3.5 CHEMISTRY (233)

Chemistry is tested in three papers: paper 1 (233/1), paper 2 (233/2) and paper 3 (233/3). Paper 1 and paper 2 are theory papers while papers 3 is a practical. Paper 1 (233/1) tests Forms 1, 2, 3 and 4 content whereby each question carries a maximum of 3 marks while paper 2 tests content from specific topics from forms 1, 2, 3, and 4 and assesses a wide range of skills. A question in paper 2 can carry up to a minimum of 10 and a maximum of 14 marks. Paper 3 assess in depth both quantitative and qualitative practical skills attained by the candidates from forms 1, 2, 3, and 4 hence assesses a wide range of skills. This report is based on the analysis of performance of candidates who for sat the year 2022 KCSE Chemistry.

3.5.1 Candidates general performance

The following table shows the performance of Chemistry in the last five years.

Table 14: Candidates Performance in Chemistry for the last five years: 2018, 2019, 2020, 2021 and 2022

Year	Paper	Candidature	Maximum Score	Mean Score	Standard Deviation
2018	1		80	19.36	14.57
	2		80	16.96	14.17
	3		40	14.44	6.45
	Overall	**656,163**	**200**	**53.76**	**33.45**
2019	1		80	20.00	14.98
	2		80	18.00	13.07
	3		40	13.00	6.70
	Overall	**691,802**	**200**	**52.17**	**32.71**
2020	1		80	15.02	14.28
	2		80	12.05	10.9
	3		40	17.95	7.47
	Overall	**740,831**	**200**	**45.01**	**30.19**
2021	1		80	12.11	10.93
	2		80	14.79	12.6
	3		40	15.43	6.85
	Overall	**820,765**	**200**	**42.02**	**28.01**
2022	1		80	14.3	11.9
	2		80	16.16	13.36
	3		40	17.83	8.14
	Overall	**875,555**	**200**	**48.05**	**30.81**

From the table, it is observable that:

(i) Candidature for chemistry increased from **820,765** in 2021 to **875,555** in 2022 an increment of about 6.83 %. It is worth noting that candidature has been improving over the years.

(ii) Performance in paper 1 improved significantly with 2.19 points from a mean of 12.11in 2021 to a mean of 14.3 in 2022. The improvement was equivalent to 18.08%.

(iii) Performance in paper 2 improved significantly with 1.37 points from a mean of 14.79 in 2021 to a mean of 16.16 in 2022. This was an improvement of 9.26%.

(iv) Performance in paper 3 improved with 2.4 points from a mean of 15.43 in 2021 to a mean of 17.83 in 2022, an equivalence increase of 15.55%.

(v) The standard deviation for paper 1 improved from 10.93 in 2021 to 11.9 in 2020 indicating that majority of the candidates' performance was clustered around the mean due to the low standard deviation. The standard deviation for paper 2 was 13.36 an improvement from 12.6. This means that the candidates' scores were well dispersed as the SD was approaching the ideal SD. The standard deviation of the practical paper improved to 8.14 in 2022 from 7.47 in 2021 indicating a better spread of the candidates' scores compared to that of 2021.

(vi) The overall performance in Chemistry improved from a mean of **42.02** in 2021 to a mean of **48.05** in 2022, an improvement of 6.03 points which equivalent to 14.35%. Teachers are advised to teach to the demand of the syllabus but not to use the textbooks only which may cover more than expected content specified in the syllabus. This will enable them to cover the syllabus in good time to allow learners time for extensive revision. **A variety of textbooks authorized by KICD should be used for instruction but not the one recommended textbook as evidenced by the use of KLB textbook which has become very familiar with most teachers**.

3.5.2 Analysis of questions performed poorly

Questions which were performed poorly are analysed and briefly discussed below. The discussion is based on comments from the chief examiners reports and analysis of the candidates' responses from sampled answer scripts. The discussion aims at pointing out candidates' weaknesses and suggestions on the measures which if put in place the performance would improve.

3.5.3 Chemistry paper 1 (233/1)

The questions which were reported to have challenged the candidates as evidenced by the poor performance are briefly discussed below in view of pointing out the candidates' weaknesses and the proposed suggestions on the measures to be put in place in order to improve future performance.

Question 3

3. (a) Write a thermochemical equation for the formation of carbon(II) oxide. (1 mark)

(b) Use the energy level diagram in **Figure 1** to answer the questions that follow.

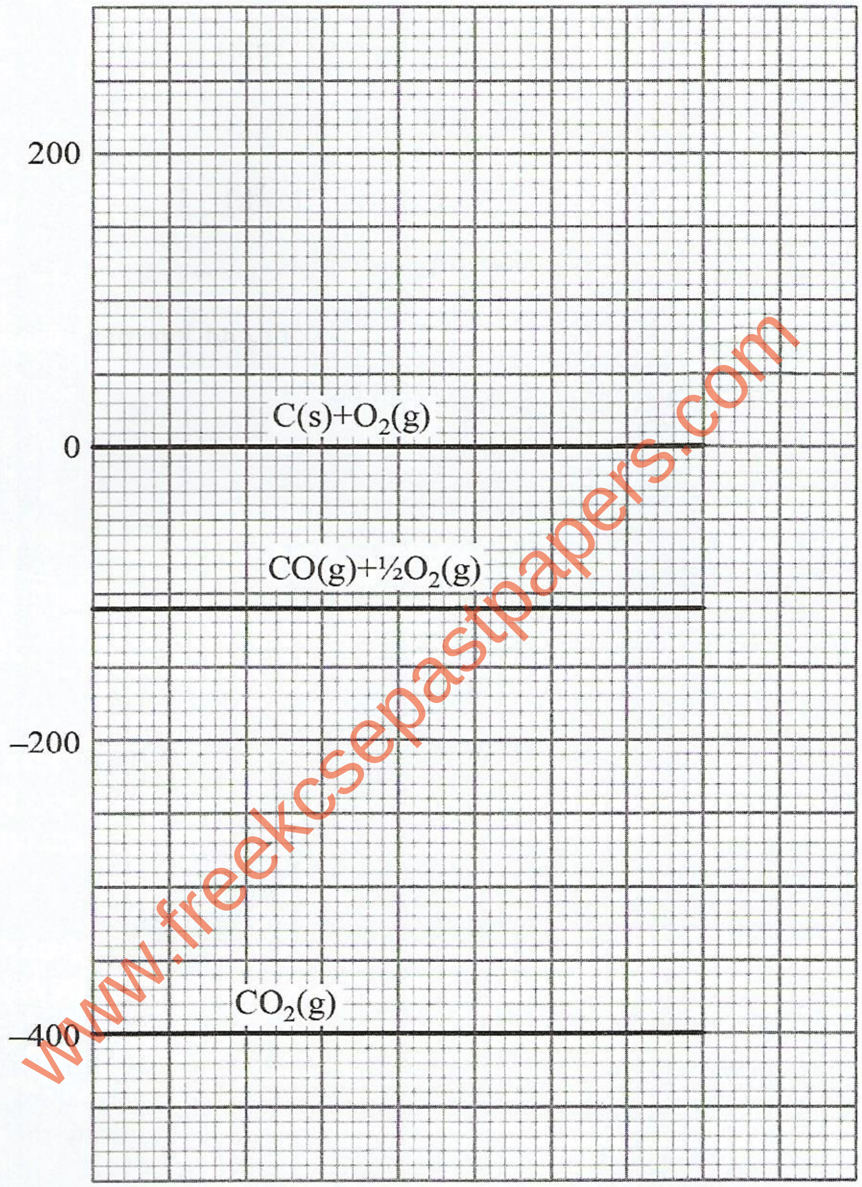


Figure 1

Determine the enthalpy change of:

(i) formation of carbon(II) oxide (1 mark)

(ii) combustion of carbon(II) oxide (1 mark)

Requirements

Candidates were required to write thermochemical equation for the formation of carbon(II) oxide and to determine the enthalpy of formation and combustion of carbon(II) oxide from a given graph.

Weaknesses
Majority of the candidates could not interpret the graph hence unable to determine the enthalpy changes.

Expected responses

(a) $C(s) + \frac{1}{2}O_2(g) \rightarrow CO(g)$; $\Delta H^{\theta}f$ (1 mark)

(b) (i) $\Delta H^{\theta}f = -110\ kJmol^{-1}$ (1 mark)

(ii) $\Delta Hc = -400 - (-110) = -290\ kJ$ (1 mark)

Advice to teachers
Teachers should expose students to more practice in graph work and interpretation of graphs in all topics.

Question 8

The mass of one molecule of a hydrocarbon is 9.33×10^{-23} g.
(Avogadro's number = $6.0 \times 10^{23}\ mol^{-1}$, C = 12.0; H = 1.0)

(a) Determine its:

(i) molecular mass (1 mark)

(ii) molecular formula (1 mark)

(b) Draw a structure of the hydrocarbon in 8(a). (1 mark)

Requirements
Candidates were required to determine the molecular mass of a hydrocarbon given the mass of one molecule and Avogadro's constant and molecular formular. Candidates were also expected draw the structure of the hydrocarbon.

Weaknesses
Majority of the candidates could not determine the molecular formula and draw the structure of the hydrocarbon.

Expected responses

(a) (i) $9.33 \times 10^{-23} \times 6.0 \times 10^{23} (\frac{1}{2}) = 55.58$

$\approx 56g\ (^1/_2)$

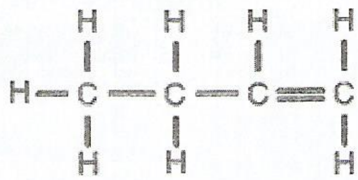
(ii) $(CH)n = 56$

$13n = 56\ (^1/_2)$

$n = 4$

$\therefore$ MF = C_4H_8 $(^1/_2)$

(b)



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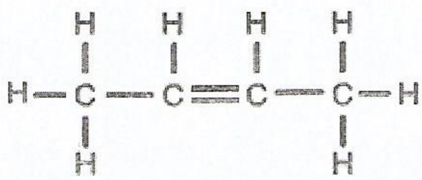

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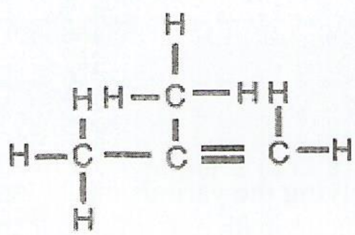


Advice to teachers

Teachers should expose learners to more calculations involving molar masses, molecular and empirical formulae, and drawing structures of compounds.

Question 13

(a) Carbon exhibits different boiling points. Explain. (1 mark)

(b) It takes 44 seconds for nitrogen(IV) oxide gas to effuse through an opening. Calculate how long it will take for an equal volume of chlorine gas to effuse through the same opening (N = 14.0; O = 16.0; Cl = 35.5). (2 marks)

Requirements

This question required candidates to explain why carbon exhibits different boiling points and to determine the time required for equal volumes of gases to effuse through the same opening given time of diffusion for one of the gases.

Weaknesses

Most of the candidates could not recognise allotropy in carbon. Some candidates could not write the formula of nitrogen(IV) oxide and chlorine correctly.

Expected Responses

(a) Carbon exists in different (½) crystalline forms/allotropes i.e diamond and graphite in the same physical state, hence different boiling points because of the different structures. (½)

(b)

$$\frac{\text{Time of effusion of } Cl_2}{\text{Timeof effusion of } NO_2} = \sqrt{\frac{\text{RMM of } Cl_2}{\text{RMM of } NO_2}}$$

$$\text{Time of diffusion of } Cl_2 = 44 \times \sqrt{\frac{\text{RMM of } Cl_2}{\text{RMM of } NO_2}} \ (^1/_2)$$

$\text{RMM}(NO_2) = 46$ (½)

$\text{RMM}(Cl_2) = 71$ (½)

Time taken by (NO_2) 44 Sec.

$$\text{Time taken by } (Cl_2) = 44 \times \sqrt{\frac{71}{46}} = 54.66 \text{ S } (^1/_2)$$

Advice to teacher

Teachers should expose the students to various relationships involving the various gas laws. Students should be given more calculations involving gas laws to ascertain adequate practice.

Question 25

Figure 3 shows how nitric(V) acid can be obtained.

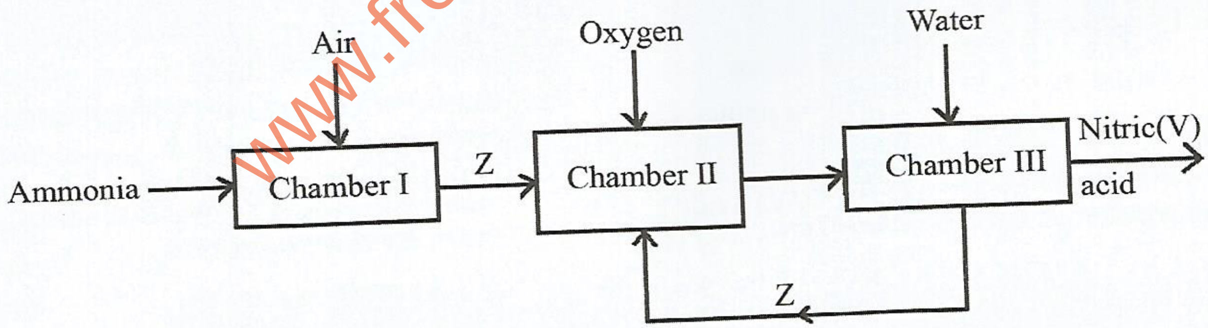


Figure 3

(a) Identify the chamber in which a catalyst is used. (1 mark)

(b) Name substance **Z**. (1 mark)

(c) Write an equation for the reaction that takes place in Chamber **III**. (1 mark)

Requirements

This question required candidates to study the flowchart on manufacture of nitric(V) acid and answer the questions.

Weaknesses

Majority of the candidates were unable to comprehend the flowchart hence they could not respond to the questions correctly.

Expected Responses

(a) Chamber I (1)

(b) Nitrogen(II) oxide (NO) (1)

(c) $3NO_2(g) + H_2O(l) \rightarrow 2HNO_3(aq) + NO(g)$ (1)

OR

$2NO_2(g) + H_2O(l) \longrightarrow HNO_3(l) + HNO_2(l)$

Advice to teachers

Teachers should expose students to flowcharts on the various industrial processes and guide them in interpreting as many flowcharts as possible.

3.5.4 Chemistry paper 2 (233/2)

Question 2

The general formula of alkanols is $C_nH_{2n+1}OH$.

(a) Draw the structure and give the name of the alkanol with n = 5. (2 marks)

Structure

Name

(b) **Table 2** gives the boiling points of some alkanols.

Table 2

n	Boiling point/°C
2	78.5
3	97.2
4	117.0

(i) On the grid provided, draw the graph of boiling point against number of carbon atoms, **n**. (3 marks)

(ii) From the graph, determine the boiling point of the alkanol with n = 5. (1 mark)

(iii) The boiling point of the alkanol with n = 2 is much higher than that of butane. Explain (C = 12.0; H = 1.0; O = 16.0). (2 marks)

(c) Alkanols are used as fuel.

(i) Give another use of alkanols. (1 mark)

(ii) Write an equation for the combustion of the alkanol with n = 2. (1 mark)

(iii) Use the bond energies in **Table 3** to calculate the enthalpy change of combustion of the alkanol with n = 2. (3 marks)

Table 3

Bond	Energy kJ/mol
C – C	348
C – H	412
C – O	360
O – H	463
O = O	496
C = O	743

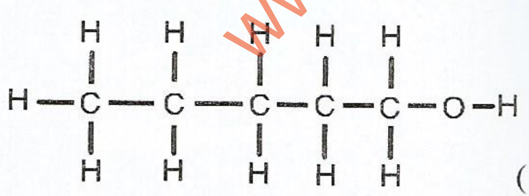
Requirements
This question required candidates to draw the structure and give the name of the alkanol. They were also expected to draw a graph of boiling points of alkanols against number of carbon atoms and to use the graph to answer some questions. They were also to give uses of alkanols, write a combustion equation and use bond energies to calculate enthalpy change of ethanol.

Weaknesses
Majority of the candidates were unable to draw and name the structure of an alkanol, draw the graph of boiling points of alkanols and use it to answer questions and calculate enthalpy change of combustion of ethanol using bond energies.

Expected Responses

(a) Formula of alkanol

$C_5H_{5\times2+1}OH \rightarrow C_5H_{11}OH$



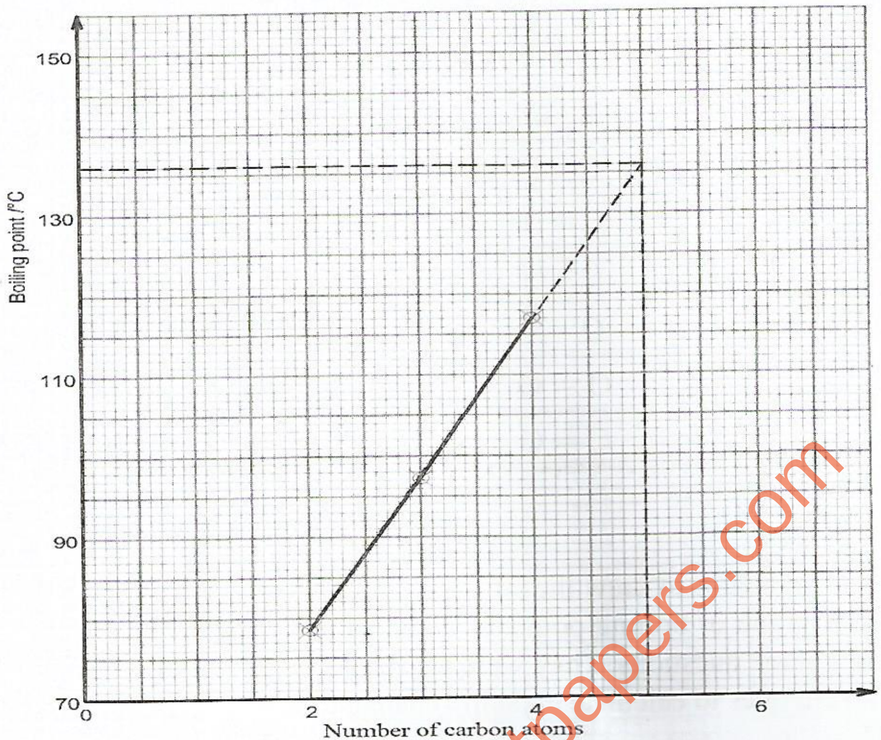
(1)

Name

Pentanol or Pentan-1-ol (1)

(Accept all correct isomers of $C_5H_{11}OH$ and their corresponding IUPAC names)

(b) (i)



Scale (plots should occupy half of the grid) - (1)

Plots - (1)

- 3 points correctly plotted (1)
- 2 points correctly plotted ($\frac{1}{2}$)
- 1 pointed correctly plotted (0)

Line (Straight line of best fit) - (1)

(ii) 136 °C (±2) (1)

(iii) Formula mass of ethanol (C_2H_5OH)

$= (12 \times 2) + (6 \times 1) + 16$

$= 46$

Butane – C_4H_{10}

Formula mass = $(12 \times 4) + 10$

$= 48 + 10$

$= 58$

Ethanol

Although RFM of butane >RFM of ethanol, there is strong hydrogen (1) bonding between ethanol molecules and weak Van der Walls forces between butane molecules (1), hence more energy required to separate the ethanol-ethanol molecules.

(c) (i)
- Used as solvents in manufacturing drugs. (1)
- Alcoholic drinks/beverages.
- Derivatives of other organic compounds.
- Used as disinfectants/antiseptics.
- Used to manufacture synthetic fibres.

(Accept any one specific derivative of alkanols

(ii) $CH_3CH_2OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$ (1)

(Ignore state symbols)

(iii)

$$\begin{array}{c} \quad H \quad H \\ \quad | \quad\; | \\ H-C-C-O-H + 3O=O \rightarrow 2O=C=O + 3H-O-H \\ \quad | \quad\; | \\ \quad H \quad H \end{array}$$

Energy for breaking bonds

$5(C-H) + (C-C) + C-O + O-H + 3\ O=O$

$= (5 \times 412) + 348 + 360 + 463 + 3(496)$ ($^1/_2$)

$= 2060 + 708 + 463 + 1488$

$= +\ 4719$ kJ ($^1/_2$)

Energy for bond formation

$4(C=O) + 6(O-H)$

$= (4 \times 743) + 6(463)$

$= -2972 + -2778$ ($^1/_2$)

$= -\ 5750$ kJ ($^1/_2$)

ΔH_C Ethanol $= +4719 + -5750$ ($^1/_2$)

$= -1031$ kJ mol^{-1} ($^1/_2$)

(Penalize $^1/_2$ mark for incorrect units used)

Advice to teachers

Teachers should guide the students in discussions in organic chemistry and involve them more in questions involving graphical work and calculations using bond energies.

Question 7

(a) (i) Give the formulae of **two ionic** compounds that can be used to prepare lead(II) sulphide salt. (1 mark)

(ii) Two moles of aqueous ammonia reacted with one mole of phosphoric(V) acid. Write an equation for the reaction that took place. (1 mark)

(b) Solid copper(II) sulphate is available either as anhydrous or hydrated salt. **Figure 4** shows enthalpy changes involved when water is added to each solid.

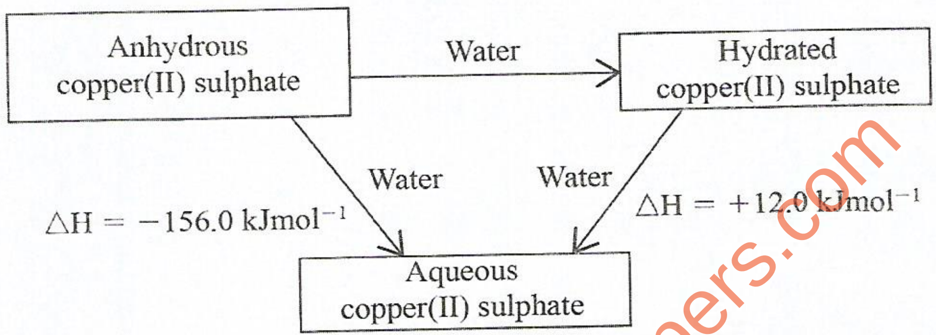


Figure 4

(i) Calculate the enthalpy change for the process:

$$CuSO_4(s) \xrightarrow{\text{Water}} CuSO_4 \cdot 5H_2O(s)$$ (1 mark)

(ii) Describe how each of the following can be prepared starting with aqueous copper(II) sulphate.

I. hydrated copper(II) sulphate. (2 marks)

II. anhydrous copper(II) sulphate. (1 mark)

(c) Aluminium hydroxide is used as an antacid.

(i) Name another compound that is used as an antacid. (1 mark)

(ii) The concentration of hydrochloric acid in the stomach is 0.01 M. If an antacid containing aluminium hydroxide is used, calculate the mass of the antacid required to neutralise 100.0 cm^3 of the stomach acid

(Al = 27.0; O = 16.0; H = 1.0). (3 marks)

Requirements

Candidates were required to comprehend an energy cycle diagram and use it to calculate enthalpy changes. They were also required to write equations and carry out calculations on the mole.

Weaknesses

Majority of candidates were unable to write equations and formulae of substances. They were also unable to carry out calculations on the mole and to calculate enthalpy changes.

Expected Responses

(a) (i) $Pb(NO_3)_2$ (½) (or any soluble salt of lead such as the ethanoate)

Na_2S (½) (or any group 1 sulphide)

(ii) $2NH_3(aq) + H_3PO_4(aq) \rightarrow (NH_4)_2HPO_4(aq)$ (1)

(Penalize ½ mark for incorrect state symbols)

(b) (i) $\Delta H = (-156.0) - (12.0)$ (½) $kJ\,mol^{-1}$

$= -168\ kJ\,mol^{-1}$ (½)

(ii) I. From the figure, the process is exothermic, $\Delta H = -12.0\ kJ$ (½), to supply the activation energy, evaporate/ heat (½) until crystals (½) start to form, allow to stand, filter and dry the crystals. (½)

II. From the figure, the process is endothermic, $\Delta H = +156.0\ kJ$ (½), heat/ evaporate (½) to dryness/use the hydrated salt from I and heat it until it changes from blue to white.

(c) (i) Magnesium hydroxide (1)

(ii) $Al(OH)_3(s) + 3HCl(aq) \longrightarrow AlCl_3(aq) + H_2O(l)$

Reaction ratio $Al(OH)_3 : HCl = 1 : 3$ (½)

RFM of $Al(OH)_3 = 27 + 48 + 3 = 78$ (½)

$$\text{Moles of acid} = \frac{100 \times 0.01}{1000}$$

$$= 0.001 \quad (½)$$

$$\text{Moles of } Al(OH)_3 = \frac{0.001}{3} \quad (½)$$

$$\text{Mass of } Al(OH)_3 = \frac{0.001}{3} \times 78\ g \quad (½)$$

$$= 0.026\ g \quad (½)$$

Advice to teachers

Teachers should expose students to many questions on writing equations, calculations on the mole and enthalpy changes. This will assist build confidence in the students in handling the topics of the mole and enthalpy changes.

3.5.5 Chemistry paper 3 (233/3)

The practical paper was tested using three questions. **Question 1** tested Knowledge, skills and competencies on:

- Testing acidity and alkalinity of solutions of substances using an indicator solution;
- Measuring and recording volumes of solutions;
- Manipulation of apparatus;
- Calculations involving moles and molarity of solutions;
- Reading and recording temperatures.
- Calculations involving enthalpy changes.

Question 2 involved qualitative analysis of an organic compound. The question required the candidates to follow the procedure provided to analyse the given compound to determine the functional group present. Candidates were required to use appropriate apparatus and chemicals, make and record observations and inferences correctly.

Question 3 involved qualitative analysis of an inorganic compound. The question required candidates to perform experiments using appropriate apparatus and chemicals, make and record observations and inferences correctly.

Majority of the candidates were able to make correct observations but had challenges in making inferring. Many of the candidates were unable to write the correct formulae of ions and use scientific language in reporting the results. In addition, the candidates experienced challenges in making inferences where they had difficulties in writing the correct inferences.

Question 1 was reported to have challenged most of the candidates. This question has been discussed in detail to give insight on the demand and expected responses.

Question 1

(a) You are provided with the following:
- **Solution A** – Indicator solution
- **Solution B** – 0.05 M compound B
- **Solution C1** – Hydrochloric acid to be used in Questions 1(a) and 1(b)

You are required to determine the concentration in moles per litre of hydrochloric acid in solution C1.

PROCEDURE I (a)

(i) Place two test tubes in a test tube rack. To the first test tube, place about 2 cm^3 of solution B. To the second test tube, place about 2 cm^3 of solution C1.

(ii) Add 2 drops of indicator solution A to each of the test tubes, shake and note the colour of each solution. Record the colours in **Table 1**.

Table 1

Solution	Colour
Solution B + indicator solution	
Solution C1 + indicator solution A	

(1 mark)

Complete the following statement:
In the titration of solution B (in a conical flask) with hydrochloric acid using indicator solution A, the colour change at the end point is from .... to .... (1 mark)

PROCEDURE II (a)

(i) Using a pipette and pipette filler, pipette 25.0 cm^3 of **solution C1** into a 250 ml volumetric flask. Add distilled water to the mark. Label this as **solution C2**.
(ii) (Fill a burette with **solution C2**.
(iii) Using a clean pipette and pipette filler, place 25.0 cm^3 of **solution B** in a 250 ml conical flask.
(iv) Titrate **solution B** with **solution C2** using 3 drops of indicator **solution A**. Record the results in **Table 2**

Table 2

	I	II	III
Final burette reading			
Initial burette reading			
Volume of solution C2 used, cm^3			

(4 marks)

Calculate the:

(i) average volume of **solution C2** used. (1 mark)
(ii) number of moles of **compound B** used. (1 mark)
(iii) number of moles of hydrochloric acid used (1 mole of compound B reacts with 2 moles of hydrochloric acid). (1 mark)
(iv) concentration in moles per litre, of hydrochloric acid in **solution C2**. (1 mark)
(v) concentration in moles per litre, of hydrochloric acid in **solution C1**. (1 mark)

(b) You are provided with **two** portions of **solid D,** sodium hydrogen carbonate each weighing **2.5 g.**

You are required to determine the heat of reaction of hydrochloric acid with aqueous sodium hydrogen carbonate.

PROCEDURE I (b)

(i) Using a 100 ml measuring cylinder, measure 30 cm^3 of distilled water and place it in a 100 ml plastic beaker.
(ii) Measure the temperature of the distilled water and record in **Table 3**.
(iii) Add one of the portions of **solid D** to the water. Stir with the thermometer and measure the minimum temperature reached. Record the reading in **Table 3**.

Table 3

Final temperature of the solution, °C	
Initial temperature of water, °C	
Temperature change, °C	

Calculate the:

(i) heat change of the solution (assume specific heat capacity of solution = 4.2 Jg^{-1}per degree, density of solution = 1.00g cm^{-3}) (1 mark)

(ii) number of moles of sodium hydrogen carbonate, **solid D** used (relative formula mass = 84). (1 mark)

(iii) heat change, ΔH_1 in $kJmol^{-1}$ of sodium hydrogen carbonate. (1 mark)

PROCEDURE II (b)

(i) Clean the 100 ml plastic beaker.

(ii) Repeat **procedure I (b)** using the second portion of **solid D** and 30 cm^3 of **solution C1** instead of 30 cm^3 of distilled water.

(iii) Record the results in **Table 4**.

Table 4

Final temperature of the solution, °C	
Initial temperature of water, °C	
Temperature change, °C	

(1½ marks)

Calculate the:

(i) heat change of the solution (assume specific heat capacity of solution = 4.2 Jg^{-1} per degree, density of solution = 1.00 g cm^{-3}). (1 mark)

(ii) heat change, ΔH_2 in $kJmol^{-1}$ of sodium hydrogen carbonate (1 mark)

(iii) heat change, $\Delta H_3 = \Delta H_2 - \Delta H_1$ for the reaction of hydrochloric acid and one mole of aqueous sodium hydrogen carbonate. (1 mark)

Requirements

Candidates were required to manipulate apparatus to measure volumes of solutions, measure and record volumes of solutions, read and record temperature of solutions, record colour s observed, manipulate data obtained and carry out calculations using the data obtained.

Weaknesses

Majority of the candidates were able to collect data and completed the tables but could not manipulate the data. Many of the candidates had challenges in observing and recording the expected colours. In addition, candidates were unable to carry out the calculations.

Expected Responses

Table 1

Solution	**Colour**
Solution **B** + indicator solution **A**	Yellow ($^1/_2$)
Solution **C1** + indicator solution **A**	Pink ($^1/_2$)

The colour change at the end point is from **yellow/orange** ($^1/_2$) to **pink/red** ($^1/_2$).

Table 2

	I	**II**	**III**
Final Burette Reading	14.85	28.50	26.75
Initial burette eading	1.05	14.85	13.20
Volume of solution (**C2** used, cm^3)	13.80	13.65	13.55

A) Complete table.. (1 mark)

B) Use of decimals (1or 2 decimal places consistently used)...................... (1 mark)

C) Accuracy (compare the candidate's correct value with the school value (S.V)...... (1 mark)

D) Principles of averaging (average values within ±0.2cm^3 of each other...........(in (i) below)

E) Final accuracy compared to the school value tied to the correct average titre) (S.V).......(1 mark)

(i) Average volume of solution **C2** used

$$= \frac{13.65 + 13.55}{2} \text{ cm}^3 (^1/_2)$$

$$= 13.60 \text{ cm}^3 \ (^1/_2)$$

(ii) Number of moles of compound **B** used.

$$= \frac{25.0 \times 0.05}{1000} \quad \text{OR} \quad \frac{0.05}{40} \quad \text{OR} \quad 0.05 \times 0.025 (^1/_2)$$

$$= 0.00125 = \left(1.25 \times 10^{-3}\right) \text{ moles } (^1/_2)$$

(iii) Moles of hydrochloric acid (C2) used = Answer in (ii) above×2

$= 0.00125 \times 2$ $(^1/_2)$

$= 0.0025$ $(^1/_2)$

(iv) Concentration of hydrochloric acid in solution **C2** $= \dfrac{\text{No.of moles in}(iii)\times 1000}{\text{Volume in }(i)}$

$$= \frac{0.0025 \times 1000}{13.60} \quad (^1/_2)$$

$$= 0.18 \text{ mol l}^{-1} \quad (^1/_2)$$

(v) Concentration of hydrochloric acid in solution **C1** $= \dfrac{\text{Answer in }(iv)\times 250}{25}$

$$\text{OR} \quad \frac{250 \times Ans(iii)}{Average\ titre} \quad \text{OR} \quad \frac{250 \times Ans(iii) \times 1000}{Average\ titre \times 25}$$

$$= \frac{0.18 \times 250}{25} \text{ mol l}^{-1} \quad (^1/_2)$$

$$= 1.8 \text{ mol}^{-1} \quad (^1/_2)$$

(b) **Table 3**

Final temperature of the solution, °C	20.0 $(^1/_2)$
Initial temperature of water, °C	23.5 $(^1/_2)$
Temperature change, °C	-3.5 $(^1/_2)$

(A) Complete table.. $(^1/_2$mark)

(B) Use of decimals (tied to the 1st and 2nd columns only) .... $(^1/_2$ mark)

(C) Accuracy (compare candidate's initial temperature reading to the initial temperature of the S.V) if within ±2 units... $(^1/_2$ mark)

(i) Heat change of the solution = 4.2 × 30 × ΔHT

$$= -(4.2 \times 30 \times (-3.5)) \text{ Joules } (^1/_2)$$

$$= +441\text{J } (^1/_2)$$

OR

$$= \frac{30}{1000} \times 4.2 \times \Delta T$$

= Answer in kJ

(ii) Moles of sodium hydrogen carbonate

$$= \frac{2.5}{84} (^1/_2)$$

$$= 0.02976$$

$$\approx 0.03 (^1/_2)$$

(iii) Heat change, $\Delta H_1 = +\frac{441}{0.03} \times \frac{1}{1000} \text{ kJ mol}^{-1} (^1/_2)$

$$= +14.7 \text{ kJ mol}^{-1} (^1/_2)$$

OR

$$= \frac{\text{answer in b(i) in kJ}}{\text{Answer in b(ii)}}$$

= Correct answer

Table 4

Final temperature of solution, °C	18.0 ($^1/_2$)
Initial temperature of solution C1, °C	24.0 ($^1/_2$)
Temperature change, °C	-6.0 ($^1/_2$)

(A) Complete table.. ($^1/_2$mark)

(B) Use of decimals (tied to the 1st and 2nd columns only) ....($^1/_2$ mark)

(C) Accuracy (compare candidate's initial temperature reading to the initial temperature of the S.V) if within ±2 units..($^1/_2$ mark)

(i) Heat change of the solution = $4.2 \times 30 \times \Delta HT$

$$= -(4.2 \times 30 \times (-6.0)) \text{ Joules } (^1/_2)$$

$$= -(-756) \text{ Joules}$$

$$= +756 \text{ J } (^1/_2)$$

OR

$$= \frac{30}{1000} \times 4.2 \times \Delta T$$

= Answer in kJ

(ii) Heat change, $\Delta H_2 = +\frac{756 \times 1}{0.03 \times 1000}$ kJ mol^{-1} ($^1/_2$)

$$= +25.2 \text{ kJ mol}^{-1} (^1/_2)$$

(iii) $\Delta H_3 = \Delta H_2 - \Delta H_1$

$$= (+25.2) - (+14.7) \text{ kJ mol}^{-1} (^1/_2)$$

$$= +10.5 \text{ kJ mol}^{-1} (^1/_2)$$

OR

$\Delta H_3 = \Delta H_2 - \Delta H_1$

= Answer in IIb(ii) – Answer in Ib(iii)
= Correct answer

Advice to teachers

Teachers should expose students to many practicals as early as possible to build confidence in the learners and to ensure that they develop the competence of manipulating the apparatus. Also, teachers should employ practical approach to teaching and learning of Chemistry. Emphasis should be made on calculations relating to moles and enthalpy changes, data manipulation, the use of correct scientific terms in reporting observations and inferences. Teachers are advised to expose learners to as many practicals as possible so as to give them an opportunity to interact with apparatus and chemicals with emphasis on following the procedure to avert accidents in the laboratory.

CONCLUSION

Although there was improved performance the three chemistry papers, the performance is still below average. This is evidenced by the low means which are far from the ideal mean. Of importance to note is that part of the practical examination involves the ability to follow instructions by the students when carrying out the experiment. Teachers should therefore train students to perform experiments with strict adherence to the instructions provided. This will enable them attain the expected results without challenges. Also, teachers should ascertain adherence to instructions when preparing the reagents for use in the practical. This will avert unnecessary pressure and frustration on the day of preparation for the practical.