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

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

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

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

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

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

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 $[Cu^{2+}]$=0.010M. (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)

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

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 Gibb's energy for the reaction. $Zn_{(s)} + Cu^{2+}_{(aq)} \rightarrow Zn^{2+}_{(aq)} + Cu_{(s)} \quad E^{O} = 1.1V$ (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 1 M solution of zinc nitrate. A voltage of 1.48 V is measured for this cell. Use the information below to calculate the concentration of silver nitrate solution used.

$E^{o}_{Zn2+/Zn} = -0.76\,V \;\; and \;\; E^{o}_{Ag+/Ag} = +0.80\,V$ (8 marks)

b) At 25^{0}C the molar conductivities of Li^{+}, Na^{+} and K^{+} are 3.87 $mSm^{2}mol^{-1}$ and 5.01$mSm^{2}mol^{-1}$ and 7.35 $mSm^{2}mol^{-1}$ 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

$$MnO_{4(aq)}^{-} + 8H_{(aq)}^{+} + 5e \rightarrow Mn_{(aq)}^{2+} + 4H_2O_{(l)} \qquad E^o = 1.51V$$

$$Sn_{(aq)}^{2+} \rightarrow Sn_{(aq)}^{4+} + 2e \qquad E^o = 0.15V$$

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

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

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). (2 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)

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:

i) resistivity (ρ). (3 marks)

ii) Conductivity. (2 marks)

iii) 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

$E_{Fe^{2+}/Fe}^{O} = -0.44V \;\; and \; E_{H+/O_2/H_2O}^{O} = 1.23V$ (5 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 $390.5\,S\,cm^2mol^{-1}$. (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; $Fe(s) + Cd^{2+}(aq) \rightleftarrows Fe^{2+}(aq) + Cd(s)$, given that

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

b) 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° 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 $8.5x10^{-7}$ 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 $Al(OH)_3$. (5 marks)

d) State and explain three functions of a salt bridge. (3 marks)