

**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**

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**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).

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1. You are provided with the following:

K: A solution of 7.45 g of an impure hydrated sodium carbonate in a 500 cm<sup>3</sup> of an aqueous solution;

L: 1.825 g of hydrochloric acid in a 500 cm<sup>3</sup> of an aqueous solution;

POP: Phenolphthalein indicator;

MO: Methyl orange indicator.

(a) Calculate the average titre value when:

(i) POP was used.

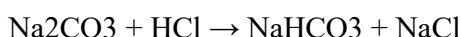
When phenolphthalein is used, the reaction is between Na<sub>2</sub>CO<sub>3</sub> and HCl forming NaHCO<sub>3</sub> and NaCl. The mole ratio is 1:1. The volume obtained corresponds to the first endpoint.

(ii) MO was used.

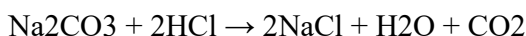
When methyl orange is used, the reaction goes to completion forming NaCl, H<sub>2</sub>O and CO<sub>2</sub>. The total moles of HCl are double those of Na<sub>2</sub>CO<sub>3</sub>, giving a titre value about twice that with POP.

(b) Write a balanced chemical equation when:

(i) POP was used.



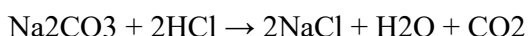
(ii) MO was used.



(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.



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

Moles of HCl in 500 cm<sup>3</sup> =  $1.825 \div 36.5 = 0.05$  mol, giving  $0.05 \div 0.5 = 0.1$  M.

If average titre for complete reaction is 25 cm<sup>3</sup>, moles of HCl used =  $0.1 \times 25 \div 1000 = 0.0025$  mol.

Moles of Na<sub>2</sub>CO<sub>3</sub> present in aliquot =  $0.0025 \div 2 = 0.00125$  mol.

Therefore in 25 cm<sup>3</sup>, mass of Na<sub>2</sub>CO<sub>3</sub> =  $0.00125 \times 106 = 0.133$  g.

In 500 cm<sup>3</sup>, mass of Na<sub>2</sub>CO<sub>3</sub> = 0.133 × 20 = 2.66 g.

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

## 2. You are provided with the following:

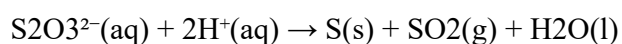
M: A solution of 0.05 M sodium thiosulphate;

N: A solution of 0.1 M nitric acid;

Stop watch; Thermometer.

### Theory:

The reaction is:



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<sup>-1</sup>).**

### Sample Results (typical pattern):

| Temperature (°C) | Temperature (K) | 1/T (K <sup>-1</sup> ) × 10 <sup>3</sup> | Time, t (s) | 1/t (s <sup>-1</sup> ) | 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<sup>3</sup>.
- On the y-axis: log(1/t).

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

**(b) Determine the slope of the graph.**

$$\text{Slope} = \Delta y \div \Delta x$$

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

$$\Delta y = -1.60 - (-2.08) = 0.48$$

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

$$\text{Slope} = 0.48 \div -0.00017 = -2823$$

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

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

Arrhenius relation:

$$\log k = (-E_a / 2.303R)(1/T) + \text{constant}$$

$$\text{So slope} = -E_a / 2.303R$$

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

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

$$E_a = 2823 \times 2.303 \times 8.314$$

$$E_a \approx 54,000 \text{ J mol}^{-1}$$

$$E_a \approx 54 \text{ kJ mol}^{-1}$$

**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 SO <sub>2</sub> , or sulphide releasing H <sub>2</sub> S gas |
| (c) | Perform a flame test                                                                                               | Brick-red flame observed                                                               | Indicates presence of Ca <sup>2+</sup> ion                                                                      |
| (d) | Add concentrated sulphuric acid to the dry sample                                                                  | Effervescence with colourless gas that turns lime water milky                          | Confirms presence of CO <sub>3</sub> <sup>2-</sup> 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 <sub>4</sub> <sup>2-</sup> 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 <sup>2+</sup> ion                                                                       |

|     |                                                             |                                                                                                       |                                                   |
|-----|-------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|---------------------------------------------------|
|     | or pass hydrogen sulphide gas slowly                        |                                                                                                       |                                                   |
| (g) | Perform confirmatory test for cations present in the sample | Black ppt with H <sub>2</sub> S confirms Pb <sup>2+</sup> ; brick-red flame confirms Ca <sup>2+</sup> | Cations are Ca <sup>2+</sup> and Pb <sup>2+</sup> |

### Questions

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

The cations are Ca<sup>2+</sup> and Pb<sup>2+</sup>, and the anion is SO<sub>4</sub><sup>2-</sup>. The most likely salt is **CaSO<sub>4</sub>·PbSO<sub>4</sub>** (double sulphate salt).

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

Cations: Calcium ion (Ca<sup>2+</sup>) and Lead ion (Pb<sup>2+</sup>).

Anion: Sulphate ion (SO<sub>4</sub><sup>2-</sup>).