



# THE CATHOLIC UNIVERSITY OF EASTERN AFRICA

**A. M. E. C. E. A**

**MAIN EXAMINATION**

**JANUARY - APRIL 2017 TRIMESTER**

**FACULTY OF SCIENCE**

**DEPARTMENT OF CHEMISTRY**

**SCHOOL FOCUSED PROGRAMME**

**CHEM 309: ELECTROCHEMISTRY**

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**Date: APRIL 2017**

**Duration: 2 Hours**

**INSTRUCTIONS: Answer Question ONE and any other Two Questions**

Useful Information

$$F = 96490 \text{ C mol}^{-1}$$

$$R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$$

$$0^\circ \text{C} = 273 \text{K}$$

$$\ln x = 2.303 \log x$$

$$\text{At } 25^\circ \text{C} \quad \frac{2.303RT}{nF} = \frac{0.0591}{n}$$

- Q1. a) (i) Using the Debye-Huckel limiting equation, calculate the mean activity coefficient of 0.002M Zinc Sulphate. **(6 marks)**

$$\left( A = 0.51 \text{ mol}^{-\frac{1}{2}} \text{ dm}^{\frac{3}{2}} \text{ at } 25^\circ \text{ for aqueous solutions} \right)$$

- (ii) Calculate the activity of 0.002m zinc sulphate. **(3 marks)**

- b) The conductivity of  $1.25 \times 10^{-1} \text{ mol dm}^{-3}$  solution of a monobasic acid is  $2.39 \times 10^{-2} \Omega^{-1} \text{ cm}^{-1}$ . Its molar conductivity of infinite dilution is  $400 \Omega^{-1} \text{ cm}^2 \text{ mol}^{-1}$ . Calculate the degree of dissociation of the acid and its dissociation constant. **(6 marks)**

- c) Briefly explain how the conductance of electrolytes can be measured. **(5 marks)**

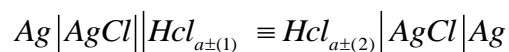
- d) Given

$$E^0(Co^{2+} | Co) = -0.2770V$$

$$E^0(Cc^{4+} | Cc^{3+}) = 1.610V$$

- (i) Represent the above information by a cell diagram. **(1 mark)**  
 (ii) Determine  $E^0$  for the cell **(2 marks)**  
 (iii) Write the overall cell reaction and the Nernst expression for the cell. **(3 marks)**
- e) Discuss the principle involved in conductimetric titrations. **(4 marks)**
- Q2. a) Given the following electrochemical cell **(4 marks)**
- $$Pb | PbCl_2 | HCl(1M) | AgCl | Ag$$
- The emf at 298K is 0.490V. If the rate of change of emf with temperature is  $1.8 \times 10^{-4} V / \text{deg}$ . calculate;
- (i)  $\Delta G$  of the cell **(2 marks)**  
 (ii)  $\Delta H$  of the cell **(2 marks)**  
 (iii)  $\Delta S$  of the cell **(2 marks)**
- b) A hydrogen electrode and normal calomel (reference electrode) electrode, gives an emf of 0.435V when placed in a certain solution of 25°C.
- (i) what is the pH of the solution? **(2 marks)**  
 (ii) what is the value of  $a_{H^+}$ ? **(2 marks)**

- c) For the following cell with transference



given emf the emf with transference at 298K is 0.0289V and that of corresponding cell without transference is 0.0169V. Calculate;

- (i) The transference number of  $H^+$  and  $Cl^-$  ions **(6 marks)**  
 (ii) The liquid junction potential **(2 marks)**  
 (iii) By considering individual electrode reaction, write the overall cell reaction. **(2 marks)**

- Q3. a) The specific conductivity of a saturated sparingly soluble salt  $MSO_4$  at 25°C was found to be  $4.63 \times 10^{-6} \text{ ohm}^{-1} \text{ cm}^{-1}$ . That of pure water was  $1.11 \times 10^{-6} \text{ ohm}^{-1} \text{ cm}^{-1}$ , calculate

- (i) The solubility of  $MSO_4$  **(2 marks)**  
 (ii) The solubility product of  $MSO_4$  **(2 marks)**

$$\Lambda^0_{MSO_4} = 287 \text{ ohm}^{-1} \text{ cm}^2 \text{ mol}^{-1}$$

- b) Briefly describe how the emf of an electrochemical cell can be determined. **(5 marks)**
- c) Calculate the equilibrium constant of the cell  $Zn | Zn^{2+} || Fe^{3+}, Fe^{2+} | Pt$  at 298K given  $Zn | Zn = -0.762 \text{ V}, Fe^{3+}, Fe^{2+} | Pt = 0.771 \text{ V}$  **(3 marks)**
- d) Briefly discuss the factors that affect the rate of which ions of an electrolyte carry charge. **(8 marks)**

- Q4. a) The resistance  $R$ , of an electrical conductor is proportional to its length and inversely proportional to its cross-sectional area ( $A$ ). Derive a relationship between the conductivity ( $K$ ) with current density ( $j$ ) and electric field intensity ( $E$ ). **(6 marks)**
- b) (i) State Kohlrausch law of independent ionic migration **(1 mark)**  
(ii) Discuss briefly the Arrhenius theory of ionization. Considering acetic acid show that the molar conductivity and the limiting molar conductivity at infinite dilution are related in the Ostwald's dilution relationship. **(6 marks)**
- c) Explain how a hydrogen electrode is used to measure pH. **(7 marks)**
- Q5. a) (i) Briefly explain how the Hittorf method is used to determine the transport numbers of ions in an electrolyte. **(6 marks)**  
(ii) Perform the analysis of the anode and cathode compartments when IF of electricity is passed through a solution of copper (II) chloride using platinum electrodes. **(6 marks)**
- b) A one liter solution of sea water was analysed and found to have the following ionic components.  
  
29.31g of NaCl, 1.83g of  $MgSO_4$ , 3.99g of  $MgCl_2$ , 1.34g of  $CaSO_4$  and 0.85g of  $K_2SO_4$ .  
  
Calculate the ionic strength of this solution.  
  
Na=23, Mg = 24, Ca=40, K=39, Cl=35.5, S=32 and O=16. **(6 marks)**
- c) Define Over-potential. **(2 marks)**

**\*END\***