THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

132/3C **CHEMISTRY 3C**

(ACTUAL PRACTICAL C)

(For Both School and Private Candidates)

Time : 3:30 Hours **ANSWERS** **Year : 2022**

Instructions

1. This paper consists of three questions, answer all questions
2. All writing should be in **blue** or **black** ink.
3. Communication devices and any unauthorised materials are **not** allowed in the examination room.
4. Write your **Examination Number** on every page of your answer booklet(s).

1. You are provided with the following:

   K: A solution of 7.45 g of an impure hydrated sodium carbonate in a 500 cm^3 of an aqueous solution;

   L: 1.825 g of hydrochloric acid in a 500 cm^3 of an aqueous solution;

   POP: Phenolphthalein indicator;

   MO: Methyl orange indicator.

(a) Calculate the average titre value when:

(i) POP was used.

When phenolphthalein is used, the reaction is between Na_2CO_3 and HCl forming $NaHCO_3$ and NaCl. The mole ratio is 1:1. The volume obtained corresponds to the first endpoint.

(ii) MO was used.

When methyl orange is used, the reaction goes to completion forming NaCl, H_2O and CO_2. The total moles of HCl are double those of Na_2CO_3, giving a titre value about twice that with POP.

(b) Write a balanced chemical equation when:

(i) POP was used.

$Na_2CO_3 + HCl \rightarrow NaHCO_3 + NaCl$

(ii) MO was used.

$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$

(c) Calculate the total overall average volume of the solution L used for complete reaction with the solution K.

The total volume corresponds to the sum of titre values obtained with phenolphthalein and methyl orange. It accounts for the two stages of neutralization.

(d) Write the overall reaction equation of the L and K.

$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$

(e) Calculate the percentage purity of the hydrated sodium carbonate.

Moles of HCl in 500 cm^3 = 1.825 ÷ 36.5 = 0.05 mol, giving 0.05 ÷ 0.5 = 0.1 M.

If average titre for complete reaction is 25 cm^3, moles of HCl used = 0.1 × 25 ÷ 1000 = 0.0025 mol.

Moles of Na_2CO_3 present in aliquot = 0.0025 ÷ 2 = 0.00125 mol.

Therefore in 25 cm^3, mass of Na_2CO_3 = 0.00125 × 106 = 0.133 g.

In 500 cm^3, mass of Na_2CO_3 = 0.133 × 20 = 2.66 g.

Percentage purity = (2.66 ÷ 7.45) × 100 = 35.7%.

2. You are provided with the following:

M: A solution of 0.05 M sodium thiosulphate;

N: A solution of 0.1 M nitric acid;

Stop watch; Thermometer.

Theory:

The reaction is:

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

Sulphur forms as a white precipitate, turning the solution cloudy. The time taken for the mark "X" beneath the beaker to disappear is used to measure the rate. The effect of temperature on rate is investigated.

(a) Plot a graph of log(1/t) against 1/T (K^{-1}).

Sample Results (typical pattern):

Temperature (°C)	**Temperature (K)**	**1/T (K^{-1}) ×10^3**	**Time, t (s)**	**1/t (s^{-1})**	**log(1/t)**
60	333	3.00	120	0.0083	-2.08
70	343	2.92	70	0.0143	-1.85
80	353	2.83	40	0.0250	-1.60

Graph:

- On the x-axis: 1/T × 10^3.
- On the y-axis: log(1/t).

- Plotting the points gives a straight line with negative slope.

(b) Determine the slope of the graph.

Slope = $\Delta y \div \Delta x$

Using (333 K, -2.08) and (353 K, -1.60):

$\Delta y = -1.60 - (-2.08) = 0.48$
$\Delta x = (2.83 - 3.00) \times 10^{-3} = -0.17 \times 10^{-3}$

Slope = $0.48 \div -0.00017 = -2823$

So slope $\approx -2.82 \times 10^{3}$

(c) Using Arrhenius equation, determine the activation energy of the reaction.

Arrhenius relation:
$\log k = (-Ea / 2.303R)(1/T) + \text{constant}$

So slope = $-Ea / 2.303R$

$Ea = -\text{slope} \times 2.303R$

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

$Ea = 2823 \times 2.303 \times 8.314$
$Ea \approx 54{,}000\ J\ mol^{-1}$
$Ea \approx 54\ kJ\ mol^{-1}$

3. Substance H contains two cations and one anion.

S/n	Experiments	Observations	Inferences
(a)	Appearance of the sample	White crystalline solid	Suggests presence of a metallic salt
(b)	Heat a small portion of the sample in a dry test tube	Colourless gas with smell of rotten eggs is released, turning lead acetate paper black	Presence of sulphate salts which decompose to give SO2, or sulphide releasing H2S gas
(c)	Perform a flame test	Brick-red flame observed	Indicates presence of Ca^{2+} ion
(d)	Add concentrated sulphuric acid to the dry sample	Effervescence with colourless gas that turns lime water milky	Confirms presence of CO_3^{2-} anion
(e)	To the small portion of the prepared solution, add dilute HCl followed by barium chloride solution	White precipitate insoluble in excess dilute HCl	Presence of SO_4^{2-} anion
(f)	To the small portion of the prepared solution, add excess ammonia solution and then add ammonium sulphide solution	Formation of black precipitate	Confirms presence of Pb^{2+} ion

	or pass hydrogen sulphide gas slowly		
(g)	Perform confirmatory test for cations present in the sample	Black ppt with H_2S confirms Pb^{2+}; brick-red flame confirms Ca^{2+}	Cations are Ca^{2+} and Pb^{2+}

Questions

(i) **Write the molecular formula for the sample.**

The cations are Ca^{2+} and Pb^{2+}, and the anion is SO_4^{2-}. The most likely salt is **$CaSO_4 \cdot PbSO_4$** (double sulphate salt).

(ii) **What are the cations and anion in the sample?**

Cations: Calcium ion (Ca^{2+}) and Lead ion (Pb^{2+}).

Anion: Sulphate ion (SO_4^{2-}).