MAASAI MARA UNIVERSITY

REGULAR UNIVERSITY EXAMINATIONS
2017/2018 ACADEMIC YEAR
FOURTH YEAR SECOND SEMESTER

SCHOOL OF SCIENCE
BACHELOR OF SCIENCE

COURSE CODE: CHE 419
COURSE TITLE: ELECTROCHEMISTRY

DATE: 17/04/2018 **TIME: 1100-1300HRS**

INSTRUCTIONS TO CANDIDATES

1. Answer Question **ONE** and any other **TWO** questions.
2. All Examination Rules Apply

QUESTION ONE (30 MARKS)

a) The standard electrode potential for a half-cell made from iron metal in a solution of iron(II) ions, Fe^{2+} (aq), has the value –0.45 V.

I. Define *standard electrode potential*. (1mks)

II. Explain the significance of the minus sign in –0.45 V. (1mks)

Consider the following table of standard electrode potentials.

	E^0 / V
$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$	–0.45
$Sn^{2+}(aq) + 2e^- \rightarrow Sn(s)$	–0.14
$H^+(aq) + e^- \rightarrow \frac{1}{2} H_2(g)$	0.00
$Sn^{4+}(aq) + 2e^- \rightarrow Sn^{2+}(aq)$	+ 0.15
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	+ 0.77
$Ag^+(aq) + e^- \rightarrow Ag(s)$	+ 0.80
$\frac{1}{2} Br_2(\ \ ) + e^- \rightarrow Br^-(aq)$	+ 1.07

From the list above:

III. State the species which is the strongest oxidizing agent. (1mks)

IV. Deduce which species can reduce Sn^{4+} (aq) to Sn^{2+} (aq) but will not reduce Sn^{2+} (aq) to Sn(s) under standard conditions. (2mks)

V. Deduce which species can reduce Sn^{2+} (aq) to Sn(s) under standard conditions. (2mks)

b) Draw a labeled diagram of a voltaic cell made from an Fe(s) / Fe^{2+}(aq) half-cell connected to an Ag / Ag^+ (aq) half-cell operating under standard conditions. In your diagram, identify the positive electrode (cathode), the negative electrode (anode), and the direction of electron flow in the external circuit. (5mks)

I. Deduce the equation for the chemical reaction occurring when the cell in part 2a is operating under standard conditions and calculate the voltage produced by the cell. (4mks)

c) Electrolysis is used in the electroplating of metals. The same amount of current is passed through separate aqueous solutions of $NiSO_4$, $Sn(SO_4)_2$ and $Cr_2(SO_4)_3$ in separate electrolytic cells for the same amount of time.
   I. State and explain which cell would deposit the greatest amount (in mol) of metal. Identify the electrode at which the metal is deposited. (4mks)
   II. For the $Sn(SO_4)_2$ cell, suggest **two** factors, other than time and current, that would affect the amount of metal deposited during electroplating. (3mks)

d) Sodium metal can be obtained by the electrolysis of molten sodium chloride.
   I. Explain why it is very difficult to obtain sodium from sodium chloride by any other method. (2mks)

   II. Explain why an aqueous solution of sodium chloride cannot be used to obtain sodium metal by electrolysis. (2mks)

   III. Predict and explain the products of electrolysis of a **concentrated** solution of NaCl (aq) using inert electrodes. Your answer should include half-equations with state symbols for the reaction at **each** electrode. (4mks)

   IV. Predict and explain the products of electrolysis of a **dilute** solution of NaCl (aq) using inert electrodes. Your answer should include half-equations with state symbols for the reaction at **each** electrode. (3mks)

QUESTION TWO (20 MARKS)

a) Clearly state the kohlrausch's law, and explain in detail the application of kohlrausch,s law. (10mks)
b) The following reaction takes place in an electrochemical cell:

$$Cu(s) + 2AgNO_3(aq) \longrightarrow Cu(NO_3)_2(aq) + 2Ag(s)$$

   I. Give an equation for the oxidation half-reaction. (2mks)
   II. Which metal is used as the anode? (1mk)
   III. Determine the EMF of the cell under standard conditions (2mks)

c) Brass is a copper containing alloy with many uses. An analysis is carried out to determine the percentage of copper present in three identical samples of brass. The reactions involved in this analysis are shown below.

Step 1: $Cu(s) + 2HNO_3(aq) + 2H^+(aq) \rightarrow Cu^{2+}(aq) + 2NO_2(g) + 2H_2O(\ )$

Step 2: $4I^-(aq) + 2Cu^{2+}(aq) \rightarrow 2CuI(s) + I_2(aq)$

Step 3: $I_2(aq) + 2S_2O_3(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$

I. Deduce the change in the oxidation numbers of copper and nitrogen in step 1. (2mks)

Copper: Nitrogen:

II. Identify the oxidizing agent in step 1. (1mk)

III. With reference to its metallic structure, describe how brass conducts electricity. (2mkS)

QUESTION THREE (20 MARKS)

a) Jerome, your classmate is having trouble understanding the reduction and oxidation. How you would you clearly explain this concept to Jerome? Feel free to use acronyms, diagrams, concept maps, examples etc. to explain. (4mks)

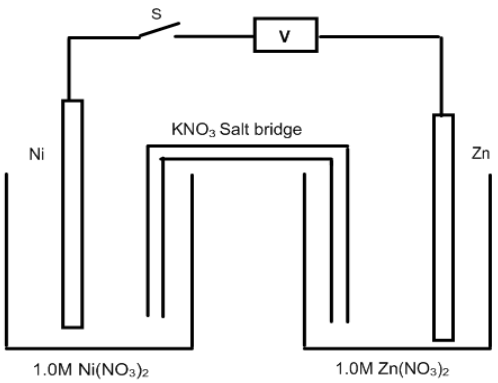
b) The net reaction when a lead acid battery is discharged is the following:
$PbO_2 + Pb + 2H_2SO_4 \rightarrow 2PbSO_4 + 2H_2O$

I. What is the function of the acid in the lead-acid storage battery used in cars? (1mk)

II. Lead is both oxidized and reduced in the net reaction. Write the redox equation for each reaction. Hint: There is only a gain of 2 electrons by the lead. (3mks)

III. Write the reaction for the formation of lead sulphate. Your equation should show what happens to the Pb^{2+}. (2mks)

c) Answer the following questions that refer to the galvanic cell shown in the diagram below



I. Identify the anode of the cell and write the half reaction that occurs there. (2mks)

II. Write the net ionic equation for the overall reaction that occurs as the cell operates and calculate the value of the standard cell potential, $E°_{cell}$. (2mks)

d) You are given two white powders, which are soluble in water. One of these powders is an ionic compound and the other is a covalent compound. Describe how you would find out which white powder is ionic and which powder is covalent. (4mks)

e) Describe in detail the Debye huckel theory (3mks)

QUESTION FOUR (20 MARKS)

a) How is limiting molar conductivity related to: (3mks)
   I. Degree of ionization and
   II. Dissociation constant

b) Describe in detail what is meant by ionic strength and how does it influence the activity of a solution (4mks)

c) Electrochemistry has a number of uses in industry and in our daily encounters, as a chemist describe at least four application of electrochemistry. Use equations where possible. (8mks)

d) In order to investigate the rate at which a reaction proceeds, a learner places a beaker containing concentrated nitric acid on a sensitive balance. A few pieces of copper metal are dropped into the nitric acid.

   I. Use the relevant half-reactions from the table of standard electrode potentials to derive the balanced net ionic equation for the reaction that takes place in the beaker. (4mks)

   II. What chemical property of nitric acid is illustrated by this reaction? (1mk)

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