

INSTRUCTIONS:

Question **ONE** is **COMPULSORY (Section A) (30 marks)**

Answer **ANY** other **TWO** questions from **Section B (each 20 marks)**

Useful formulae

$R = \rho(\frac{l}{A}), \pi = 3.142$

$\kappa = \frac{1}{R} \times Cell\ constant$

$\Lambda_m = \frac{\kappa \times 1000}{C}$

$\alpha = \frac{\Lambda_m^c}{\Lambda_m^\infty}$

$\mathrm{K} = \frac{C\alpha^2}{1-\alpha}$

$Log\ K_c = \frac{nE_{cell}^o}{0.0591}$

$E = E^O - \frac{0.059v}{n} \log k$

$\mu = \frac{\lambda}{zF}$

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

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

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Define the following terms (2 marks)

i. Resistance

ii. Electrolyte

b) State two differences between electronic conductance and electrolytic conductance. (4 marks)

c) Calculate the equilibrium constant of the reaction. (3 marks)

$$Cu_{(s)} + 2Ag^{+}_{(aq)} \rightarrow Cu^{2+}_{(aq)} + 2Ag_{(s)} \qquad E^{O} = 0.46V$$

d) Differentiate between a primary and secondary reference electrode. (2 marks)

e) Explain why secondary reference electrodes are preferred over standard hydrogen electrode (SHE). (3 marks)

f) The standard electrode potential for a Daniell cell is 1.1V. Calculate the standard Gibb's energy for the reaction. $Zn_{(s)} + Cu^{2+}_{(aq)} \rightarrow Zn^{2+}_{(aq)} + Cu_{(s)} \quad E^{O} = 1.1V$ (3 marks)

g) Account for the following:

i. Alkaline medium inhibits rusting of iron (1 mark)

ii. Iron does not rust even if the zinc coating is broken in a galvanized iron pipe. (2 marks)

h) Define a reversible cell (2 marks)

i) State and explain two functions of a salt bridge (4 marks)

j) Differentiate between electrowinning and electrorefining as used in electrolysis. (2 marks)

k) Define junction potential as used in electrochemistry. (2 marks)

QUESTION TWO (20 MARKS)

a) The following chemical reaction is occurring in an electrochemical cell

$Mg_{(s)} + 2Ag^{+}$(aq) (0.0001 M) $\longrightarrow$ $Mg^{2+}(aq)(0.1M) + 2Ag_{(s)}$

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;

i. E^{o} value for the electrode $2\ Ag^{+}(aq)/2Ag(s)$ (1 mark)

ii. Standard cell potential (E^o) (1 mark)

iii. Cell potential (E_{cell}) (3 marks)

iv. Symbolic representation of the above cell (1 mark)

v. Will the cell reaction be spontaneous (1 mark)

b) Illustrate with relevant chemical equations discharging reactions of a lead acid battery. (4 marks)

c) The conductivity of 0.001028 mol L^{-1} acetic acid is $4.95 \times 10^{-5}\ S\ cm^{-1}$. Calculate the dissociation constant (k_a) if Λ_m^o for acetic acid is $390.5\ S\ cm^2 mol^{-1}$ (5 marks)

d) i. Explain why electrolysis of aqueous solution of sodium chloride gives hydrogen at cathode and chlorine at anode (1 mark)

ii. Write the overall reaction given that $E^o_{Na^+/Na} = -2.71V$;

$E^o_{H_2O/H_2} = -0.83V;\ E^o_{Cl_2/2Cl^-} = +1.36V;\ E^O_{H+/O_2/H_2O} = +1.23V$ (3 marks)

QUESTION THREE (20 MARKS)

a) Use the information below to answer the questions that follow

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

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

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°C if the concentration of Cu^{2+} is 0.01M. (5 marks)

b) The electrical resistance of a column of 0.05mol/L NaOH of diameter 1cm and length 50cm is 5.55×10^3 ohm. Calculate

i. resistivity (ρ) (3 marks)

ii. Conductivity (2 marks)

iii. Molar conductivity (2 marks)

c) Demonstrate using relevant chemical equations all the steps involved in rusting of iron given that $E^O_{Fe^{2+}/Fe} = -0.44V\ \ and\ E^O_{H+/O_2/H_2O} = 1.23V$ (6 marks)

QUESTION FOUR (20 MARKS)

a) Use the information given below to calculate the equilibrium constant (K_c) of the electrochemical reaction; $Fe(s) + Cd^{2+}(aq) \rightleftarrows Fe^{2+}(aq) + Cd(s)$, given that.

$E^o_{Cd2+/Cd} = -0.40V \ and \ E^o_{Fe2+/Fe} = -0.44V.$ (5 marks)

b) The Specific conductivity of a saturated solution of $Al(OH)_3$ at 298k is $8.5x10^7$ S cm^{-1}.If molar conductance at infinite dilution of $Al(OH)_3$ is 140.05 S cm^2/moL, calculate the solubility and Ksp of $Al(OH)_3$. (10 marks)

c) State two advantages of hydrogen oxygen fuel cell over the ordinary cell (2 marks)

d) State three physical limitations of battery performance (3 marks)

QUESTION FIVE (20 MARKS)

a) At 25°C the molar conductivities of Li^+, Na^+ and K^+ are 3.87 mSm^2mol^{-1} and 5.01mSm^2mol^{-1} and 7.35 mSm^2mol^{-1} respectively. Calculate the mobilities of Li^+, Na^+ and K^+. (5 marks)

b) Explain the principle of the hydrogen -oxygen fuel cells (2 marks)

c) Differentiate between electrolytic cells and concentration cells with suitable examples. (4 marks)

d) 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)

e) State three modes through which mass transport occurs (3 marks)