MACHAKOS UNIVERSITY

University Examinations 2016/2017

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FOURTH YEAR FIRST SEMESTER EXAMINATION FOR BACHELOR OF EDUCATION

SCH 401: ELECTROCHEMISTRY

DATE: 25/7/2017 **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).

Required data

- F = 96500 C
- Atomic mass of Cu = 64, Ag = 107, N = 14, O = 16

SECTION A - COMPULSORY.
QUESTION ONE (30 MARKS)

a) i Define the following terms as used in electrochemistry:

i) Electrolysis (1 mark)

ii) Charge (1 mark)

iii) Over-potential (1 mark)

ii Distinguish between the terms Resistance and Resistivity and show the relationship between them. (3 marks)

b) In a Hittorf cell experiment, a solution of silver nitrate was electrolysed between silver electrodes. The amount of silver nitrate in the anode compartment was 0.227 g before electrolysis and 0.2819 g after electrolysis. During electrolysis, 0.0194 g of copper was deposited on the cathode of copper coulometer in series with the Hittorf cell.

i Calculate the transport number of Ag^+ and NO_3^- ions (4 marks)

ii Which of the ions (between Ag+ and NO_3^-) carry majority of the current?(1 mark)

c) The table below shows the conductance data at infinite dilution at 25 ºC.

Electrolyte	λ ($\Omega^{-1}cm^2mol^{-1}$)
Sodium butyrate (NaBu)	82.6
Hydrochloric acid (HCl)	426.2
Sodium Chloride (NaCl)	126.5

From the table calculate the molar conductance of Butyric acid (HBu) at infinite dilution. (3 marks)

d) In a moving boundary experiment a current of 1.6 mA was applied to 0.02 M NaCl solution at 25 ºC using $CdCl_2$ as the indicator solution. It was found out that the boundary had moved 10 cm in 3453 seconds in a tube of cross sectional area 0.1115 cm^2. The conductivity of the sodium chloride at 25 ºC was 2.313 x 10^{-3} $\Omega^{-1}cm^2mol^{-1}$. Calculate:

i The transport number of Na^+ ions (3 marks)

ii The mobility of Na^+ ions (3 marks)

e) Given the metals silver and copper and solutions of $AgNO_3$ and $Cu(NO_3)_2$ at 25 ºC;
(Cu^{2+}/Cu, E^θ = +0.337 V and Ag+/Ag, E^θ = +0.7991 V),

i. Construct a cell which will operate spontaneously (give your answer in conventional short-hand notation) (1 mark)

ii. Write the equations at the anode, cathode and the overall reaction (3 marks)

iii. Given that the concentration of $Cu(NO_3)_2$ is 0.01 M and $AgNO_3$ is 0.05 M, calculate the EMF of the cell (3 marks)

iv. Calculate the equilibrium constant (K_{eq}) for the reaction (2 marks)

v. Calculate the ΔG^o of the cell reaction (1 mark)

SECTION B: ANSWER ANY TWO QUESTIONS

QUESTION TWO (20 MARKS)

a) Explain how a fourth year chemistry student would be able to determine the transference number of H^+ ions in an aqueous solution of HCl using moving boundary method. Include diagrams and equations where necessary. (6 marks)

b) Given the following cell with transference;

$Ag/AgCl/HCl\ (a_1)\ \ HCl\ (a_2)/AgCl/Ag$

If the EMF of the cell with transference at 298 K is 0.02802 V and the EMF of the corresponding cell without transference is 0.01696 V. Calculate the transport number of the hydrogen ions and chloride ions (4 marks)

c) The variation of molar conductivities with concentrations of an aqueous solution of a given salt is as shown in the table below;

Concentration (mol dm^{-3})	0.0005	0.001	0.005	0.01	0.02	0.05	0.1
Molar conductivity ($\Omega^{-1}cm^2mol^{-1}$)	131.4	130.5	127.2	124.8	121.4	115.2	109.1

i By plotting a graph, determine the molar conductance at infinite dilution of the solution (6 marks)

ii Calculate the apparent degree of ionization (α) for the solution at concentration of 0.015 mol dm^{-3} (2 marks)

iii Based on information from Q 2c ii), above classify the above aqueous salt solution in the above. Justify your answer. (2 marks)

QUESTION THREE (20 MARKS)

a) Distinguish between faradaic and non-faradaic currents (2 marks)

b) Explain the basic working principles of the following electroanalytical techniques:

i. Anodic stripping voltammetry (5 marks)

ii. Polarography (5 marks)

c) State and explain three types of electrochemical biosensors (6 marks)

d) Highlight two (2) advantages of fuel cells over conventional energy sources (2 marks)

QUESTION FOUR (20 MARKS)

a) Explain the following terms:

i. Transport number (1 mark)

ii. Molar conductivity (1 mark)

iii. Salt bridge (1 mark)

iv. Degree of ionization (1 mark)

b) Explain five (5) factors that determine the conductance of an electrolyte (10 marks)

c) i State the Kohlausch law of independent migration of ions (2 marks)

ii The molar conductances of aqueous sodium acetate, hydrochloric acid and sodium chloride at infinite dilution are 0.0091 s m^2 mol^{-1}, 0.0425 s m^2 mol^{-1} and 0.01281 s m^2 mol^{-1} respectively. Calculate the molar conductance of acetic acid at infinite dilution (4 marks)

QUESTION FIVE (20 MARKS)

a) Define the term corrosion (1 mark)

b) Highlight two advantages and two disadvantages of using each of the following techniques in corrosion monitoring

i Linear polarization resistance technique (4 marks)

ii Corrosion potential measurement technique (4 marks)

c) Explain the working and the electrochemistry principles of;

i Alkaline fuel cells (6 marks)

ii Phosphoric acid fuel cells (5 marks)