



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

- $F = 96500 \text{ C}$
- 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 °C.

Electrolyte	λ ($\Omega^{-1}\text{cm}^2\text{mol}^{-1}$)
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 °C 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 °C was $2.313 \times 10^{-3} \Omega^{-1}\text{cm}^2\text{mol}^{-1}$. 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 $\text{Cu}(\text{NO}_3)_2$ at 25 °C;
(Cu^{2+}/Cu , $E^\theta = +0.337 \text{ V}$ and Ag^+/Ag , $E^\theta = +0.7991 \text{ V}$),
- 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)

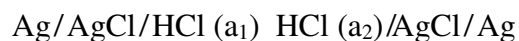
- iii. Given that the concentration of $\text{Cu}(\text{NO}_3)_2$ is 0.01 M and AgNO_3 is 0.05 M, calculate the EMF of the cell (3 marks)
- iv. Calculate the equilibrium constant (K_{eq}) for the reaction (2 marks)
- v. Calculate the ΔG° of the cell reaction (1 mark)

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;



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 ($\Omega^{-1}\text{cm}^2\text{mol}^{-1}$)	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 $0.015 \text{ mol dm}^{-3}$ (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 Kohlrausch 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 $0.0091 \text{ s m}^2 \text{ mol}^{-1}$, $0.0425 \text{ s m}^2 \text{ mol}^{-1}$ and $0.01281 \text{ s m}^2 \text{ mol}^{-1}$ 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)