THE UNITED REPUBLIC OF TANZANIA
NATIONAL EXAMINATIONS COUNCIL
ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

132/2 **CHEMISTRY 2**

(For Both School and Private Candidates)

Time: 2:30 Hours **Tuesday, 19th February, 2013 a.m.**

Instructions

1. This paper consists of **twelve (12)** questions in sections A, B and C.
2. Answer **five (5)** questions by choosing at least **one (1)** question from each section.
3. Each question carries **twenty (20)** marks.
4. Mathematical tables and non-programmable calculators may be used.
5. Cellular phones are **not** allowed in the examination room.
6. Write your **Examination Number** on every page of your answer booklet(s).
7. For calculations you may use the following constants:
   - Gas constant, R = 8.31 J $mol^{-1}K^{-1}$ or 0.082 atm$mol^{-1}K^{-1}dm^3$
   - GMV = 22.4 dm^3
   - 1 litre = 1dm^3 = 1000 cm^3
   - 1 Faraday = 96,500 $Cmol^{-1}$
   - Velocity of light, c = 3.0 x 10^8 m/s
   - Atomic masses: H = 1, C = 12, O = 16, Na = 23, S = 32, Ca = 40, Fe = 56, Cr = 52, Ag = 108.

SECTION A

1. (a) The reaction of $NO_{(g)}$ and $O_{2(g)}$ is represented by the equation $2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$. The rate of the reaction is given by the rate equation: Rate of reaction $= k[NO]^2[O_2]$. This reaction is proposed to follow the mechanism below:

$2NO_{(g)} \underset{k_2}{\overset{k_1}{\rightleftharpoons}} N_2O_{2(g)}$ (fast)

$N_2O_{2(g)} + O_{2(g)} \xrightarrow{k_3} 2NO_{2(g)}$ (slow)

$2NO_{(g)} + O_{2(g)} \xrightarrow{?} 2NO_{2(g)}$ (Net).

Show that the proposed mechanism is consistence with the given rate equation. **(5 marks)**

(b) Giving reasons argue for or against the statement that, "reactions with large equilibrium constants are very fast". **(2 marks)**

(c) The initial rate of reaction $2A + 2B \rightarrow C + D$ is determined by different initial conditions with the results listed in the following table:

Experiment	[A](M)	[B](M)	Initial rate (ms^{-1})
1	0.185	0.133	3.35×10^{-4}
2	0.185	0.266	1.35×10^{-3}
3	0.370	0.133	6.75×10^{-4}
4	0.370	0.266	2.70×10^{-3}

(i) What is the order of reaction with respect to each reactant?

(ii) Calculate the value of the rate constant. **(8 marks)**

(d) A certain first order reaction is 45% complete in 65 seconds. What are the rate constant and half-life of this reaction? **(5 marks)**

2. (a) Classify the following species as Brönsted acid/bases. Explain by suitable equations the reasons for the selection made: S^{2-}, HCO_3^-, H_2O, NH_3. **(6 marks)**

(b) Explain the two major components of the buffer solution. **(2 marks)**

(c) Calculate the number of grams of sodium acetate (CH_3COONa) which are to be added to 500 cm^3 of 0.12 M acetic acid (CH_3COOH) to give a buffer solution of pH 4.60. Assume the volume of the solution does not change on adding sodium acetate given that, Ka = 1.8×10^{-5} $moldm^{-3}$. **(10 marks)**

(d) Mention four applications of buffer solution. **(2 marks)**

3. (a) Mention four factors that can affect the solubility of a salt. **(2 marks)**

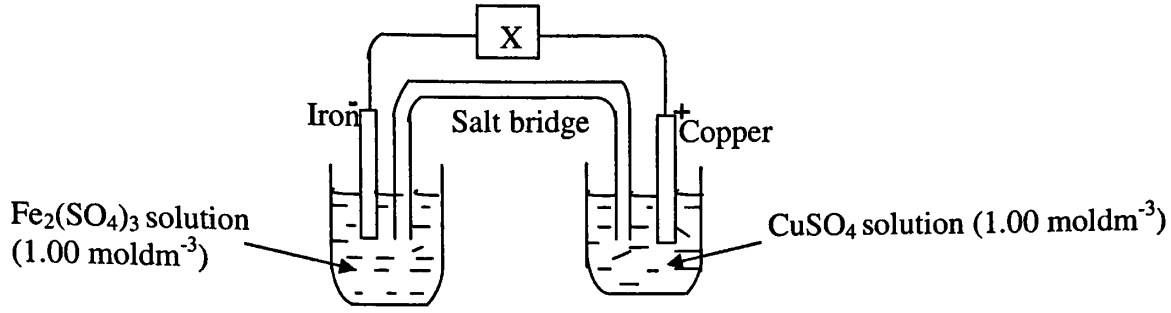
(b) Compare the efficiency of zinc and tin as rust protective covering materials in iron, given the following standard reduction potentials at 25 °C:

Sn/Sn^{2+} $E^\ominus = -0.14$ V.

Zn/Zn^{2+} $E^\ominus = -0.76$ V.

Fe/Fe^{2+} $E^\ominus = -0.44$ V. **(6 marks)**

(c) The following apparatus can be used to measure the standard electrode potential of Fe/Fe^{3+} electrode. Study it and then answer the following questions:



(i) Name the instrument that could be used at X to measure the e.m.f. of the cell.
(ii) What is the molarity of Fe^{3+} ions in iron (III) sulphate solution?
(iii) State the function of the salt bridge.
(iv) Give the conventional representation of the cell.
(v) Write equations to represent the cell reaction.
(vi) If the e.m.f. of the cell is +0.38 V, find the standard electrode potential of the Fe^{3+}/Fe electrode given that the standard electrode potential of Cu^{2+}/Cu electrode is 0.34 V.

(12 marks)

4. (a) Define the following terms:
(i) Electrolytic conductivity.
(ii) Molar conductance.
(iii) Dilution.
(iv) Ionic mobility.
(v) Transport number. **(5 marks)**

(b) Calculate the e.m.f. of the following concentration cell:
$Cu_{(s)}/Cu^{2+}_{(aq)}(0.025\ M)//Cu^{2+}_{(aq)}(1.5\ M)/Cu_{(s)}$, given that $E^{e}_{Cu^{2+}/Cu} = +0.34$ V. **(9 marks)**

(c) 0.111M ethanoic acid has an electrolytic conductivity of 5.21×10^{-2} Sm^{-1} at 25 °C. At infinite dilution the acid has a molar conductivity (molar conductance) of 3.91×10^{-2} Sm^2mol^{-1}. Calculate the degree of dissociation of the acid. **(6 marks)**

SECTION B

5. (a) Observe the isomers $[Co(NH_3)_5Br]SO_4$ and $[Co(NH_3)_5SO_4]Br$, then answer the questions that follow:
(i) Name the isomers.
(ii) What ions will the isomers yield in solution?
(iii) Give two chemical tests that could be used to distinguish between the isomers.
(iv) What is the oxidation state and coordination number of cobalt in the complexes?

(15 marks)

(b) 50 cm^3 of a solution of 0.1 M $[Co(NH_3)_5Br]SO_4$ was mixed with 50 cm^3 of a solution of 0.1 M KBr and the solution was made up to 200 cm^3. What is the concentration of Br^{-1} in this solution? (Assume the two compounds ionize completely and each supply two ions in solution).

(5 marks)

6. (a) State Hess's law of constant heat summation. **(2 marks)**

(b) Calculate the enthalpy change for the reaction $3C_{(graphite)} + 4H_{2(g)} \rightarrow C_3H_{8(g)}$ using the following information:

(i) $C_3H_{8(g)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(l)}$ $\Delta H = -2219.1$ kJ.
(ii) $C_{(graphite)} + O_{2(g)} \rightarrow CO_{2(g)}$ $\Delta H = -393.5$ kJ.
(iii) $H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)}$ $\Delta H = -285.8$ kJ. **(4 marks)**

(c) Briefly describe the following terms:

(i) Ionization energy.
(ii) Atomization energy.
(iii) Lattice energy. **(6 marks)**

(d) (i) Draw a well labelled Born-Harber cycle for the formation of $NaCl_{(s)}$. **(4 marks)**

(ii) By using the following reactions, calculate the lattice energy of sodium chloride.

$Na_{(s)}\ \frac{1}{2}Cl_{2(g)} \rightarrow NaCl_{(s)}$ $\Delta H = -411$ kJmol^{-1}.
$Na_{(s)} \rightarrow Na_{(g)}$ $\Delta H = +107$ kJmol^{-1}.
$Na_{(g)} \rightarrow Na^+ + e^-$ $\Delta H = +496$ kJmol^{-1}.
$\frac{1}{2}Cl_{2(g)} \rightarrow Cl_{(g)}$ $\Delta H = +122$ kJmol^{-1}.
$Cl_{(g)} + e^- \rightarrow Cl^-$ $\Delta H = -349$ kJmol^{-1}. **(4 marks)**

7. (a) Which indicator would you use when titrating propanoic acid with sodium hydroxide solution? Give reason for your choice. **(2 marks)**

(b) Indicate the acid-base conjugate pairs in the following reactions:

(i) $HCl + CH_3COOH \rightleftharpoons CH_3COOH^+ + Cl^-$.
(ii) $NH_2^- + H_2O \rightleftharpoons NH_3 + OH^-$. **(4 marks)**

(c) The dissociation constant of an acid-base indicator HA is 1.0×10^{-6}. The colour of the unionized indicator is blue and its ionized form is yellow. What would be the colour of this indicator in a solution whose pH is 4? Give explanation to support your answer. **(6 marks)**

(d) An aqueous solution was prepared from unknown amounts of ethanoic acid and sodium ethanoate. If the pH of the solution was found to be 5, what is the value of the ratio $\frac{[CH_3COO^-]}{[CH_3COONa]}$ given that the dissociation constant of ethanoic acid is 1.8×10^{-5} moldm^{-3}? **(8 marks)**

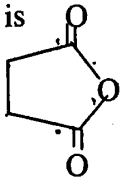
8. Assume that you are appointed to be a manager of iron extraction industry. One of your duties is to orient new employees how the extraction of iron takes place in the blast furnace. Design a lesson which describes the extraction of iron in the furnace to teach new employees of the industry. In your lesson include outline diagram of the blast furnace, raw materials required, reactions taking place in the furnace as well as the formation and uses of slag. **(20 marks)**

SECTION C

9. (a) By using chemical reactions, show how benzaldehyde (C_7H_6O) reacts with the following compounds:

(i) Acidified potassium permanganate solution.
(ii) 2,4-dinitrophenylhydrazine.
(iii) Zinc amalgam and concentrated HCl acid. **(6 marks)**

(b) Predict the product of the reaction of one mole of succinic anhydride with two moles of ammonia given that the structure of succinic anhydride is **(2 marks)**



(c) A compound **S** is composed of 64.86% C; 13.5% H; and 21.64% O. **S** reacts with PCl_5 to form compound **P** and a gas **Q** which produces dense white fumes with aqueous ammonia. **S** also reacts with the mixture of iodine and sodium hydroxide solution to form sodium salt **R** and triiodomethane.

(i) Determine the empirical formula of **S**.
(ii) Find the molecular formula of **S**, given that its molecular mass is equal to 74.
(iii) Give a structural formula of five (5) possible isomers of **S**.
(iv) Name compound **S**, **P**, **Q** and **R**.
(v) Write the chemical equations for the reaction between **S** and PCl_5; **S** and a mixture of I_2 and NaOH. **(12 marks)**

10. (a) Describe electrophilic substitution in benzene. **(8 marks)**

(b) Using examples of nitration and halogenation, show how electrophilic substitution occurs in benzene ring. **(12 marks)**

11. (a) Show how ethylamine reacts with the following molecules:

(i) Benzaldehyde
(ii) Cyclohexane
(iii) Nitrous acid (HONO) at freezing temperature
(iv) Propanoyl chloride (CH_3CH_2CClO). **(8 marks)**

(b) From the knowledge you have on the functional groups, write chemical equations showing what happens when compound $O=\underset{\displaystyle CH_3}{\overset{\displaystyle |}{C}}\text{-}CH_2\text{-}CH_2\text{-}CH(OH)\text{-}CH_2\text{-}CO_2H$ reacts with the following reagents:

(i) Acidified potassium permanganate.
(ii) Ethanol in the presence of acid.
(iii) Potassium pentachloride.
(iv) Lithium aluminium tetrahydride catalyst.
(v) Iodine in the presence of sodium hydroxide and, then warm. **(7.5 marks)**

(c) (i) Define condensation reaction.
(ii) Explain how nylon-66 can be prepared and why is it called nylon 66? **(4.5 marks)**

12. (a) Describe the negative effects of the following practices on soil:

(i) Overliming
(ii) Repeated irrigation
(iii) Excessive use of ammonium sulphate. **(6 marks)**

(b) Comment on each of the following statements:

(i) Not all calcium and magnesium containing compounds can be used as liming materials.
(ii) Aluminium contributes to soil acidity.
(iii) Ion exchange in the soil system is a reversible process. **(6 marks)**

(c) A certain soil contains the following ions in meq/100g of oven dry soil: Ca^{2+} = 10.00; Mg^{2+} = 5.00; Na^{+} = 0.50; Mn^{2+} = 5.00; Al^{3+} = 2.00; H^{+} = 12.00; and K^{+} = 1.50. If the cation exchange capacity (c.e.c) of the soil is 24 meq/100 g of oven dry soil, calculate the

(i) percentage of base saturation.

(ii) quantity in grams of Ca^{2+} present in 100 g of oven dry soil. **(8 marks)**