THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

032/2 **CHEMISTRY 2**

ALTERNATIVE TO PRACTICAL

(For Both School and Private Candidates)

Time: 3 Hours **ANSWERS** **Year: 2013**

Instructions

1. This paper consists of five questions. Answer all questions.

2. Each question carries 10 marks

1. Figure 1 represents one of the laboratory experiments. Study it carefully and then answer the questions that follow.

(a)(i) Identify the apparatuses labelled A, B, C, and D and state the use of each.

A – Thermometer, used to measure the temperature of the vapors to ensure proper separation.
B – Fractionating column, used to separate different liquids based on their boiling points.
C – Round-bottom flask, used to contain the mixture and provide uniform heating.
D – Condenser, used to cool and condense the vapors back into liquid form.

(ii) Giving reasons for your answers, state which apparatus in (a) (i) above do the following processes occur:

Evaporation – Occurs in C (Round-bottom flask), where the liquid mixture is heated to produce vapors.
Condensation – Occurs in D (Condenser), where the vapors cool down and turn back into liquid form.

(b) (i) Name liquid E and explain why it is first collected.

Liquid E is ethanol. It is first collected because ethanol has a lower boiling point (78°C) than water, so it evaporates and condenses before water.

(ii) Give a reason as to why water moves in and out as shown in Figure 1.

Water flows in and out of the condenser to ensure efficient cooling of the vapors, preventing loss of volatile components.

(c)(i) What is the name of the experiment?

The experiment is called fractional distillation.

(ii) Why is apparatus A inserted to the level of the column outlet rather than into the boiling liquid?

Apparatus A (thermometer) is placed at the column outlet to measure the temperature of the vapors, ensuring accurate separation of liquids based on their boiling points.

2.(a) Briefly explain the colour changes which will be observed when each of the following indicators is used in the titration of potassium hydroxide with nitric acid (assume nitric acid is in the burette).

S/n	Indicator	Colour at the starting point	Colour at the end point
(i)	Methyl orange	Yellow	Red
(ii)	Phenolphthalein	Pink	Colourless
(iii)	Litmus solution	Blue	Red

(b) In a certain volumetric analysis experiment, 0.1M nitric acid was titrated against 25 cm^3 of NaOH solution. Methyl orange was used as an indicator. The results of the experiment were recorded as shown in Table 1.

Table 1

Titration	Pilot	1	2	3
Final Volume (cm^3)	20.80	25.50	39.50	35.00
Initial Volume (cm^3)	0.00	5.00	20.00	15.00
Titre value (cm^3)	20.80	20.50	19.50	20.00

Questions:

(i) Complete Table 1 by calculating the titre value for each column.
The completed table is shown above.

(ii) Determine the mean titre value.
Mean titre value = (20.50 + 19.50 + 20.00) / 3 = 20.00 cm^3

(iii) Calculate the concentration of the base solution in g/dm^3 and mol/dm^3.
Using the equation:
Moles of acid = Molarity × Volume (in dm^3)
Moles of HNO_3 = 0.1 × (20.00 / 1000) = 0.002 moles

Since the reaction is:
$HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$
Moles of NaOH = Moles of HNO_3 = 0.002 moles

Concentration of NaOH in mol/dm^3 = Moles / Volume (in dm^3)
= 0.002 / (25.0 / 1000)
= 0.08 mol/dm^3

Molar mass of NaOH = 23 + 16 + 1 = 40 g/mol
Concentration in g/dm^3 = 0.08 × 40 = 3.2 g/dm^3

(c) What volume of water should be added to the 25 cm^3 of NaOH to make a 0.01M solution?

Using dilution formula:
$C_1V_1 = C_2V_2$
$(0.08)(25) = (0.01)(V_2)$
$V_2 = (0.08 \times 25) / 0.01$
V_2 = 200 cm^3
Volume of water to be added = 200 - 25 = 175 cm^3

3. Two voltameters were connected in series as shown in Figure 2. One of the voltameters contained dilute sulfuric acid and the other contained dilute copper (II) sulfate solution. Electrodes labelled B, C, D, and E were made of platinum.

(a)(i) What law of electrolysis is represented by Figure 2? State the law.

The law of electrolysis represented is Faraday's First Law of Electrolysis. It states that the mass of a substance deposited or liberated at an electrode is directly proportional to the quantity of electricity passed through the electrolyte.

(ii) Name one factor that affects the discharge of ions in the experiment represented by Figure 2.

The nature of the electrode affects the discharge of ions, as platinum electrodes are inert and do not participate in the reaction, allowing selective discharge of ions.

(b)(i) Write balanced equations for the reactions which take place at C and D.

At electrode C (Anode in sulfuric acid voltameter):
$2H_2O(l) \text{ ---> } O_2(g) + 4H^+(aq) + 4e^-$

At electrode D (Cathode in copper sulfate voltameter):
$Cu^{2+}(aq) + 2e^- \text{ ----> } Cu(s)$

(ii) What are the colour changes which would be observed if the electrolysis was allowed to continue to completion?

The blue colour of copper (II) sulfate solution would fade as Cu^{2+} ions are reduced and deposited as copper metal. In the sulfuric acid voltameter, the solution may become more acidic due to the formation of H^+ ions at the anode.

(c)If 125 cm^3 of oxygen gas measured at s.t.p. had been collected from one of the electrodes, calculate:

(i) The quantity of electricity.

1 mole of O_2 gas at STP = 22.4 dm^3 = 22400 cm^3
Moles of O_2 collected = 125 cm^3 / 22400 cm^3 = 0.00558 moles
From the anode reaction:
$2H_2O \text{ ----> } O_2 + 4H^+ + 4e^-$
1 mole of O_2 requires 4 moles of electrons, so:
Moles of electrons = 0.00558 × 4 = 0.02232 moles

Charge (Q) = n × F = 0.02232 × 96500 C
Q = 2154.48 C

(ii) The mass of copper deposited.

From Faraday's Law:
1 mole of Cu (63.5 g) requires 2 moles of electrons.
Moles of Cu deposited = 0.02232 / 2 = 0.01116 moles
Mass of Cu = 0.01116 × 63.5 = 0.709 g

4. The reactions between sodium thiosulphate ($Na_2S_2O_3$) solution of different concentrations and nitric acid were allowed to take place at 45°C. The speed of these reactions were then measured by placing a beaker containing the reactants on a piece of white paper with a cross mark (x). The time taken for the cross to become invisible due to the precipitate formed was recorded as shown in Table 2.

Table 2

Beaker	Concentration ($mol.dm^{-3}$)	Time taken (t) (s)	Rate 1/t (sec^{-1})	Concentration × t ($mol.dm^{-3}.sec$)
1	1.6×10^{-3}	25	0.040	4.00×10^{-2}
2	1.3×10^{-3}	30	0.033	3.90×10^{-2}
3	1.0×10^{-3}	39	0.0256	3.90×10^{-2}
4	0.6×10^{-3}	61	0.0164	3.66×10^{-2}

(a)(i) What causes the precipitate to occur in the reaction?

The precipitate occurs due to the formation of sulfur (S) as a solid in the reaction between sodium thiosulphate and nitric acid:

$Na_2S_2O_3(aq) + 2HNO_3(aq) \rightarrow 2NaNO_3(aq) + SO_2(g) + S(s) + H_2O(l)$

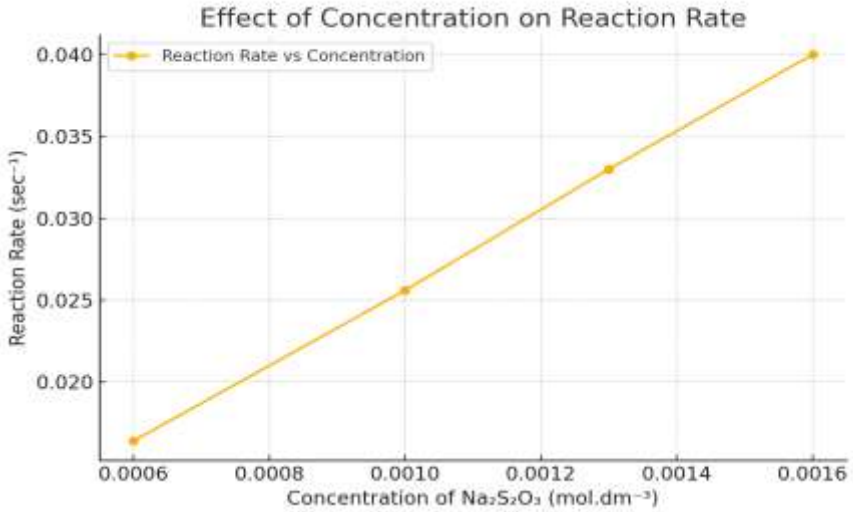
(ii) Write the ionic equation between the acid and sodium thiosulphate.

$S_2O_3^{2-}(aq) + 2H^+(aq) \rightarrow SO_2(g) + S(s) + H_2O(l)$

(b)(i) Complete Table 2 by calculating the rate for each time taken and the product of concentration and time.

(ii) What do you notice about the values of the product of concentration and time?

The values of concentration × time are approximately constant, showing that the reaction follows an inverse relationship between concentration and time.
(c)(i) Plot a graph of reaction rate (sec^{-1}) against concentration of sodium thiosulphate.



(ii) What is the effect of concentration of $Na_2S_2O_3$ on the rate of reaction?

As the concentration of $Na_2S_2O_3$ increases, the reaction rate increases. This is because a higher concentration provides more reactant molecules per unit volume, leading to a greater frequency of effective collisions and thus a faster reaction.

5. Sample NP contains one cation and one anion. A series of experiments to identify ions in the sample were performed and corresponding observations were recorded as shown in Table 3. Carefully fill in the inference column and hence identify the ions present in sample NP.

Table 3

S/n	Experiment	Observation	Inference
(a)	Appearance of sample NP.	White crystalline solid.	Sample NP is a salt that is likely ionic and soluble.
(b)	A spatulaful of solid sample NP was dissolved in distilled water.	The sample was soluble, forming a clear, colourless solution.	Sample NP contains colourless ions, indicating absence of transition metals.
(c)	A spatulaful of sample NP was heated in a dry test tube.	White sublimate.	Presence of ammonium (NH_4^+) ions, as ammonium salts sublime upon heating.
(d)	To a spatulaful of solid sample NP in a test tube, concentrated H_2SO_4 was added, the mixture was slightly warmed, and the gas given off was tested.	The gas given off forms white dense fumes with gaseous ammonia.	Presence of chloride (Cl^-) ions, as HCl gas is released.
(e)	To another spatulaful of solid sample NP in a test tube, MnO_2 and H_2SO_4 were added and the mixture was slightly warmed. The gas given off was passed over wet litmus paper.	The yellowish-green gas given off bleached the wet litmus paper.	Presence of chloride (Cl^-) ions, as chlorine gas (Cl_2) is produced.
(f)	NaOH solution was added to a solid sample NP in a test tube and warmed. The gas given off was tested.	The gas given off turns litmus paper from red to blue.	Presence of ammonium (NH_4^+) ions, as NH_3 gas is evolved.

Conclusion

(i) The anion present in the sample NP is Cl^-, and the cation is NH_4^+.

(ii) The chemical name of sample NP is ammonium chloride.

(iii) Write a balanced chemical equation for the reaction taking place in experiment (f).

$NH_4Cl(s) + NaOH(aq) \longrightarrow NaCl(aq) + NH_3(g) + H_2O(l)$