THE UNITED REPUBLIC OF TANZANIA

MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

CANDIDATES' ITEM RESPONSE ANALYSIS REPORT ON THE DIPLOMA IN SECONDARY EDUCATION EXAMINATION (DSEE), 2023

CHEMISTRY

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732 CHEMISTRY

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FOREWORD

The National Examinations Council of Tanzania is delighted to issue the Candidates' Item Response Analysis (CIRA) report on the Diploma in Secondary Education Examination (DSEE) 2023 in Chemistry subject. This report aims to provide feedback to student-teachers, tutors, parents, policymakers and the public in general on the candidates' performance and the extent to which the instructional objectives were met.

Principally, the candidates' responses to the examination questions indicate what the education system was able/unable to offer in the two year Diploma in Secondary Education course. Thus, it evaluates the effectiveness of the education system in general and education delivery in particular.

Specifically, the report aims to provide a clear understanding of the reasons behind the candidates' success or failure in the Chemistry subject. These include the ability to interpret the questions, follow instructions and grasp the concepts and the principles related to the subject. In addition, the report indicates that some of the candidates scored low marks because they failed to interpret the requirements of the questions, and they lacked sufficient knowledge about the concepts on which they were tested.

The National Examinations Council of Tanzania believes that, the feedback provided in this report shall serve as a basis for educational stakeholders to act appropriately to improve teaching and learning. This will ultimately improve candidates' performance in the future examinations administered by the Council.

Finally, the Council expresses its sincere gratitude to all individuals who participated in preparing this report.

Dr. Said A. Mohamed
EXECUTIVE SECRETARY

1.0 INTRODUCTION

This report presents the performance of the candidates who sat for the DSEE 2023 in the Chemistry subject. The examination was comprised of two papers: Chemistry 1 (Theory paper) and Chemistry 2 (Practical paper). The candidates were required to answer all questions in paper 1 and 2.

The examination aimed to assess the candidates' competences in applying knowledge and skills they acquired in Chemistry to solve day-to-day life challenges, manage a chemistry laboratory and assess learners' achievement according to the contents and objectives stipulated in the syllabus.

Data analysis indicates that 851 (99.42%) out of 872 (100%) candidates who sat for the examination passed, whereas five candidates (0.6%) failed. Their overall performance in this subject in 2023 decreased by 0.14 per cent compared to 2022 where 99.56 per cent passed. Table 1 provides a comparative analysis of grade performance between 2022 and 2023.

Table 1: Comparison of Candidates' performance in 2022 and 2023

Year	Candidates		Number of Candidates and Percentage				
	Registered	Passed	Grades				
			A	B	C	D	F
2022	1815	1793	0	90	1121	582	8
		99.56%	0	5.0%	62.3%	32.3%	0.4%
2023	872	851	2	95	554	200	5
		99.42%	0.2%	10.9%	63.5%	22.9%	0.6%

Table 1 shows that many candidates (62%) scored C for two consecutive years. Conversely, only 2 candidates scored A in 2023.

This report is organized into five sections: the introduction, analysis of the candidates' performance on each question, analysis of performance on each topic, conclusions and recommendations. Additionally, Appendices I and II which summarise the performance on each topics and Appendices III and IV which illustrate the comparison of the candidates' performance per topic in Chemistry 1 and Chemistry 2 in 2022 and 2023 have been embedded.

The analysis categorised the performance into three levels: good (70 - 100), average (40 - 69) and poor (0 - 39). Three colours (green, yellow and red) indicate good, average and poor performance respectively.

2.0 ANALYSIS OF CANDIDATES' PERFORMANCE ON EACH QUESTION

This part analyses the candidates' performance in Chemistry Paper 1 and 2. The analysis combines both statistical data and candidates' responses presenting the findings through figures and tables while incorporating relevant extracts from the candidates' responses.

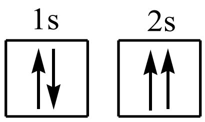
2.1 732/1 Chemistry 1: Theory Paper

The Chemistry theory paper comprised of two sections, A and B. Section A consisted of ten short-answer questions, each carrying four (04) marks. In contrast, Section B comprised four structured questions each carrying 15 marks. The candidates were required to attempt all the questions in sections A and B. The pass mark for Section A was 2.0 while for Section B was 6.0.

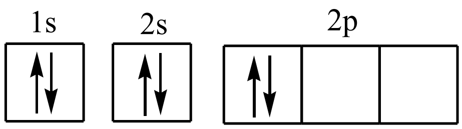
2.1.1 Question 1: General Chemistry

The question required the candidates to observe/study each electronic configuration and suggest the violated rule/principle. The electronic configuration were as follows:

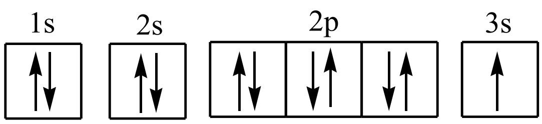
(a) *Beryllium, Be:*



(b) *Carbon, C:*



(c) *Sodium, Na:*



This question was attempted by all 872 (100%) candidates. Among them, 656 (75.2%) scored from 0 to1.5 marks; 70 (8%) scored from 2.0 to 2.5 marks; and 146 (16.8%) scored from 3.0 to 4.0 marks. Their distribution of scores is summarized in Figure 1.

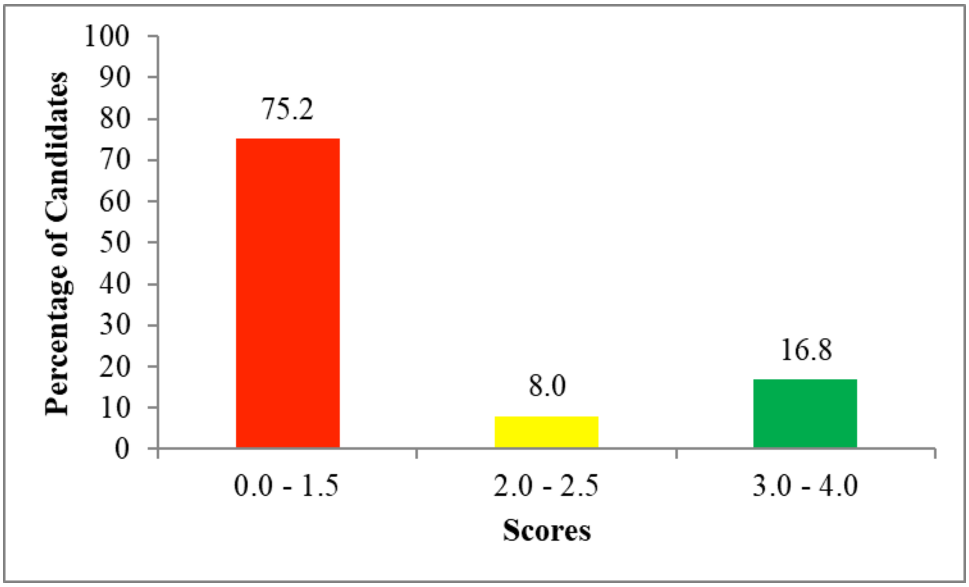


Figure 1: *Candidates' Performance on Question 1*

Figure 1 indicates that the candidates' performance on this question was weak since only 24.8 percent of the candidates passed as they scored from 2.0 to 4.0 marks.

Those who scored from 0 to 1.5 marks provided incorrect responses to most parts of the question due to lack of knowledge about electronic configuration of atoms. Their responses revealed insufficient knowledge of the rules and principles applied in filling electrons in orbitals. For instance, in part (a), one candidate incorrectly stated that *Hund's rules of maximum multiplicity was violated* in electronic configurations of beryllium and carbon. Additionally, another candidate incorrectly wrote that *the doublet rule was violated* in part (b), despite no violation of any rule or principle in this question.

Similarly, in part (c), most candidates incorrectly stated that the question violated Paul's exclusive principle, while others mistakenly wrote that Hund's rule was violated. Their incorrect responses indicated a lack of understanding of the rules/principles governing the filling of electrons in orbitals. Extract 1.1 provides an example of such incorrect response from one of the candidates.

1	i) It is MarKonKoff's rule.
	ii) Aufubal rule
	iii) MarKonKoff's rule.

Extract 1.1: A sample of an incorrect response to question 1.

In Extract 1.1, the candidate incorrectly cited violated rules in (i) wrote Markovnikov's rule instead of Paul's exclusive principle and (ii) wrote Aufbau rule instead of Hund's rule. Additionally, in part (iii) the candidate wrongly stated Markovnikov's rule which was not relevant to the question.

The candidates who scored from 2.0 to 2.5 marks on this question demonstrated insufficient knowledge about the principles and rules that govern the filling of electrons in orbitals. Although they provided correct responses to part (a), they failed to respond to parts (b) and (c). Their responses were attributed by two electrons in 2s orbital spin in one direction.

Conversely, the candidates who scored full marks in all parts correctly identified the violated rule/principle in parts (a) and (b). For instance, one candidate noted that *the two electrons in 2s orbital spin in the same direction hence violated Paul's exclusion principle.* In part (b), another candidate explained that *two electrons in 2p are paired before the orbital is singly occupied hence violating Hund's rules of maximum multiplicity*. Moreover, the candidates recognized that in part (c), all electrons were correctly filled. Hence, no rule or principle was violated. Extract 1.2 is illustrative of a correct response from one of the candidates.

1	(a) The violated rule is Paul's Exclusion principle which is states that, "No two (2) electrons in an orbital can have the same set of all four quantum numbers".
	(b) The violated rule is Hund's rule of maximum multiplicity, which states that "Pairing is not allowed in an orbital, until all ~~to~~ orbital are singly occupied by electron then pairing begins".
	(c) No violated rule/principle because the electron configuration of sodium (Na) is written correctly by observing all rules.

Extract 1.2: A sample of a correct response to question 1.

In Extract 1.2, the candidate correctly stated the violated rules in parts (a) and (b). Similarly, the candidate correctly commented that there was no violation of any rules/principle as per question requirement in part (c).

2.1.2 Question 2: Chemical Kinetics, Energetics and Equilibrium

The candidates were required to assess the effect of rate of chemical reaction in cooking some foods and preserving of fruits and vegetables in a refrigerator by using the knowledge of chemical kinetics. The question were as follows:

Justify the following facts by using the knowledge from chemical kinetics:

(a) *Some foods require higher temperature during cooking.*

(b) *Fresh fruits and vegetables are stored in a refrigerator.*

(c) *Some foods require baking soda ($NaHCO_3$) during cooking.*

The question was attempted by all 872 candidates (100%). Of whom, 476 (54.6%) scored from 0 to 1.5 marks; were 182 (20.9%) scored from 2.0 to 2.5 marks; and 214 (24.5%) scored from 3.0 to 4.0 marks. The distribution of their scores on this question is shown in Figure 2.

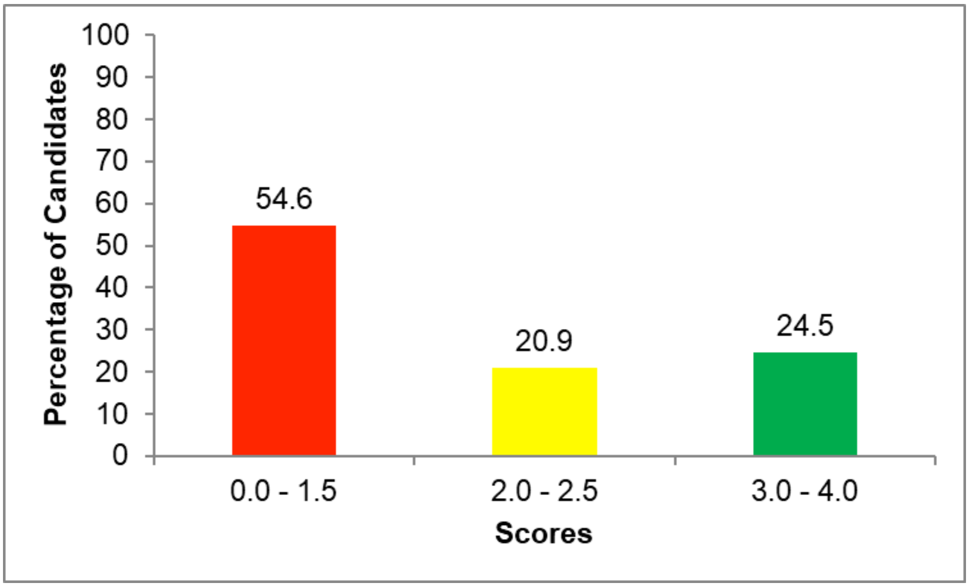


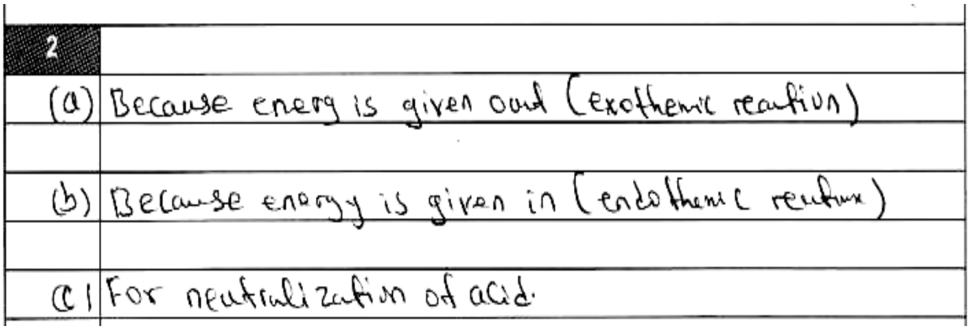
Figure 2: *Candidates' Performance on Question 2*

Analysis shows that the candidates' overall performance on this question was average. Whereby 396 (45.8%) scored from 2.0 marks or above. Moreover, 476 (54.6%) of the candidates who attempted the question failed by scoring from 0 to 1.5 marks.

The candidates who scored 54.6 per cent exhibited poor performance. They provided irrelevant responses to all parts (a) to (c). For instance, in part (a), one candidate incorrectly stated that some food requires higher boiling points *because they have high boiling points*. Other candidates had a misconception that *temperature is used to increase the surface area for the reaction to take place*. The candidates failed to associate the effects of temperature on the rate of chemical reaction with the actual practice in real life situations. Similarly, in part (b), the candidates provided inappropriate explanation for storing fresh fruits and vegetables in the refrigerator. For example, one candidate wrote that fresh fruits and vegetables are stored *in order to avoid ripening or drying.* Another candidate wrote that refrigerators *have low boiling point due to higher freezing point*.

In part (c), some candidates related the use of baking powder ($NaHCO_3$) during cooking with yeast in some foods such as bread. For example, one of the candidates wrote that baking powder is used during cooking *in order* *to increase food taste such as colour, texture and smell.* Another candidate wrote that baking powder *adds flavours and make the food soft.*

Moreover, one candidate wrote that they use baking powder in cooking *to increase sodium and carbonate ions in the body,* which is incorrect. Another candidate incorrectly wrote baking powder is added *to avoid chemical change of cooked food.* Additionally, another candidate suggested that baking powder is used *to neutralize the acidic medium of food and provide the optimum temperature for the enzymes digestions in the stomach.* Their responses indicate that the candidates lacked adequate knowledge about the effects of temperature and catalyst in the rate of chemical reaction. Extract 2.1 presents a sample of an incorrect response from one of the candidates.



2	
(a)	Because energy is given out (exothermic reaction)
(b)	Because energy is given in (endothermic reaction)
(c)	For neutralization of acid.

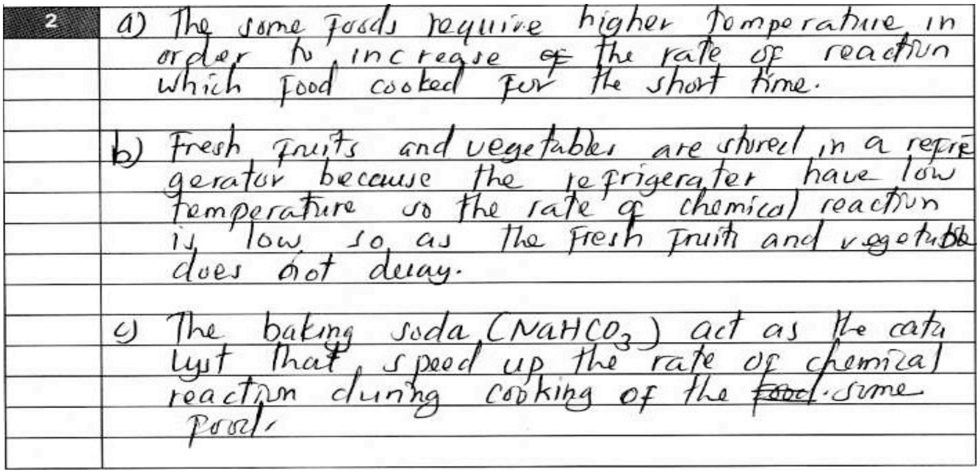
Extract 2.1: A sample of an incorrect response to question 2.

In Extract 2.1, the candidate incorrectly wrote exothermic reaction, endothermic reaction and neutralization of acid in steady of justifying the knowledge of chemical kinetics how it is applied in cooking foods and preserving fruits.

The candidates who scored average marks on this question exhibited the existence of both relevant and irrelevant responses or answered part (a) but missed the marks in part (b). This suggests that they had insufficient knowledge of the rate of chemical reaction.

Conversely, 24.5 per cent of candidates scored full marks. These provided correct responses to all parts of the question. For instance, in part (a), one of the candidates correctly stated that *some food require higher temperature during cooking since temperature increases the rate of reactions.* Another candidate stated that *higher temperature is required in order to increase the collision of reacting particles and rate of reaction becomes faster, hence the food will be cooked within short period of time.*

These responses indicate that the candidates possessed adequate knowledge of chemical kinetics. In part (b), most of the candidates correctly wrote that storing fresh fruits and vegetables in the refrigerator slows the rate of chemical reaction of decomposing bacteria. They also noted that the lower the temperature the lower the chemical reactions. Hence, fruits and vegetables will not be affected by decomposing bacteria. Furthermore, in part (c), the candidates correctly indicated that *baking soda acts as catalyst that speed up the rate of reaction by lowering the activation energy. This helps the food to be prepared within short period of time.* Extract 2.2 is illustrative of a correct response from one of the candidates.


2 a) The some foods require higher temperature in order to increase of the rate of reaction which food cooked for the short time.

b) Fresh fruits and vegetables are stored in a refrigerator because the refrigerater have low temperature so the rate of chemical reaction is low so as the fresh fruit and vegetable does not decay.

c) The baking soda ($NaHCO_3$) act as the catalyst that speed up the rate of chemical reaction during cooking of the ~~food~~ some food.

Extract 2.2: A sample of a correct response to question 2.

In Extract 2.2, the candidate provided correct responses to all parts of the question. In part (a), the candidate correctly wrote that some food requires high temperature in cooking to increase the rate of chemical reaction, and the food is cooked in a very short time. In part (b), the candidate correctly wrote that fresh fruits and vegetables are stored in the refrigerator because its low temperature slows down the rate of chemical reaction and thus prevents the food from decaying. Similarly, in part (c), the candidates correctly showed that $NaHCO_3$ was used as a catalyst.

2.1.3 Question 3: Chemical Kinetics, Energetics and Equilibrium

This question intended to assess the candidates' ability to use the rate law to write the rate expression. The question asked as follows:

Study the following reactions then write the rate expression in respect to the concentration of the reactants and products:

(a) $NO_2(g) + CO(g)$ à àÜ $CO_2(g) + NO(g)$

(b) $S_2O_8^{2-}(aq) + 3I^-(aq)$ à àÜ $2SO_4^{2-}(aq) + I_3^-(aq)$

(c) $2N_2O_5(g)$ à àÜ $4NO_2(g) + O_2(g)$

All 872 candidates (100%) attempted this question. Their overall performance on this question was weak; only 111 (12.7%) scored 2.0 marks or above, whereas the majority 761 (87.3%) failed. Table 2 provides a detailed breakdown of the candidates' performance on this Question.

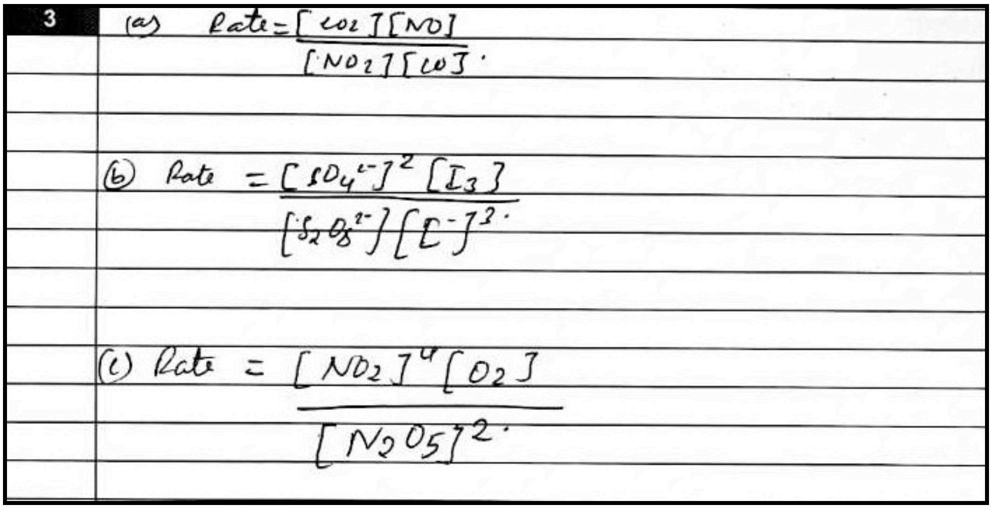
Table 2: Candidates' Performance on Question 3

S/N	Range of scores	Total no. of candidates	Percentages of candidates
1.	0.0 - 1.5	761	87.3
2.	2.0 – 2.5	15	1.7
3.	3.0 – 4.0	96	11

The majority of the candidates (87.3%) scored from 0 to 1.5 marks. They lacked sufficient knowledge of writing the rate expression. The candidates failed to interpret the requirement of the question and provided incorrect responses to almost all parts of the question. The question seems to have challenged many candidates. Hence, they wrote the rate raw equation and equilibrium constant instead of the rate expression. For example, one candidate wrote the rate law equation as follows: $Rate = K[NO_2]^m[CO]^n$. While another candidate wrote equilibrium constant as follows: $Rate = \frac{[CO_2][NO]}{[NO_2][CO]}$. The two answers were contrary to the requirement of the question; rate expression was supposed to be written as:

$$\text{Rate} = -\frac{\Delta\left[S_2O_8^{2-}\right]}{\Delta t} = -\frac{1}{3}\frac{\Delta\left[I^-\right]}{\Delta t} = \frac{1}{2}\frac{\Delta\left[SO_4^{2-}\right]}{\Delta t} = \frac{\Delta\left[I_3^-\right]}{\Delta t}$$

These responses suggest that the candidates confused between equilibrium constant, the rate law equation and rate expression. Extract 3.1 presents an incorrect response from one of the candidates.



3 (a) $Rate = \frac{[CO_2][NO]}{[NO_2][CO]}$.

(b) $Rate = \frac{[SO_4^{2-}]^2[I_3]}{[S_2O_8^{2-}][I^-]^3}$.

(c) $Rate = \frac{[NO_2]^4[O_2]}{[N_2O_5]^2}$.

Extract 3.1: A sample of an incorrect response to question 3.

In Extract 3.1, the candidate mistakenly wrote the expression of equilibrium constant instead of the rate expression in all parts, from (a) to (c).

The candidates who scored average marks on this question managed to attempt part (a) correctly but struggled in writing the rate expression using 1,3,2 and 1 as stoichiometric coefficients in parts (b) and (c). This was attributed to candidate's inadequate knowledge of writing the rate expression.

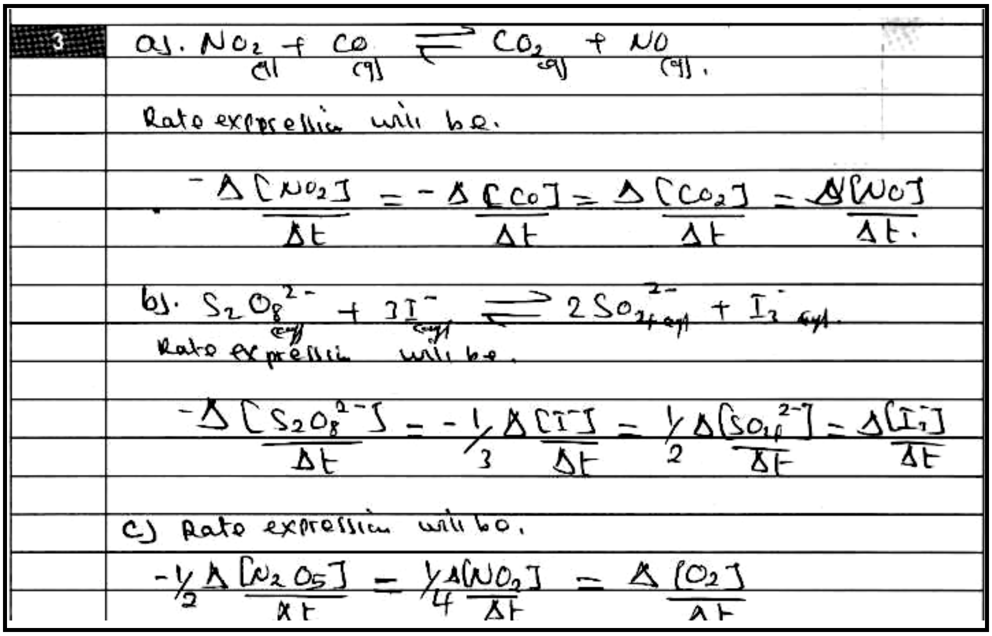
Conversely, only 96 (11%) of the candidates scored high marks on this question. These candidates correctly showed the rate expression in all parts of the question. In part (a), they wrote the rate expression by using respective stoichiometric coefficient. Similarly, in part (b), the candidates correctly wrote the rate expression using stoichiometric coefficient of 1,3,2, and 1. For instance, one candidate wrote:

$$Rate = -\frac{\Delta[S_2O_8^{2-}]}{\Delta t} = -\frac{1}{3}\frac{\Delta[I^-]}{\Delta t} = \frac{1}{2}\frac{\Delta[SO_4^{2-}]}{\Delta t} = \frac{\Delta[I_3^-]}{\Delta t}$$

Likewise, in part (c), the candidates correctly attempted the question by using the stoichiometric coefficient of 2,4, and 1. For example, one of the candidates wrote the rate expression as follows:

$$Rate = -\frac{1}{2}\frac{\Delta[N_2O_5]}{\Delta t} = \frac{1}{4}\frac{\Delta[NO_2]}{\Delta t} = \frac{\Delta[O_2]}{\Delta t}$$

The responses given by these candidates signify that the candidates had sufficient knowledge of writing the rate expression. Extract 3.2 presents a sample of a correct response from one of the candidates.


3 (a). $NO_{2(g)} + CO_{(g)} \rightleftharpoons CO_{2(g)} + NO_{(g)}$.

Rate expression will be.

$$-\frac{\Delta[NO_2]}{\Delta t} = -\frac{\Delta[CO]}{\Delta t} = \frac{\Delta[CO_2]}{\Delta t} = \frac{\Delta[NO]}{\Delta t}.$$

(b). $S_2O_8^{2-}{}_{(aq)} + 3I^-{}_{(aq)} \rightleftharpoons 2SO_4^{2-}{}_{(aq)} + I_{3(aq)}$.

Rate expression will be.

$$-\frac{\Delta[S_2O_8^{2-}]}{\Delta t} = -\frac{1}{3}\frac{\Delta[I^-]}{\Delta t} = \frac{1}{2}\frac{\Delta[SO_4^{2-}]}{\Delta t} = \frac{\Delta[I_3]}{\Delta t}$$

(c) Rate expression will be.

$$-\frac{1}{2}\frac{\Delta[N_2O_5]}{\Delta t} = \frac{1}{4}\frac{\Delta[NO_2]}{\Delta t} = \frac{\Delta[O_2]}{\Delta t}$$

Extract 3.2: A sample of a correct response to question 3.

In Extract 3.2, the candidate wrote correctly the rate expression in all parts (a) to (c) with their respective stoichiometric coefficients.

2.1.4 Question 4: Volumetric Analysis

This question assessed the candidates' ability in using numeric skills and manipulation of formula about the mole concept of volumetric analysis in solving different problems. The question consists of two parts, (a) and (b), and it asked as follows:

(a) How many moles are there in 35.8 g of magnesium ribbon?

(b) Justify that 3.58 moles of zinc granules contain 232.7 g.

All 872 (100%) candidates attempted the question. Among them, 152 (17.4%) scored from 0 to 1.5 marks; 293 (33.6%) scored from 2.0 to 2.5 marks; and 427 (49%) scored from 3.0 to 4.0 marks. The distribution of the candidates' scores on this question is shown in Figure 3.

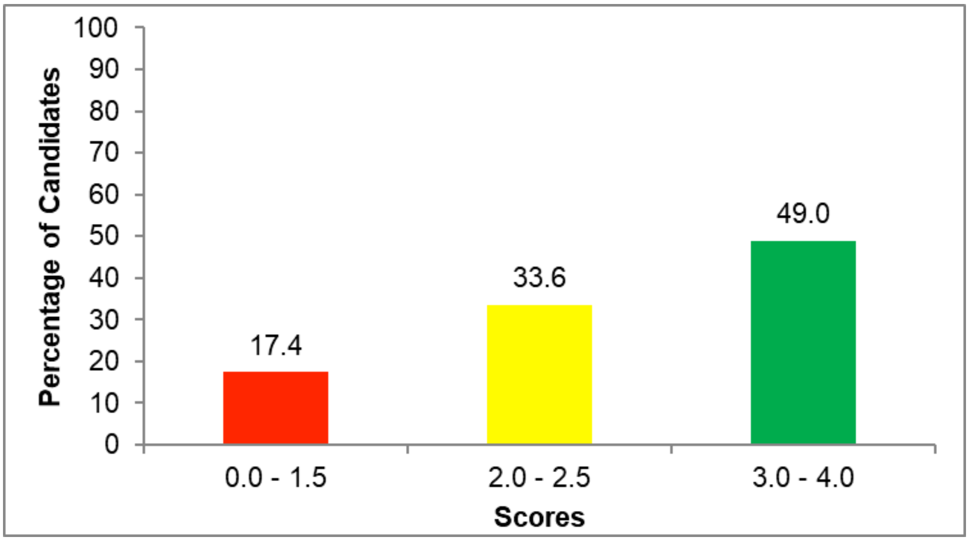


Figure 3: *Candidates' Performance on Question 4*

Figure 3 shows that the candidate's performance on this question was good, with the majority 720 (82.6%) scoring 2.0 marks or above.

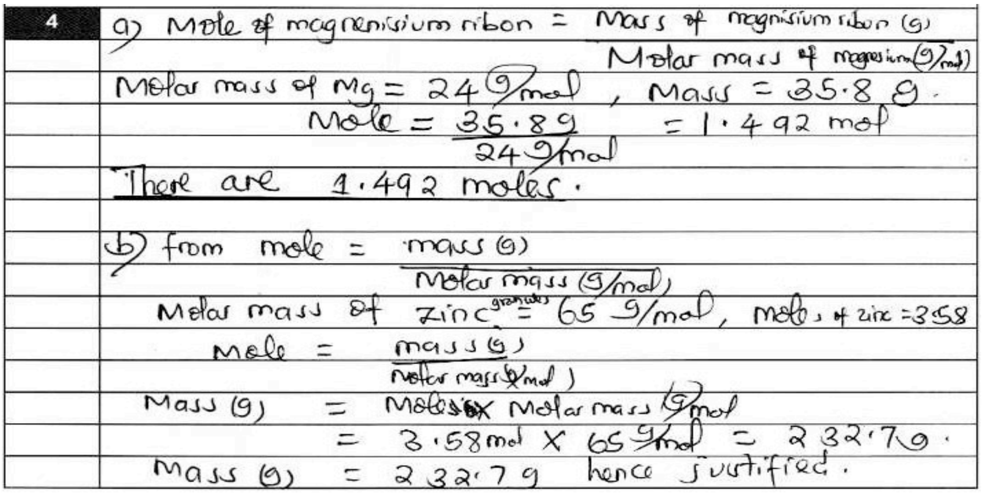
The analysis of the candidates' performance indicates that 427 (49%) of those who scored high marks demonstrated an adequate understanding of the question. For instance, in part (a), the candidates correctly calculated the numbers of moles of magnesium ribbon as per the requirement of the question. In part (b), the candidates justified by using calculation that 3.58 moles of zinc granules contain 232.7g as presented by one of the candidates who calculated as follows:

1 mole of zinc contain 65g
3.58 moles of zinc contain Xg
1 mole = 65g
3.59 moles = xg

$$X = \frac{3.58\,mole \times 65g}{1\,mole} = 232.7g$$

The amount present = 232.7g

The correct responses given to this question indicate that the candidates had adequate knowledge about the mole concept of volumetric analysis as Extract 4.1 shows.


4 a) Mole of magnenisium ribon = Mass of magnisium ribon (g) / Molar mass of magnesium (g/mol)
Molar mass of Mg = 24 g/mol, Mass = 35.8 g.
Mole = 35.8 g / 24 g/mol = 1.492 mol
There are 1.492 moles.
b) from mole = mass (g) / Molar mass (g/mol)
Molar mass of zinc granules = 65 g/mol, moles of zinc = 3.58
Mole = mass (g) / molar mass (g/mol)
Mass (g) = Moles x Molar mass g/mol
= 3.58 mol x 65 g/mol = 232.7 g.
Mass (g) = 232.7 g hence justified.

Extract 4.1: A sample of a correct response to question 4.

In Extract 4.1, the candidate correctly calculated the number of moles of magnesium ribbon in part (a). Similarly, in part (b), the candidate justified through calculation that 3.58 moles of zinc granules contain 232.7 g.

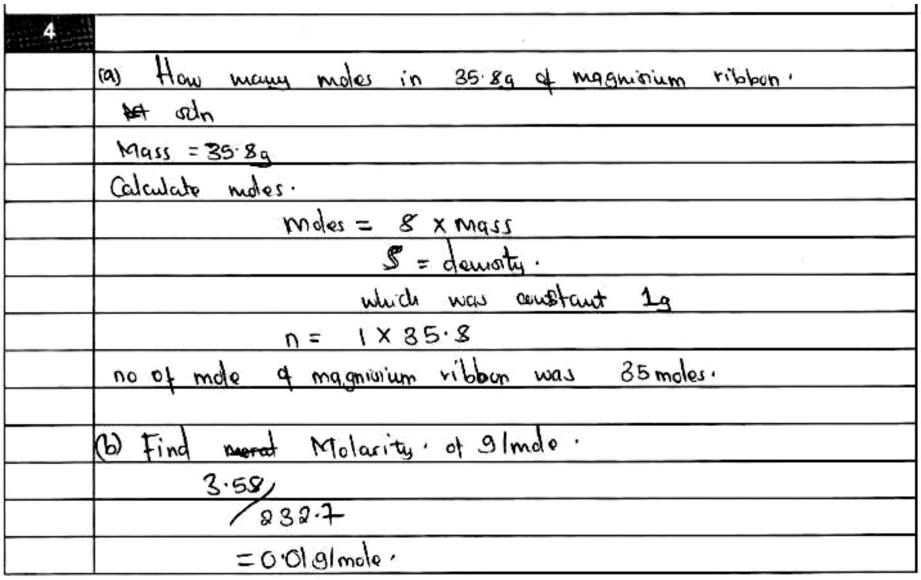
Furthermore, the candidates' responses indicate that 33.6 percent of the candidates who attempted this question had an average level of understanding of the subject matter. They demonstrated insufficient knowledge of numerical skills since they failed to compute the correct sign and units of each question, resulting in the loss of some marks. Some of candidates used the correct formula in both parts (a) and (b) but lacked mathematical skills of manipulating the data effectively.

Contrarily, 152 (17.4%) of the candidates who scored low marks provided incorrect responses to both parts. Their responses indicated that most of the candidates incorrectly wrote the formula for calculating the number of moles in part (a). For instance, one candidate incorrectly wrote: *number of moles = mass x molar mass.* Another candidate proposed that; *number of moles = molarity x concentration.* Other correctly presented the formula for finding the number of moles but failed in mathematical skills in substituting the data. For instance, one candidate wrote formula correct as follows:

Number of mole (n) = $\frac{mass\,(g)}{molar\,mass\left(g/mol\right)} = \frac{24g/mol}{35.8g} = 0.67mol$

The candidate failed in substituting data into the formula; mistakenly, the candidate divided 24g/mol by 35.8g instead of dividing 35.8g by 24 g/moles. Likewise, other candidates wrote that the *number of moles = mass/concentration.* Although this formula is used in volumetric analysis calculations, it is not correct for calculating the number of moles as per the question requirement.

Furthermore, some candidates attempted part (b) incorrectly. These candidates failed to recognize that the mass of zinc granules is the same as mass of zinc metal. For instance, one candidate wrote that *if mass of zinc metal is 65g, then mass of zinc granules is 2 x 65g = 130g.* This misunderstanding was attributed to their inadequate knowledge of the mole concept in volumetric analysis techniques. Extract 4.2 shows an incorrect response from one of the candidates.


4

(a) How many moles in 35·8g of magnesium ribbon.

~~At~~ soln

Mass = 35·8g

Calculate moles.

moles = ρ x mass

ρ = density.

which was constant 1g

n = 1 x 35·8

no of mole of magnesium ribbon was 35 moles.

(b) Find ~~morat~~ Molarity of g/mole.

3·58 / 232·7

= 0·019/mole.

Extract 4.2: A sample of an incorrect response to question 4.

In Extract 4.2, the candidate incorrectly calculated the number of moles of magnesium ribbon using the irrelevant formula that the number of moles = *density x mass,* in part (a). In part (b), the candidate wrote the incorrect formula which resulted in the wrong calculations. The candidate incorrectly calculated the molarity = 3.58/232.7= 0.019 moles.

2.1.5 Question 5: Electrochemistry

The question assessed the candidates' ability on using principle of mechanism of buffer solution to explain what will happen if a small amount of an acid or base is added to the buffer solution. The question asked as follows:

What will happen to a buffer solution made of CH_3COOH and CH_3COONa when the following solutions are added?

(a) *Dilute HCl*

(b) *Dilute NaOH*

The question was attempted by all 872 candidates (100%). Among them, 790 (90.6%) scored from 0 to 1.5 marks; 51 (5.8%) scored from 2.0 to 2.5 marks; and 31 (3.6%) scored from 3.0 to 4.0 marks. Table 3 illustrate the candidates' scores on this question.

Table 3: Candidates Performance on Question 5

S/N	Range of scores	Total no. of candidates	Percentages of Candidates
1.	0.0 - 1.5	790	90.6
2.	2.0 – 2.5	51	5.8
3.	3.0 – 4.0	31	3.6

Table 2 shows that 790 (90.6%) scored from 0.0 to 1.5 marks; of these, 727 (83.4%) scored zero. Hence, their overall performance on this question was weak since only 82 candidates (9.4%) scored from 2.0 to 4.0 marks.

The candidates who scored low marks (0.0 to 1.5) were 90.6 per cent. These gave incorrect responses to both parts (a) and (b). For instance, while attempting part (a), one of the candidates incorrectly suggested that *dilute HCl is added in buffer solution in order to increase the concentration of hydrogen ions hence the solution will be more acidic*. Another candidate incorrectly wrote that the addition of dilute HCl leads to *nucleophilic substitution reaction whereby hydroxyl atoms from acetic acid will be replaced by Cl from dilute HCl to form acyl compound and water* as follows:

$$CH_3COOH + \text{Dil. } HCl \longrightarrow CH_3COCl + H_2O$$

These responses signify that the candidates had insufficient skills in explaining the mechanisms of buffer solution that are taking place in a small addition of HCl. In this case, the candidate did not know that the nucleophilic substitution reaction takes place in organic chemistry but not in electrochemistry. The candidates did not know that the presence of acetic acid and sodium acetate may lead to nucleophilic substitution reactions when dilute HCl is added to the buffer solution.

Likewise, in part (b), the candidates had various misconceptions about the effects of adding dilute NaOH to the buffer solution. One candidate asserted that *when dilute NaOH is added in buffer solution increases the concentration of sodium ion hence solution will be more basic*. Another one wrote that addition of NaOH in the buffer solution *leads to the formation of alcohols and chlorides*. Generally, these candidates failed to describe the effects of addition both dilute HCl and NaOH in the buffer solution. These responses signify that the candidates lacked adequate knowledge about the mechanism of buffer solution as applied in electrochemistry, whereas others failed to understand the requirement of the question. Hence, they provided irrelevant responses as Extract 5.1 shows.

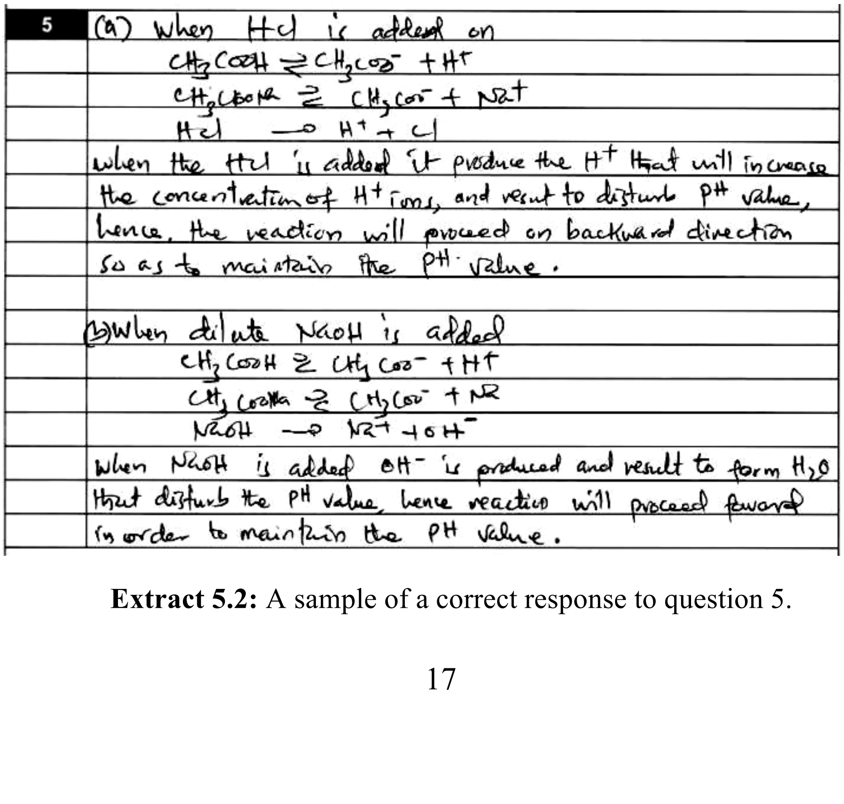
5	(a) $CH_3COOH + HCl \rightarrow CH_3COOCl + H_2O$
	$CH_3COONa + HCl \rightarrow CH_3COO^- + NaCl + H^+$
	In CH_3COOH when added HCl the ~~reaction~~ the product is
	acetyl chloride and water which is high acid than in CH_3COONa
	which produce acetylene, sodium chloride and hydroxyl ion which
	is basic in nature.
	(b) $CH_3COOH + NaOH \rightleftharpoons CH_3COONa^+ + OH^-$
	$CH_3COONa + NaOH \rightleftharpoons 2CH_3COONa + OH^-$
	The concentration of reaction is very high because of
	strong base which used to react in CH_3COOH and CH_3COONa

Extract 5.1: A sample of an incorrect response to question 5.

In Extract 5.1, the candidate provided incorrect response to both parts (a) and (b). For instance, in part (a), the candidate wrongly wrote that the addition of HCl leads to acetyl chloride and water which is higher acid than in CH_3COONa which produce acetylene, sodium chloride and hydroxyl ion which is basic in nature. Similarly, in part (b), the candidate explained the concentration of the reaction to be very high because of strong base, which reacts with CH_3COOH and CH_3COONa, instead of explaining the effects of pH of solution on the addition of dilute NaOH to the buffer solution.

In contrast, 5.8 per cent of the candidates had average performance on this question; they demonstrated insufficient knowledge of the buffer solution. Most of them correctly attempted one part and missed the rest of the question, hence scoring averagely.

However, only 31 (3.6%) of the candidates, who scored high marks from 3.0 to 4.0, correctly described the effects of pH when dilute HCl and dilute NaOH is added to the buffer solution. For instance, in part (a), the candidates correctly described the mechanism involved in the addition of dilute HCl to the buffer solution as one of the candidates wrote: *When small amount of HCl is added to the system it ionizes completely to release H* $^+$ *ion and Cl* $^-$ *ions. The H* $^+$ *ions reacts with the acetate ions (*CH_3COO^-*) until all the added H*$^+$ *ions are finished hence the overall pH of the solution remain unchanged.* Similarly, in part (b), most of the candidates correctly described the mechanism involved upon addition of dilute NaOH to a buffer solution. For example, one of the candidates explained that *upon addition of dilute NaOH to the system, the base ionizes completely to release Na*$^+$ *ions and OH*$^-$ *ions, the added OH*$^-$ *ions will react with the present H*$^+$ *ions and shift the equilibrium to the right by forcing the acetic acid to ionize and release more H*$^+$ *ions that will react until all the added OH*$^-$ *ions are depleted and maintain the previous pH.* Extract 5.2 is an example of a correct response to this question.


5 (a) When HCl is added on
$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$
$CH_3COONa \rightleftharpoons CH_3COO^- + Na^+$
$HCl \rightarrow H^+ + Cl$
when the HCl is added it produce the H^+ that will increase the concentration of H^+ ions, and result to disturb pH value, hence, the reaction will proceed on backward direction so as to maintain the pH value.

(b) When dilute NaOH is added
$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$
$CH_3COONa \rightleftharpoons CH_3COO^- + Na$
$NaOH \rightarrow Na^+ + OH^-$
When NaOH is added OH^- is produced and result to form H_2O that disturb the pH value, hence reaction will proceed foward in order to maintain the pH value.

Extract 5.2: A sample of a correct response to question 5.

In Extract 5.2, the candidate correctly wrote that, when HCl is added it produces the H^+ that will increase the concentration of H^+ ion. Consequently, the reaction will move backwards to maintain the pH value. Similarly, in part (b), the candidates correctly wrote that, when NaOH is added, it produces OH^- ion which result to the formation of water. Hence, the reaction will move forward to maintain the pH value.

2.1.6 Question 6: Transition Metal Chemistry

The question required to evaluate the ability of candidates to examine the IUPAC names of the given complexes and justify the observation of each case. The IUPAC names were as follows:

(a) $[Fe(CN)_6]^{4-}$
Hexacyanoiron(II).

(b) $[Cu(NH_3)_4]SO_4$
Tetraamminecopper(II) sulphate.

(c) $[Cr(H_2O)_4Cl_2]Cl$
Tetraquadichlorochromate(III) chloride.

All 872 candidates (100%) attempted the question. Among them, 478 (54.8%) scored from 0.0 to 1.5 marks, with 255 (29.2%) candidates scoring zero. Further analysis shows that 81 candidates (9.3%) scored from 2.0 to 2.5 marks, and 313 (35.9%) scored from 3.0 to 4.0 marks. Figure 4 summarizes their performance on this question.

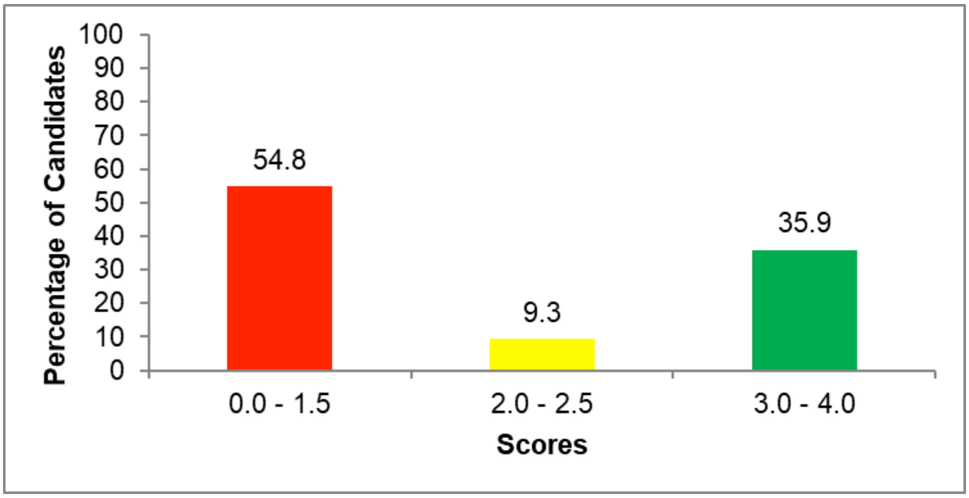


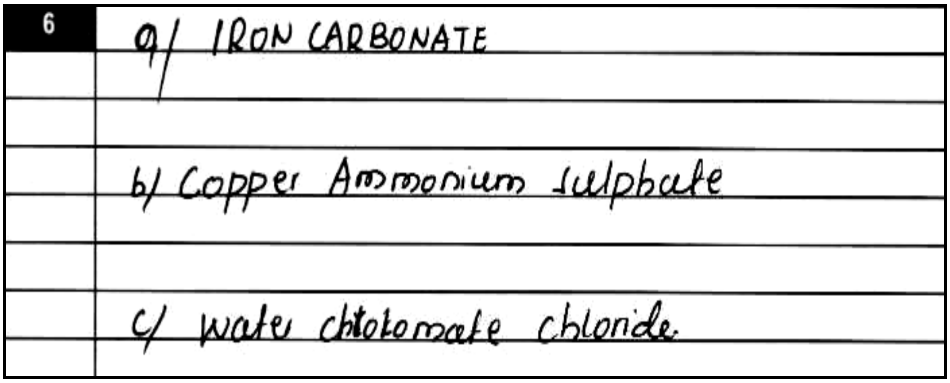
Figure 4: *Candidates' Performance on Question 6*

Figure 4 indicates that their general performance on this question was average since 394 (45.2 %) of the candidates scored from 2.0 to 4.0 marks.

Analysis indicates that those who performed low marks (0.0 - 1.5) lacked adequate knowledge of the rules of naming complex compounds. They failed to justify the observed IUPAC names of the given complex compounds in parts (a) to (c) as the question required. Some of the candidates incorrectly stated the oxidation number present in each complex compound. For example, one candidate wrote that the oxidation number of *Fe is +2* in part (a), *copper has +2* in (b), and *chromium has +1* in part (c). Additionally, other candidates incorrectly wrote the number of ligands in each question. For instance, one candidate incorrectly wrote that there were *six ligands* in part (a), *four ligands* in (b) and *six ligands* in complex compound (c). Their responses indicate that the candidates had inadequate knowledge of using rules in naming complex compounds according to the IUPAC names.

Similarly, some candidates knew how to name complex compounds but failed to meet the requirement of the question. For instance, one candidate wrote that the compound in part (a) *has negative charge ion which located outside the blacket hence it should be named as Hexacyanoiron*(II). Likewise, another candidate indicated that in parts (b) and (c) are *neutral compounds because do not have charged species, sulphate and Chloride are placed outside the blacket* in part (b) and (c), respectively, but all the candidates incorrectly named the complex compounds.

Lastly, some candidates failed to observe rules governing the naming of cationic and anionic complex compounds. They did not know that the names of cationic complex compound should end with *–ate* while anionic complex should end with *–ium*. For instance, one of the candidates' responses to part (a) incorrectly named the given complex compound *(hexacyanoiron(II)ion.* The response indicated that candidate had inadequate knowledge of naming complex compounds. Extract 6.1 shows a sample of an incorrect response from one of the candidates.



6

a/ IRON CARBONATE

b/ Copper Ammonium sulphate

c/ water chlotomate chloride.

Extract 6.1: A sample of an incorrect response to question 6.

In Extract 6.1, the candidate failed to give correct names of ligands in all parts (a) to (c). For instance, the candidates wrote carbonate instead of cyanide in part (a), ammonium instead of ammine in part (b), and water instead of aqua in part (c).

Further analysis shows that 81 (9.3%) of the candidates scored from 2.0 to 2.5 marks. They partially adhered to what the question required them to do. These candidates had partial knowledge of naming complex compounds. For instance, in part (a), one of the candidates wrote *Hexacyanoferrate (III)ion*. This showed that he candidate had knowledge and skills in naming complex compounds but failed to calculate its oxidation numbers.

Moreover, 313 candidates (35.9%) had good performance; they scored from 3.0 to 4.0 marks. These candidates had sufficient knowledge of naming complex compounds. They made correct observation of the given complexes and gave relevant justifications. In part (a), one of the candidates who responded correctly to the question stated that *the named complex compounds violated rules and principle of naming anionic complexes. The naming of anionic complexes was supposed to end with suffix 'ate' hence the correct name is Hexacyanoferrate(II)ion.* In part (b), the candidate realized *that the given name was correct since it observed all rules for naming complex compounds*. Likewise, in part (c), another candidate commented that *the given name of complex compound was not correct since, it violated rules of naming cation complexes that ends with suffix –ium (Tetraaquadichromium(III) chloride*). Extract 6.2 presents another example of a correct response to this question.

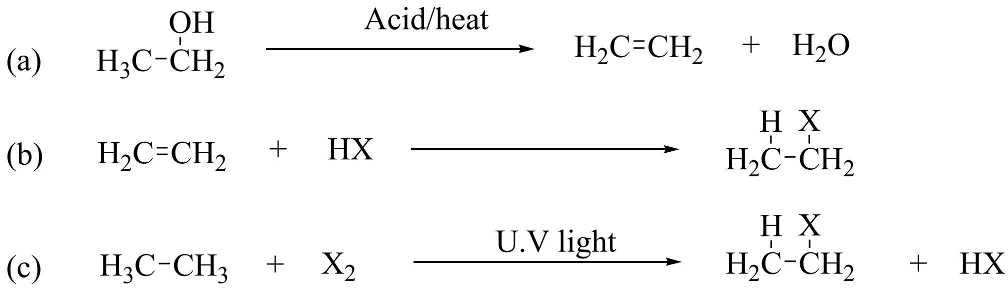
6	a) $[Fe(CN)_6]^{4-}$
	Hexacyanoiron (II) → It is incorrect because for the
	central atom preffixes must end with ate, so the
	correct is Hexacyanoferrate (II) ions
	b) $[Cu(NH_3)_4]SO_4$
	Tetraamminecopper(II) sulphate → It is correct since
	Cations are named first and the anions at last but
	when ~~ion~~ anions are ~~to~~ outside the bracket the name
	are remain as it is.
	(c) $[Cr(H_2O)_4Cl_2]Cl$
	Tetraquadichlorochromate (III) chloride → It is incorrect since
	chromate can be written when chlorine can be act as
	a cation and not anion hence can become as
	Tetraaquadichlorochromium (III) chloride

Extract 6.2: A sample of a correct response to question 6.

In Extract 6.2, the candidate gave the correct observation and justification of the named complex compounds in parts (a) to (c).

2.1.7 Question 7: Organic Chemistry

This question required the candidates to suggest and give reason whether the reaction is free radical substitution, elimination or electrophilic addition. The reactions were as follows:



The question was attempted by all 872 (100%) candidates. Among them, 509 (58.4%) scored from 3.0 to 4.0 marks; 88 (10.1%) scored from 2.0 to 2.5 marks; 275 (31.5%) scored from 0.0 to 1.5 marks, with 131 (15%) scoring zero. The distribution of their scores is summarised in Figure 5.

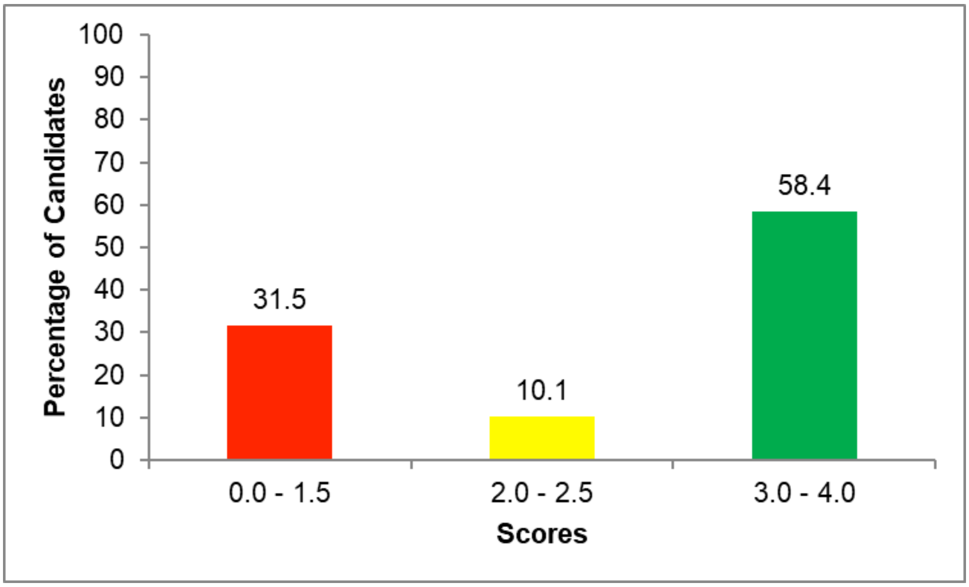
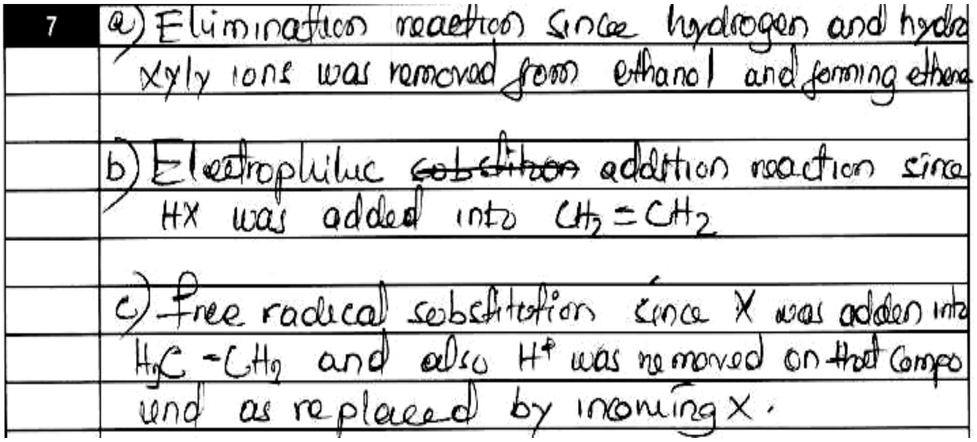


Figure 5: *Candidates' Performance on Question 7*

Figure 5 indicates that the candidates' performance on this question was average since 597 candidates (68.5%) scored from 2 to 4 marks.

A total of 509 (58.4%) candidates scored high marks (3.0 - 4.0). These candidates demonstrated adequate knowledge about all parts of the question. In part (a), one of the candidates wrote *elimination reaction since it involved the loss of water molecule from alcohol to form an alkene*. Similarly, in part (b), another candidate wrote *electrophilic addition reaction since an electrophile (H^+) is added first followed by nucleophile (X^-)*. In part (c), the candidate attempted it correctly by indicating the free radical substitution reaction. For instance, one of the candidates indicated that *the reaction involved free radical substitution reaction because a free X' has replaced H atom from a saturated hydrocarbon (CH_3CH_3)*. These candidates demonstrated adequate mastery of the types of organic reaction as Extract 7.1 illustrates.


7 a) Elimination reaction since hydrogen and hydroxyly ions was removed from ethanol and forming ethene

b) Electrophilic ~~substitution~~ addition reaction since HX was added into $CH_2=CH_2$

c) Free radical substitution since X was added into H_3C-CH_3 and also H^+ was removed on that compound as replaced by incoming X.

Extract 7.1: A sample of a correct response to question 7.

In Extract 7.1, the candidate correctly identified the types of organic reaction in all three parts, (a) to (c).

Furthermore, 88 (10.1%) of the candidates who attempted this question had average performance scoring from 2 to 2.5 marks. They partially recognised the type of organic reactions by providing both relevant and irrelevant responses to all parts from (a) to (c). These varied responses indicate that the candidates had limited knowledge of organic reactions.

However, further analysis shows that 275 candidates (31.5%) performed poorly by scoring 0 to 1.5 marks. These candidates did not know type of organic reactions, and some of them misinterpreted the question. Most candidates gave incorrect answers to all part from (a) to (c). For example, in part (a), one of the candidates wrote: *Electrophilic addition reaction, due to presence of acids or heat condition*. Another candidate wrote: *Free radical substitution reaction due to presence of lone pair in water molecule*. In the other case, another candidate indicates; *it is free radical substitution due to dehydration of water molecules to form alkene, which is nucleophile, and water (neutral molecules*).

Similarly, in part (b), most of the candidates wrote irrelevant responses. This was evidenced by one candidate who wrote: F*ree radical substitution reaction due to tendency of lone pair in oxygen to exist at their own.*

Another candidate incorrectly suggested that the *presence of free radicals give chances for atoms to move free from one point to another combining with alkenes to form alkyl halide compounds.*

In contrast, most of the candidates correctly identified the type of organic reactions and provided appropriate justifications in part (c). For instance, one of the candidates wrote: *Elimination reactions because in this reaction some of atoms are removed without replacement.* Likewise, those who attempted this part wrongly had inadequate knowledge of organic reactions. For instance, one candidate wrote that it is *elimination reaction because of the presence of U.V light that makes atoms or group of atoms to be eliminated*. Furthermore, another candidate wrote that *it is free radical substitution reaction due to the presence of one unpaired orbital in it.* Such responses imply that the candidates had inadequate knowledge of the types of organic reactions. Extract 7.2 supports this observation further.

7

(a) Substitution reaction, Because ethane Substitute its Component atom which is Hydroxly to form alken e and water

(A) Electrophilic addition, Because an electrophile has been added a Nucleophile, an electrophile Such as OH^- has added H^+ to form water.

(b) Substitution reaction → Because a compound at om Such as hydrogen halide has been Substituted to fo Vicinal Compounds Such as Hydrogen atom and Hal ogen

(c) Elimination reaction, Because ethane has el iminate Hydrogen atom to Combine with halogen to form hydrogen halide.

Extract 7.2: A sample of an incorrect response to question 7.

In Extract 7.2, the candidate incorrectly described the types organic reactions, which did not address the demand of the question.

2.1.8 Question 8: Analysis of O-level Chemistry Curriculum Materials

In this question, the candidates were required to suggest six components that are essentials to design Chemistry teacher's guide for Form II secondary school. All the 872 candidates (100%) attempted the question. Among them, 268 (30.7%) scored from 0 to 1.5 marks; 148 (17%) scored from 2.0 to 2.5 marks; and 456 (52.3%) candidates scored from 3.0 to 4.0 marks, as Figure 6 indicates.

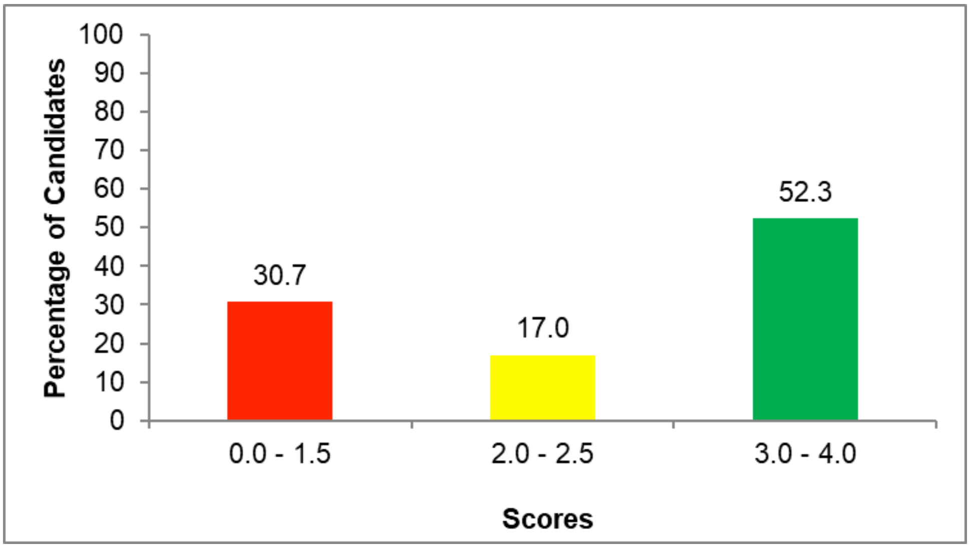
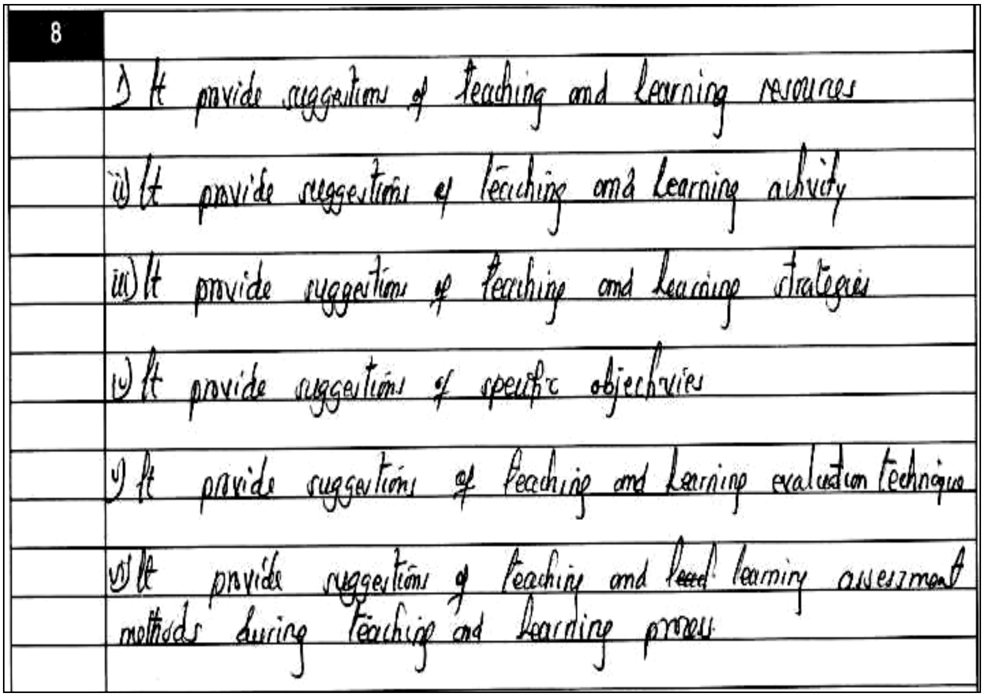


Figure 6: *Candidates' Performance on Question 8*

Their overall performance on this question was good since 604 (69.3%) of the candidates scored 2.0 marks or above.

Figure 6 shows that 456 (52.3%) of the candidates scored highly from 3.0 to 4.0 marks because they were knowledgeable about O-level Chemistry curriculum materials. Thus, they met the requirement of the question. Most of these candidates correctly indicated the required components of the teacher's guide. For example, one candidate wrote: (i) *Suggestion of learning objectives, (ii) Teaching and learning resources, (iii) Teaching and learning activities, (iv) Teaching methodologies, strategies and techniques, (v) Teaching and learning aids, and (vi)* Pr*actical and learners' activities.* These candidates had adequate knowledge of the O-level

Chemistry curriculum materials. Extract 8.1 shows an example of a correct response from one of the candidates.


8

i) It provide suggestions of teaching and learning resources

ii) It provide suggestions of teaching and learning activity

iii) It provide suggestions of teaching and learning strategies

iv) It provide suggestions of specific objectives

v) It provide suggestions of teaching and learning evaluation technique

vi) It provide suggestions of teaching and ~~lead~~ learning assessment methods during teaching and learning process

Extract 8.1: A sample of a correct response to question 8.

In Extract 8.1, the candidate provided the correct responses in part (i) to (iv), with the exception of parts (v) and (vi) whose responses were unclear.

Further analysis shows that 148 (17%) of the candidates scored marks, ranging from 2.0 to 2.5 marks. Their average performance was attributed to their partial knowledge of analysis of O-level chemistry curriculum materials. Hence, the candidates wrote both correct and incorrect responses scoring average marks.

In contrast, the candidates whose performance on this question was poor provided answers that did not address the requirements of the question. For instance, one candidate wrote the characteristics of teaching aids, such as the *quality of the guide, accessibility, portability, nature of the learners and durability*. This candidate wrongly considered the teacher's guide similar to teaching aids. While another candidate indicated *topic, sub topic, publisher, year of publication, name of the author,* and *place of publication*. These responses indicate a confusion between the components of the teacher's guide and features to consider when writing references.

Likewise, some candidates listed factors for curriculum development rather than a teacher's guide. For instance, one of the candidates wrote:

Philosophy of the country, political ideology, nature of subject matter, curriculum of the country and *needs of the society*. Furthermore, other candidates confused curriculum materials with teaching materials when describing the components of teacher's guide. For instance, one candidate listed: *Syllabus, teacher's manual, textbook, scheme of work, lesson plan and lesson notes*. The first three items are examples of curriculum materials, whereas the last three are teaching and learning materials. This misconception arises from viewing the teacher's guide as a type of curriculum materials. Further analysis shows that some candidates indicated preliminary information of the book rather than the teachers' guide components. For instance, one candidate wrote: *Cover page, name of the guide, author, title of the guide, table of content, and organization of chapters*. Another candidate wrote; *teachers guide is used by teachers alone while teacher's manual is used by both teachers and students*. Although the candidates gave correct statements on the differences between the teacher's guide and teacher's manual they were contrary to the requirements of the question. Generally, candidates lacked adequate knowledge of the O-level Chemistry Curriculum Materials. Thus. They failed to address the requirements of the question. Extract 8.2 exemplifies this observation further.

8	The following are the essential for the guide.
	i) should be relevance to the user
	ii) should be simplicity
	iii) should be clarity
	iv) should be efficient
	v) should be valid
	vi) should be reliable.

Extract 8.2: A sample of an incorrect response to question 8.

In Extract 8.2, the candidate incorrectly outlined *simplicity, clarity, valid,* and *reliable,* which are characteristics of a good test. Other two points *relevant to the user* and *efficient* did not relate to the essential features of the teacher's guide.

2.1.9 Question 9: Planning and Preparation for Teaching

The question required to assess the ability of candidates to explain significance of ICT in the teaching of Chemistry. The question were as follows;

The introduction of ICT has brought the development in different areas, especially the educational sector. Briefly explain any four significance of ICT in the teaching of Chemistry.

The question was attempted by all 872 (100%) candidates. Among them, 768 (88%) scored from 3.0 to 4.0 marks; 72 (8.3%) scored from 2.0 to 2.5 marks; and 32 (3.7%) scored from 0 to 1.5 marks. Their performance on this question is summarised in Figure 7.

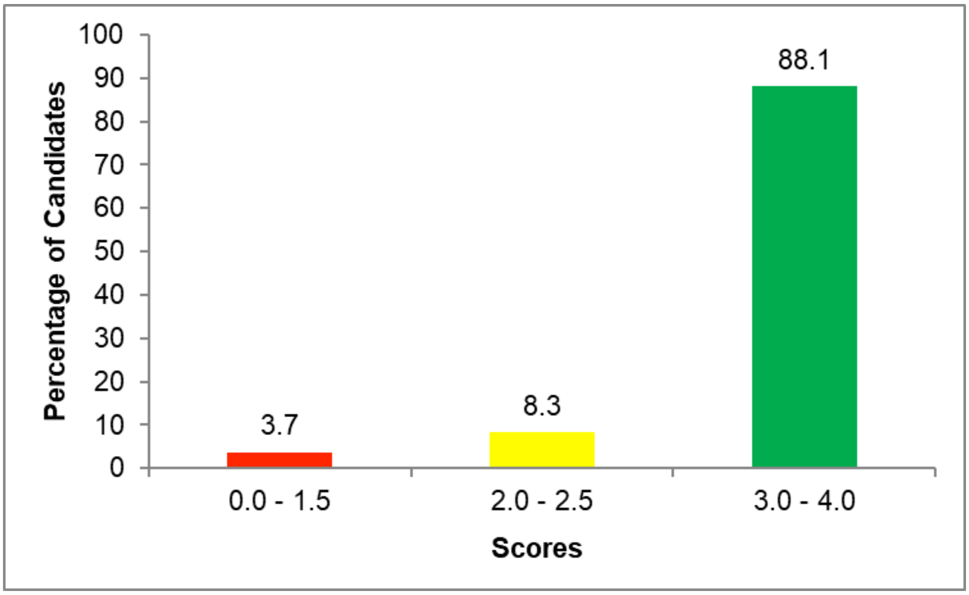


Figure 7: *Candidates' Performance on Question 9*

Figure 7 indicates that the candidates' general performance on this question was good as 840 (96.3%) scored 2.0 marks or above. Among these, 607 (69.6%) scored full marks. Only 32 (3.7%) of the candidates failed by scoring from 0 to 1.5 marks.

A total of 768 candidates (88%) scored high marks on this question. These candidates demonstrated adequate mastery of planning and preparation for teaching. They correctly highlighted the significance of ICT in teaching of Chemistry. For instance, one of the candidates stated: *(a) ICT increases the level of understanding of the lesson (b) it also increases students' interest* *towards the lesson (c) it reduces verbal words to the teachers and (d) it also increases independent study.* Such responses indicate their adequate knowledge about the application of Information and Communications Technology (ICT) in teaching and learning Chemistry as Extract 9.1 illustrates.

9 Significance of ICT

(i). It simplify teaching and learning process Forexample the use of simulation programms Computer aided programs such as drill which simplify teaching and learning process.

(ii). It facilitate distance learning example teleconferencing through the use of internet

(iii). It solve the scarcity of teacher, This is due to the use of ICT programs such as tutorial programs.

(iv). It save time; Forexample the use of Computer during teaching and learning it save time of [illegible]

Extract 9.1: A sample of a correct response to question 9.

In Extract 9.1, the candidates correctly wrote it simplify teaching and learning, facilitates distance learning, and saves time. The candidate provided the relevant point example the use of a projector by one teacher to teach large group of students that would require several streams with many teachers.

Further analysis indicates that those candidates with average scores provided partially correct answers. Some candidates wrote both relevant and irrelevant points on significance of ICT in teaching Chemistry. For instance, one candidate wrote that *ICT is used to simplify understand of abstract concepts by the use of animation and simulations, motivates teaching and learning to both teachers and students, it important in employment and promote entertainment*. The first two points were correctly stated while the last two points were incorrect. The responses given showed that the candidates possess some ICT skills however, failed to understand the requirement of the question.

However, 32 candidates (3.7%) had poor performance on the question. Their scores ranged from 0 to 1.5 marks. Among them, 07 (0.8%) scored zero. These candidates lacked relevant skills in using ICT in teaching and learning Chemistry. Some of the candidates misunderstood the question focusing on listing ICT devices rather than explaining the significance of ICT for teaching and learning Chemistry. For instance, one candidate mentioned: *(i) computer, (ii) projectors, (iii) pointer, (iv) projector screen.* Although the candidate knew which ICT devices are used in teaching and learning, their responses did not address the requirement of the question.

Others incorrectly outlined various fields/subjects/sectors where ICT could be applied. Examples include: *(i) in mathematical sectors, (ii) in medical field (iii) physics subjects and (iv) industrial sectors*. Such responses indicate a lack of proper understanding of the question's requirement as Extract 9.2 shows it further.

9 (i) it helps for employment
- Due to that from ICT, information and communication technology people ca apply salary so as to get employment

(ii) It helps for facilitation of business sectors

(iii) It used for improvement of infrastructure due to road, railway

(iv) It help for military sectors
Due to giving information from one to another.

(v) It brings and promote cooperation and entertainment to the people.

Extract 9.2: A sample of an incorrect response to question 9.

In Extract 9.2, the candidate incorrectly outlined the application of ICT in other domains like employment, business, military and entertainment.

2.1.10 Question 10: Assessment Procedures in Chemistry

This question was intended to evaluate the candidates' ability in using results from the Chemistry test to calculate the spread for each of the test scores. The question asked as follows:

Suppose you have administered Chemistry tests among Form II and III students and the results were as follows:
Form II: 65, 67, 95, 41, 25, 55, 41, 71, 41 and 51.
Form III: 77, 67, 66, 71, 68, 72, 69, 75, 61 and 76.

a) Calculate the spread for each of the test scores.
b) What do the two spread values in 10 (a) mean?

Since the question was compulsory, all the 872 (100%) candidates attempted it. Of whom, 822 (94.3%) scored from 0 to 1.5 marks; 31 (3.6%) scored from 2.0 to 2.5 marks; and 19 (2.2%) scored from 3.0 to 4.0 marks. Only 15 candidates (1.7%) scored full marks. The distribution of their scores is shown in Figure 8.

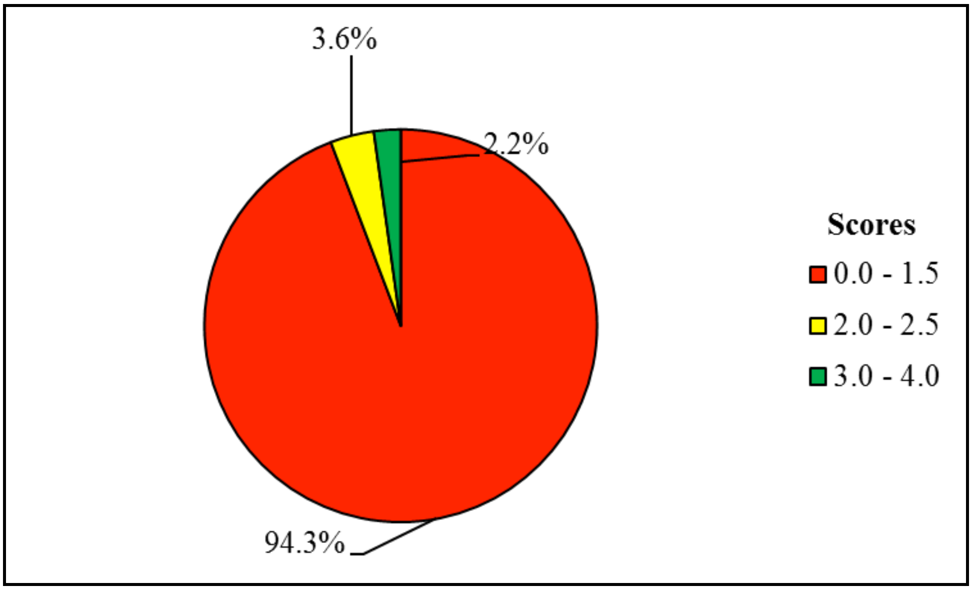


Figure 8: *Candidates' Performance on Question 10*

Figure 8 shows that the candidates' performance on this question was weak since 822 (94.3%) scored from 0 to 1.5 marks, with 810 (92.9%) score zero.

Analysis indicates that 94.3 per cent of them incorrectly responded to the question. These candidates failed to calculate the spread of each test scores in part (a). Their failure was attributed to their misconception of the key word used *spread* in both parts (a) and (b). The candidates interpreted *spread* as mean scores. Thus, they incorrectly calculated the mean score of the test rather than *spread*. One of the candidates responded as follows;

In Form II, Mean $= \dfrac{65 + 67 + 95 + 41 + 25 + 55 + 41 + 71 + 41 + 51}{10}$

$= \quad 55.2$

Therefore, the required mean score is 55.2 marks.

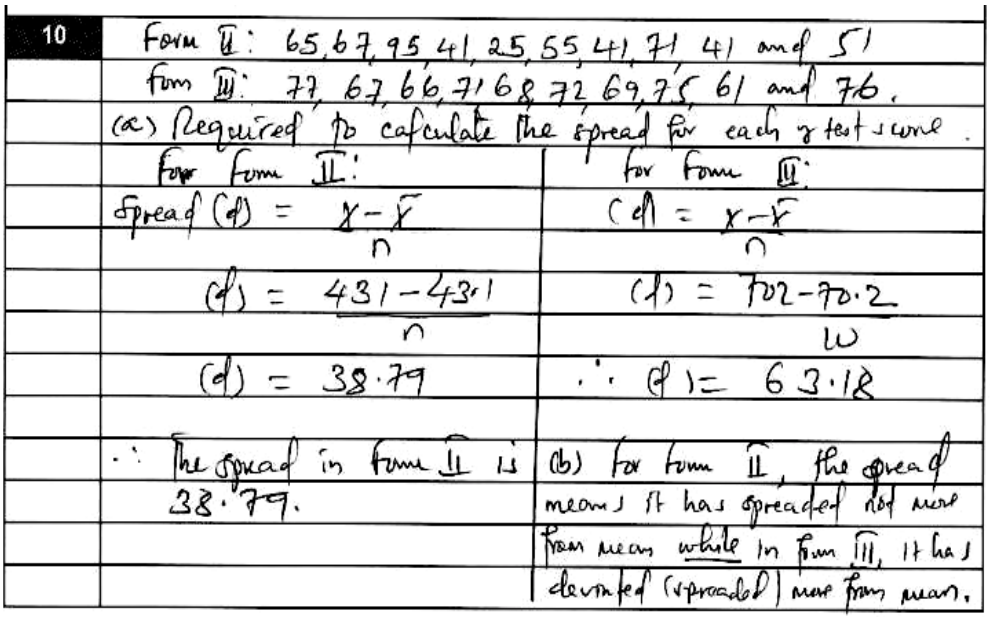
Similarly, in Form III

Mean $= \dfrac{77 + 67 + 66 + 71 + 68 + 72 + 69 + 75 + 61 + 76}{10}$

$= \quad 69.9$

Therefore, the mean score is 69.9 marks.

Additionally, other candidates skipped the question. This signify lack of knowledge on assessment procedures in Chemistry. However, others correctly calculated the spread of test scores in Form II and III in part (a). This was done by calculating the difference between the highest scores and the lowest scores. However, the same candidate missed the marks allotted to part (b), because of failure to interpret the two spread values obtained in part (a); hence, the candidate did not score the full marks. Extract 10.1 illustrates such an incorrect response to this question.



10 Form II: 65, 67, 95, 41, 25, 55, 41, 71, 41 and 51
Form III: 77, 67, 66, 71, 68, 72, 69, 75, 61 and 76.
(a) Required to calculate the spread for each of test score.

For form II:	for form III:
Spread (d) = X − X̄ / n	(d) = X − X̄ / n
(d) = 431 − 43.1 / n	(d) = 702 − 70.2 / 10
(d) = 38.79	∴ d) = 63.18
∴ The spread in form II is 38.79.	(b) For form II, the spread means it has spreaded not more from mean while in form III, it has deviated (spreaded) more from mean.

Extract 10.1: A sample of an incorrect response to question 10.

In Extract 10.1, the candidate incorrectly calculated the mean scores instead of spread from the given Forms II and III data in part (a). In part (b), the candidate incorrectly commented that for Form II the spread means it has spread not more from mean values while in Form III it has diverted more from the mean.

However, 31 (3.6%) of the candidates scored averagely on this question. Some of them lacked mathematical skills; hence, they failed to calculate the spread of the students' scores. Others correctly calculated the spread but failed to interpret the values obtained.

Conversely, 19 candidates (2.2%) demonstrated good performance on this question. They provided correct responses to both parts (a) and (b) of the question. This indicated that they knew how to standardise test scores. For instance, one of the candidates correctly calculated the spread scores for each of the test scores in Form II and III to *get 70 and 16 respectively* in part (a). This was done by calculating the differences between the highest and lowest scores. Similarly, in part (b), the candidates correctly interpreted the spread values obtained in part (a). In Form II, there were noticeable differences in the students' score value spread of 70. This value implies that there were both students with higher abilities and students with lower abilities. In contrast, there were margin differences in students' scores range value of 16 in Form III. This implies that the students' abilities in this class were relatively similar. Extract 10.2 presents a sample of a correct response from one of the candidates.

10	(a)
	Spead for Form II = high score − Low scores
	= 95 − 25
	= 70
	The spread for Form II = 70
	form III = 77 − 61
	= 16
	The spread for form III is 16
	(b) The spread for form II mean that in the class there
	are learner of different ability; lower achiever and higher
	achiever but for form III; there are learner of equal or
	the same learning ability or achievement.

Extract 10.2: A sample of a correct response to question 10.

In Extract 10.2, the candidate gave relevant responses to both parts (a) and (b).

2.1.11 Question 11: Environmental Chemistry

This question was intended to test the candidates' ability to overcome problems caused by water pollution. The question asked as follows:

Bondeni Village is facing a serious water pollution problem in its water sources. Suggest six ways to overcome the problem.

The question was attempted by all 872 (100%) candidates. Among them, 736 (84.4%) scored from 10.5 to 15.0 marks, with 100 (11.5%) scoring full marks; 130 (14.9%) scored from 6.0 to 10.0 marks; and 06 (0.7%) scored from 0.5 to 5.5 marks. Table 4 summarises their performance on this question.

Table 4: Candidates Performance on Question 11

S/N	Range of scores	Total no. of candidates	Percentages of Candidates
1.	0.0 - 5.5	06	0.7
2.	6.0 – 10.0	130	14.9
3.	10.5 – 15.0	736	84.4

Table 4 indicates that the overall performance on this question was good since 866 (99.3%) of the candidates scored average or above, whereas 06 candidates (0.7%) failed by scoring from 0 to 5.5 marks.

Furthermore, the analysis shows that 736 (84.4%) of the candidates scored high marks on this question. These candidates comprehended the question and provided relevant responses about the measures for controlling water pollution. For instance, one candidate correctly explained six control measures as follows: (i) *People should avoid discharge sewage wastes from domestic to the water bodies,* (ii) *People should find alternative ways for wastes disposal*, (iii) *Proper use of industrial fertilizer*, (iv) *Continuous environmental education to the people*, (v) *Enactment of by-laws* (vi) *reducing deforestation around the water sources*. These responses reflect sufficient knowledge of environmental degradation and water pollution. Extract 11.1 shows a sample of a correct response from one of the candidates.

11

Water pollution is the addition of unwanted materials in sources of water such as lake, river, ocean as well as dams. Unwanted materials which ~~a~~ have lead to the water pollution as follow chemicals from industry, silt, as well as plastic materials. Bondeni Village can use the following ways in order to overcome the problem of water pollution:

Proper methods of farming near to the source of water. Good methods of farming near to the sources of water its very important because poor methods of farming like shifting cultivation can increase the existance of water pollution to the water.

Preventing the industrial chemicals releasing to the source of water. Industrial activities such as mining activities can ~~en~~ involves high amount of chemical released so that the chemicals releasing should be proper handling to prevent water pollution.

Preventing overgrazing near to the sources of waters. Overgrazing can increase amount of silt and impurity substance in water sources hence to prevent excess amount of cattles can reducing water pollution.

Proper methods of fishing. Bondeni Village should required to use proper methods of ~~sh~~ fishing and to avoid poor method of fishing like the use of bomb during fishing activities.

Avoiding cutting of plants or trees near the source of water. Bondeni ~~sta~~ village should required to avoiding the cutting of trees or plants near the sources of water because the existance of plants ~~and~~ or trees can preventing water from impurity and make water safe for ~~use~~ useful activities.

11 Cont.

Encouraging education of environmental conservation based on sources of water, Bonderi Village can overcome the problems of water pollution when each people or member within the village can be aware about environmental conservation in water sources which can help to avoiding the problems of water pollution.

Finally water pollution have different negative impact to the environment among of these are loss of acquatic organisms like fish, Also spread of diseases such as cholera. Hence the government should support and provide policy about "environmental conservation".

Extract 11.1: A sample of a correct response to question 11.

In Extract 11.1, candidates correctly described control measures for water pollution as per the requirement of the question.

Further analysis reveals that 130 (14.9%) of the candidates scored averagely from 6 to 10 marks. These candidates' responses were partially correct. They either gave less than the required points or mixed correct and incorrect points with irrelevant descriptions.

Conversely, 06 (0.7%) of the candidates demonstrated inadequate knowledge of water pollution; therefore, they scored from 0 to 5.5 marks. These scores were attributed by insufficient (few) points as required by the question. The majority of the candidates incorrectly explained the control measures to overcome the water pollution problem. For example, one candidate incorrectly wrote: *Water pollution could be overcomed by treating water bodies with detergents and water guard*. Similarly, another candidate wrote: *Irrigation activities should be stopped* as incorrect answer. The candidates intended to suggest poor irrigation schemes that pollute water. Besides, a few candidates confused water with land pollution. For instance, one candidate erroneously suggested the *use of incineration methods in order to control water pollution*. However, incineration is used for burning of harmful solid materials. All these responses revealed that the candidates had insufficient knowledge of environmental degradation and their control measures. An example of an incorrect response is shown in Extract 11.2.

11 Cont.	
	Avoid people in bad use of water;
	Due to this we can see in order to stop
	water pollution we should avoid people who
	are using water in bad situation like
	throwing dust, swimming due to this can
	cause pollutant in water so we should avoid it.
	Government support in putting
	Security in some areas' Due to this we
	can prevent the water pollution due to the
	presence of securities can help to scared the
	people in dirtify the water.
	Avoid soil erosion' Due to this,
	we can see that the presence of soil erosion
	can lead in water pollution in our environment
	so we should ~~prope~~ prevent it for the better
	Use in other day in our society,

11 Cont.	
	To make own place for the
	people who practice with agriculture
	due to this point so as to avoid the
	pollution of water.
	To make own source of water
	to the people how engaging with construction
	due to this point for the people how
	practice in construction of houses can
	also have their own water source
	so as to avoid water pollution
	Generally water pollution is
	common in the village place so
	I advice all the people from the
	village to be aware with that who to
	keep water clean,

Extract 11.2: A sample of an incorrect response to question 11.

In Extract 11.2, the candidate described incorrect points, contrary to the requirement of the question. This that candidate lacked sufficient knowledge about environmental chemistry.

2.1.12 Question 12: Organic chemistry

The question required the candidates' ability of using knowledge obtained from organic chemistry to demonstrate types of isomers exhibited by alkenes and draw structure and IUPAC names from dehydration of alkenes. The question asked as follows:

(a) Explain the phenomenon of isomerism.

(b) Outline the two types of isomers exhibited by alkenes by citing one example in each.

(c) Draw and give the IUPAC names of alkenes that will be obtained from the dehydration of the following compounds:

(i) 2 – methylpentan-3-ol

(ii) Propan – 2 – ol

(iii) 3-methylbutan – 2 – ol

(iv) 4,5 – dimethylhexan – 3 – ol

This question was compulsory, and all 872 candidates attempted it. Among them, 596 (68.3%) scored from 0 to 5.5 marks; with 220 (25.2%) scoring zero; 216 (24.8%) scored from 6.0 to 10 marks; and 60 candidates (6.9%) scored from 10.5 to 15 marks. Their performance on this question is summarised in Figure 9.

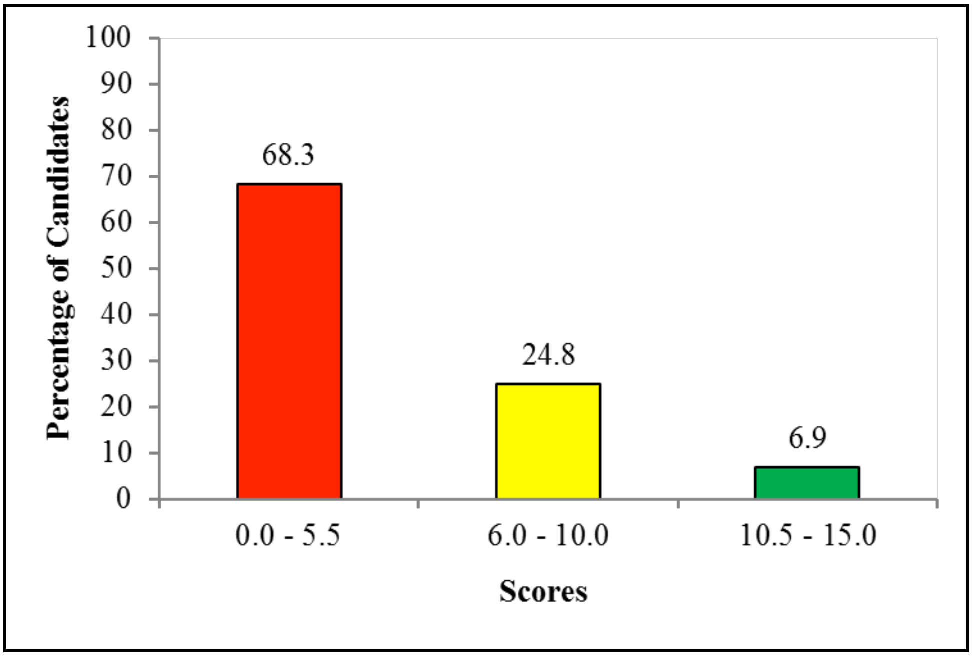


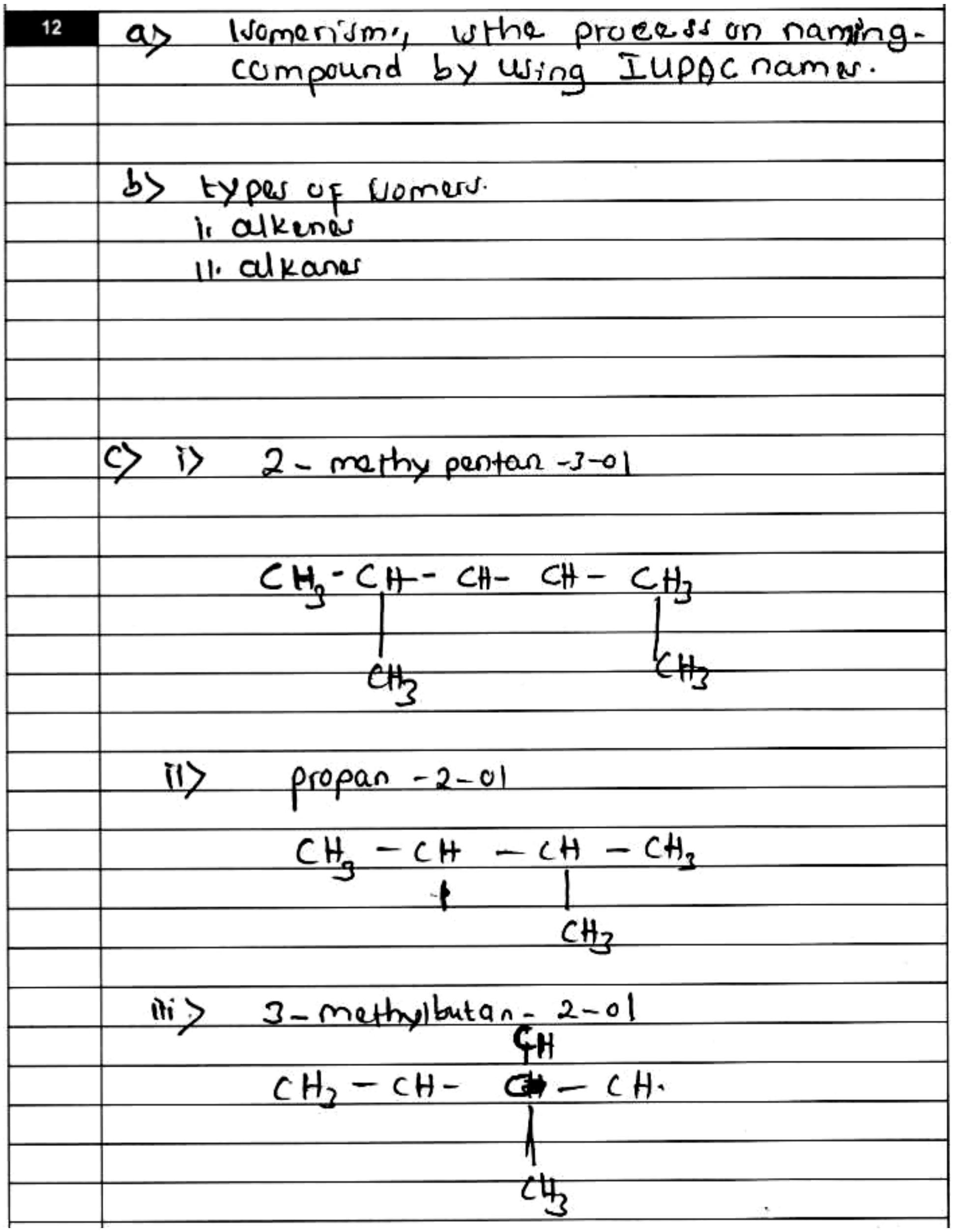
Figure 9: *Candidates' Performance on Question 12*

Figure 9 indicates that the candidates' overall performance on this question was weak since only 31.7 per cent of them scored 6 marks or above.

Their performances indicate that 596 (68.3%) of them scored from 0 to 5.5 marks. The candidates explained the concept of isomerism incorrectly. They confused the key term '*isomerism'* with '*isomers'* in part (a). Most of them incorrectly defined isomers instead of isomerism. For instance, one candidate defined isomerism as *organic compounds of the same molecular formula but different in structural formula.* In addition, another candidate wrote: *The process of shifting of position of arrows in a compound*. Some of these candidates defined isomerism as *the breaking down of the compound to obtain other compound by changing of the substituent group*. The candidates' responses indicated that they had limited knowledge of isomerism of hydrocarbons. Thus, they failed to explain it as used in hydrocarbons.

In part (b), most of the candidates gave irrelevant responses about two types of alkene exhibited by alkenes compounds. For example, one candidate incorrectly mentioned *unsaturated alkane and saturated alkene*. This response reflects their inadequate knowledge of the concept of unsaturated alkane and saturated alkene. Another candidate wrote *multiple bond* and *pi-bond*. These two terms used interchangeably, meaning the organic compound containing more than one bond. A few others also indicated sub-classes of alkenes exhibited in geometrical isomerism. For example, one of the candidate wrote *cis- and trans alkenes*. Their responses focused on one out of the two types of isomers exhibited by alkenes. Therefore, they partially attempted the question because they focused on only one aspect.

Additionally, in part (c), candidates incorrectly wrote the IUPAC names of alcohol compounds instead of naming the structures of alkenes obtained due to alcoholic dehydration. For instance, one candidate copied the given names of organic compounds in items (i) to (iv) and wrongly wrote (i) *2-methylpentan-3-ol* and (ii) *propa-2-ol*. Others converted alcohols to alkenes but provided incorrect structures and IUPAC names of the alkene compound formed. For instance, one candidate named: (i) *3-methylbut-3-ene* (ii) *Prop-2-ene* (iii) *3-methylbut-2-ene*. All these responses revealed the candidates' insufficient knowledge of organic chemistry. Extract 12.1 shows a sample of an incorrect response to this question.


12 a> Isomerism, is the process on naming compound by using IUPAC names.

b> types of isomers.
i. alkenes
ii. alkanes

c> i> 2 - methy pentan -3-01

$CH_3 - CH(CH_3) - CH - CH - CH_3$ (with CH_3 below the last CH)

ii> propan -2-01

$CH_3 - CH - CH(CH_3) - CH_3$

iii> 3 - methylbutan - 2-01

$CH_2 - CH - C(OH)(CH_3) - CH.$

Extract 12.1: A sample of an incorrect response to question 12.

In Extract 12.1, the candidate gave an incorrect definition of isomerism in part (a). In addition, they candidate failed to state the types of isomers in alkene in part (b); instead, the candidate mentioned the groups of hydrocarbons, alkane and alkenes. Furthermore, the candidate failed to present the structural formula of alkene and draw the incorrect structures in part (c).

Besides, the candidates who scored average marks on this question had limited knowledge of organic chemistry. Most of them correctly attempted part (a) but failed in parts (b) and (c). Others provided both relevant and irrelevant responses to parts (a), (b) and (c); hence, they missed some marks and scored averagely.

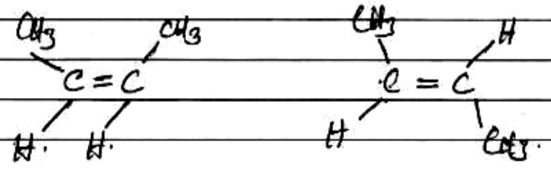
Conversely, 60 candidates (6.6%) scored high marks. These correctly responded to all or some parts of the question. Their correct responses stemmed from their good mastery of organic chemistry. For example, one candidate correctly defined isomerism as the *existence of same compounds in different structural formula* in part (a) and mentioned *positional isomerism which is characterized by differing in position of the double bond in part (b),* such as, but-2-ene and but-1-ene. The second was *geometrical isomerism where restricts on rotation of the molecules as a results of attached molecules experiences different orientations including cis- and trans-isomerism* for instance, *cis-but-2-ene* and *trans –but-2-ene*. Similarly, in part (c) the candidates gave correct IUPAC names to compounds (i) to (iv). For instance, one candidate named the given compounds as follows: *(i) 2-methylpent-2-ene, (ii) Prop-1-ene, (iii) 2-methylbut-2-ene* and *(iv) 2,3-dimethylhex-3-ene.* Generally, these relevant responses indicated the candidates' adequate knowledge of organic chemistry. Extract 12.2 is a sample of a correct response from one of the candidates.

12

(a) Isomerism refers to the process of forming a Compounds that have the same molecular masses but differs in chemical reaction and arrangement of atoms. Example $CH_3-CH_2-CH_2-CH_3$ (Butane) also Can be $CH_3-CH(CH_3)-CH_3$.

(2-methylpropane)

(b) (i) geometrical isomerism.



Cis isomer Trans isomer

(ii) Positional isomerism.

$CH_3CH_2CH=CHCH_3$ $CH_2=CHCH_2CH_2CH_3$

pent-2-ene pentene.

(c) (i) 2-methylpentan-3-ol.

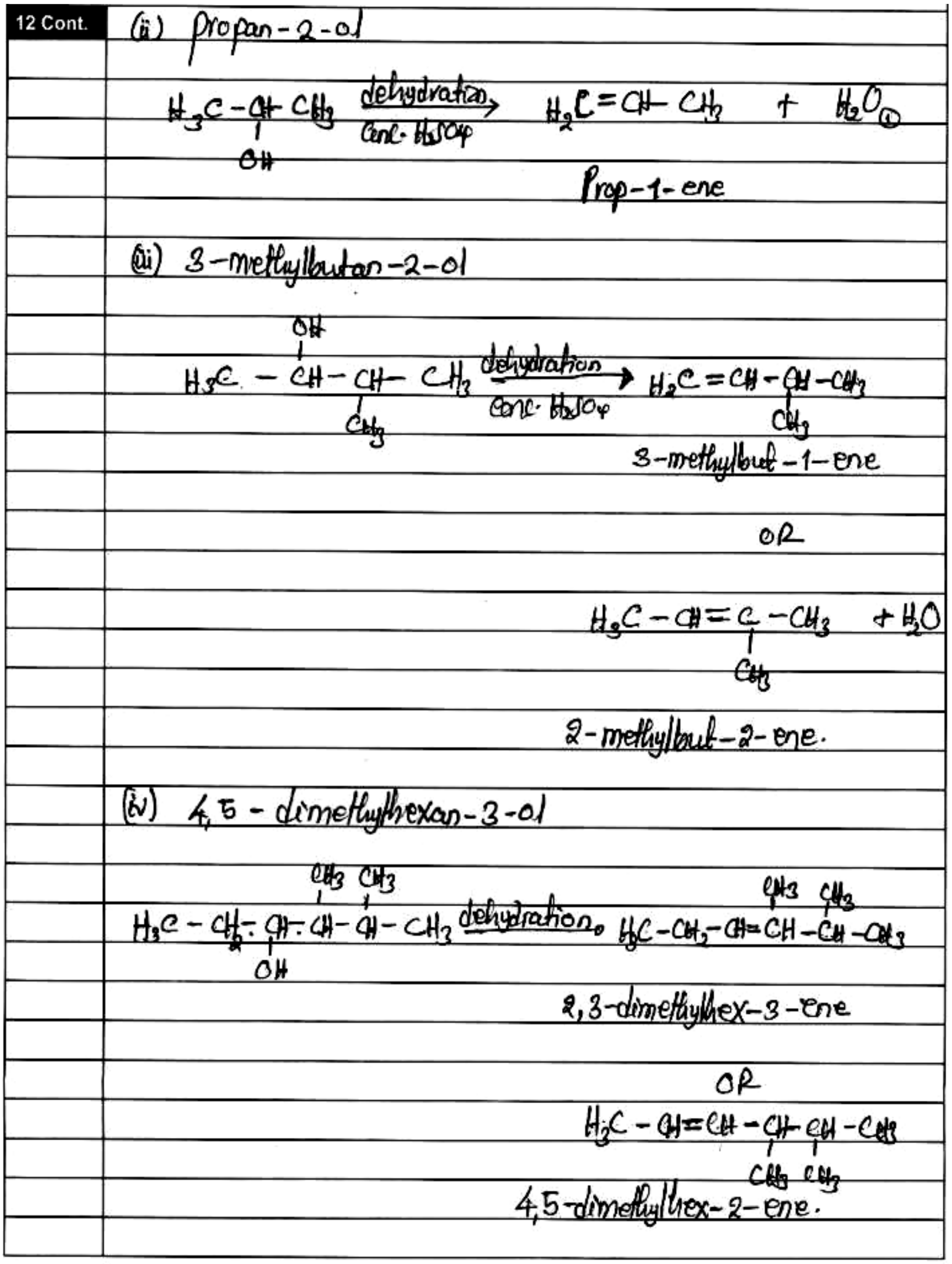
$H_3C-CH(CH_3)-CH(OH)-CH_2CH_3 \xrightarrow[\text{Conc. } H_2SO_4]{\text{dehydrating}} H_3C-C(CH_3)=CH-CH_2CH_3 + H_2O$

2-methylpent-2-ene

or

$H_3C-CH(CH_3)-CH=CH_2CH_3 + H_2O$

4-methylpent-2-ene



Extract 12.2: A sample of a correct response to question 12.

In Extract 12.2, the candidate correctly presented the answer in parts (b) and (c). However, the candidate used the term ‘process’ instead of ‘existence’ in defining isomerism. Therefore, the response to part (a) cannot be considered the best definition of isomerism.

2.1.13 Question 13: Environmental Chemistry

This question had two parts (a) and (b), in part (a), the question tested candidates' ability to justify the statement that advancement in chemistry resulted into more negative impacts on the environment. And in part (b), the candidate required to identify six teaching and learning materials. All 872 (100%) candidates attempted the question. The data in Figure 10 shows that 39 (4.5%) of the candidates scored from 10.5 to 15.0 marks; 661 (75.8%) scored from 6.0 to 10.0 marks; and 172 (19.7%) scored from 0.0 to 5.5 marks.

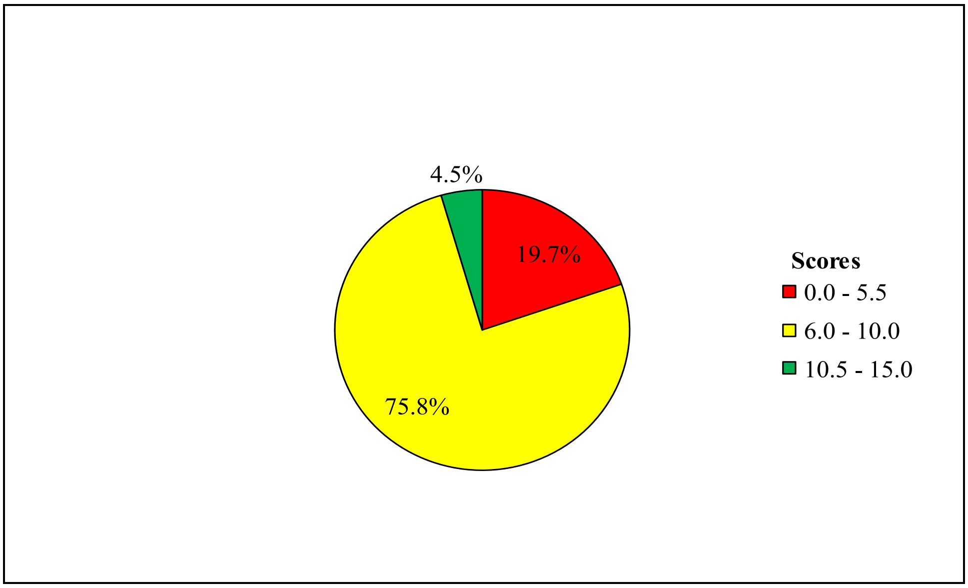


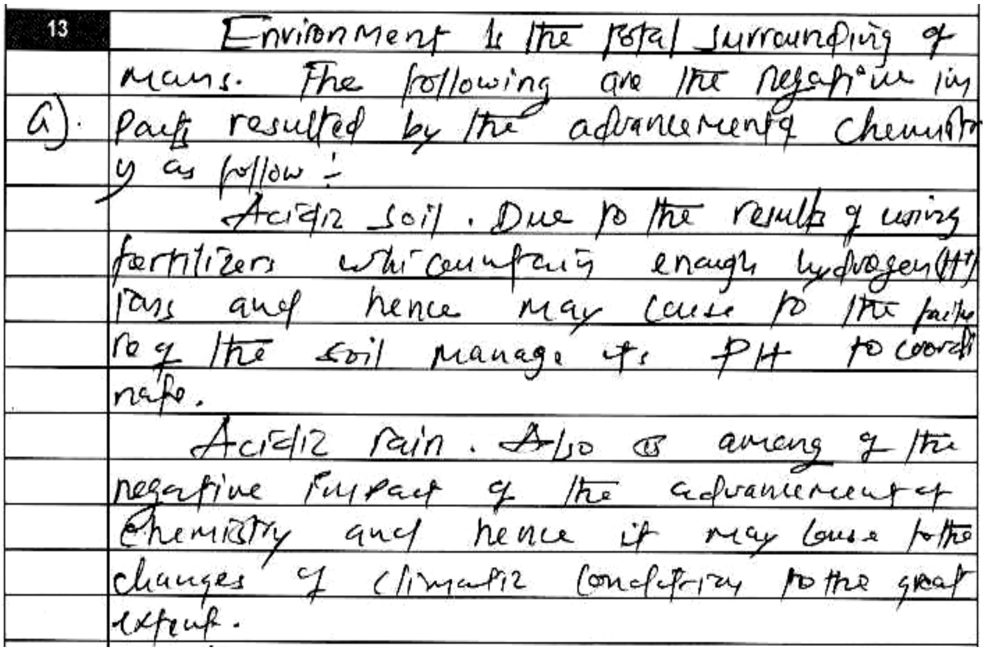
Figure 10: *Candidates' Performance on Question 13*

Analysis shows that their overall performance on this question was good because 80.3 per cent of all the candidates who attempted this question scored average or good marks.

The analysis of their responses indicates that 4.5 per cent of those who scored from 10.5 to 15.0 marks demonstrated a good mastery of environmental chemistry in parts (a). In this part, the candidates correctly identified harmful chemical substances (pollutants) introduced into the environment due to the advancement of chemistry. Most of them correctly indicated several impacts of the advancement of Chemistry on the environment. For example, one candidate described *manufacture and use of pesticides, fertilizers and herbicides pollutes the environment; manufacture of chemicals such as mercury and cyanides affect the environment;*

exploration of fossil fuels which are used in engines for automobiles release gases such as CO and CO_2; the use nuclear energies has exposed the world into exposure of harmful rays and radioactive remains, and *manufacture and use of chlorofluorocarbons (CFCs) in the air conditions and refrigerators release gases that are harmful to the ozone and contributes to greenhouse effects*. These responses portrayed their good mastery of environment chemistry.

Likewise, in part (b), they correctly identified the required teaching and learning materials. One of the candidates listed *chalks, papers, pen, exercise books and subject books, projector, duster* and *ruler.* Such responses indicate that the candidates had adequate knowledge of teaching and learning materials. Extract 13.1 presents a sample of a correct response from one of the candidates.


13
Environment is the total surrounding of mans. The following are the negative im part resulted by the advancement of chemistry as follow:-
a). Acidic soil. Due to the results of using fertilizers which containing enough hydrogen (H+) ions and hence may cause to the failure of the soil manage its PH to coordinate.
Acidic rain. Also is among of the negative impact of the advancement of chemistry and hence it may cause to the changes of climatic conditions to the great extent.

Human disease. like cancer. Also may be resulted to the advancement of chemistry which may lead to facilitate and being cause human health problem due to the emission

Destruction of ozone layer. Highly caused by the industries emitting different radiation and being capable for sustaining and managing at a great extent and therefore it forces.

Death of aquatic organism. Also resulted by the advancement of chemistry due to the use of mercury and other dangerous organism

To sum up not only the advancement of chemistry cause negative impact but also brought positive impact which include medicine for treating illness.

13 Cont. rent gases like sulphur dioxide gas and carbonmonoxide gas which are harmful when exposes to the atmosphere.

Therefore; not only that the advancement of chemistry resulted to negative impacts but also it have some of the positive impacts such as advancement of health services, increase of productivity, development of industries and also improvement of agricultural sectors.

(b) The teaching and learning materials identified are ÷

i/ Books
ii/ Chalks
iii/ Pens
iv/ Blackboard.
v/ Ruler
vi/ Models.

Extract 13.1: A sample of a correct response to question13.

In Extract 13.1, the candidates presented some correct responses to parts (a) and (b) of the question. However, they did not clearly explain human diseases like cancer in part (b).

Furthermore, the candidates who scored below average marks on this question misunderstood the requirement of the question. Some of them provided either weak points or strong points with weak explanations. Moreover, some of them misinterpreted the question and discussed the positive impacts of the advancement in chemistry.

However, the candidates who scored low marks from (0 - 5.5) gave responses that were contrary to the demands of the question. In part (a), one candidate incorrectly mentioned *deforestation, bare land, increase poverty, hunger, and droughts as* environmental impacts caused by chemistry advancement. Another candidate incorrectly stated *underdevelopment, visual disability,* and *increase poverty*. The candidates wrote mixed both correct and incorrect responses that could not be justified. These responses revealed that they had inadequate knowledge of the negative environmental impact of chemistry advancements.

Similarly, in part (b), most of the candidates did not understand the term *materials* as used in the context of this question. Different candidates attached various interpretation to the word materials. Most candidates linked it with curriculum materials, others with teaching aids, and a few others with teaching and learning documents. Those who wrongly perceived it as components of curriculum materials listed of O-level Chemistry curriculum materials. For instance, one candidate incorrectly listed (i) *chemistry syllabus*, (ii) *chemistry textbooks*, (iii) *teachers' guide*, and (iv) *teacher manual*. Conversely, others mixed both correct and incorrect responses; hence, they did not score full marks.

Similarly, those who considered it as teaching aids wrongly stated *seeds, fruits, stones*, *bottle tops*, *perishable good* and *improvised boxes or bottles*. Others indicated teaching and learning documents instead of teaching and learning materials. For example, one candidate incorrectly listed *lesson notes, lesson plans, class journal, logbook* and *scheme of work.* Additionally, another candidate mistakenly mentioned *charts, models, articles, journals* and *audio-visual.* Those candidates had adequate knowledge of planning and preparation for teaching, but they failed to respond according the context and the requirement of the question as Extract 13.2 illustrates.

13 a) Environment Aio all things that sorrounding in human being. Example Air, houses, water, and trees this things it help the human to survival to the environment also There are Two Types of environment which are Natural environment and artificial environment which can help all human to survival. The following are the impact of the environment which are.

Increace of burning forest, when the human can burning the forest can dest cauce the environment so environment can cause the air pollution example Oxygen lack to the human duo to desturb the environment to the human.

Increace of crazing the animal in the small area, This are the Overcrazing increazing due to the people can keeping the animal to the small area can affected the environment also can cauce the deceace to human example The deaseace which can cauce to human.

Increace the digging in the ~~small~~ same crops in the same area, so that when diggig the same crops in the same are can cauce the environment soil also the soil can be lack of fertiliser because the digging the farmer in the same area so can increace the environment disturb

Increace the cutting down trees without replacement, also when we ~~ca~~ cutting down trees without replacement can affected the environment example Deforestation when the people can cutting down the trees without replacement.

Increace the population of people in the area, also when the people ~~at~~ have high large number of people in the same area which can lead the enviroment also the number of people in the area can be lack of oxygen and some of people can death.

Finally The are the ~~impact~~ of the ~~enviro~~ environment which help the human being to survival their fitness also can be support the people also to the the another activities when the people come to affect the environment like cutting down tree without the replacement of another trees.

(b) Interview is the conversational in which suppose the oral presentation between one people and another people also the interview need the face to face when asking the question there are two types of interview which are structured, semi structured and unstructured. The following are the material which used to ~~itentify~~ identify teaching and Learning material which are

syllabus, Is the book which specify the particular material at the different Level also the ~~ex~~ example of the syllabus which are ~~form~~ A Level which syllabus contain the form up to form four so this the syllabus can help you to identify the teaching and Learning material

Supplementary material, are the material which help the teacher to teaching the more effective and that are the supplementary which can guide you when teaching and learning the material

Teacher manual, also the manual are The activities which help the teacher participate when act example in the practical so this are the

Extract 13.2: A sample of an incorrect response to question13.

In Extract 13.2, the candidate provided irrelevant responses such as burning forests, increase overgrazing, increase of digging in the same crop, cutting down tree and increase in population. These responses did not relate to negative environmental impacts of the advancement of chemistry.

2.1.14 Question 14: Volumetric Analysis

This question required the candidates to evaluate the effectiveness of anhydrous sodium carbonate as primary standard reagent in standardizing hydrochloric acid. The question asked as follows;

Always primary standard reagents are used to standardize secondary standard reagents. In four points, evaluate the effectiveness of anhydrous sodium carbonate in standardizing hydrochloric acid.

The question was attempted by all 872 candidates (100%); whom, 572 (65.6%) scored from 0.5 to 5.5 marks; 156 (17.9%) scored from 6.0 to 10 marks; and 144 (16.5%) scored from 10.5 to 15.0 marks, with 05 (0.6%) scoring full marks. The candidates' performance on this question is summarised in Figure 11.

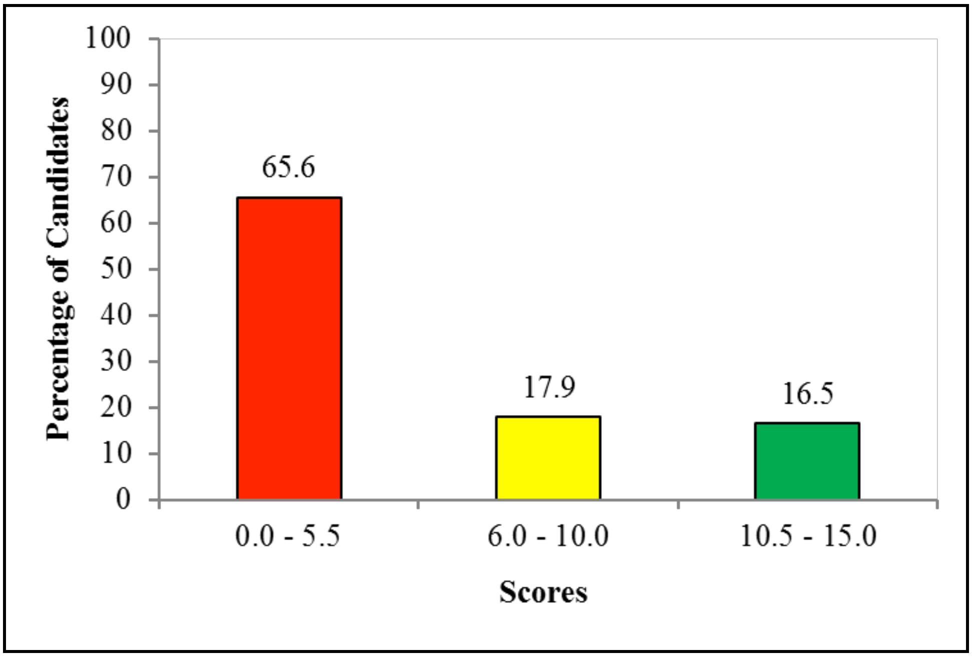
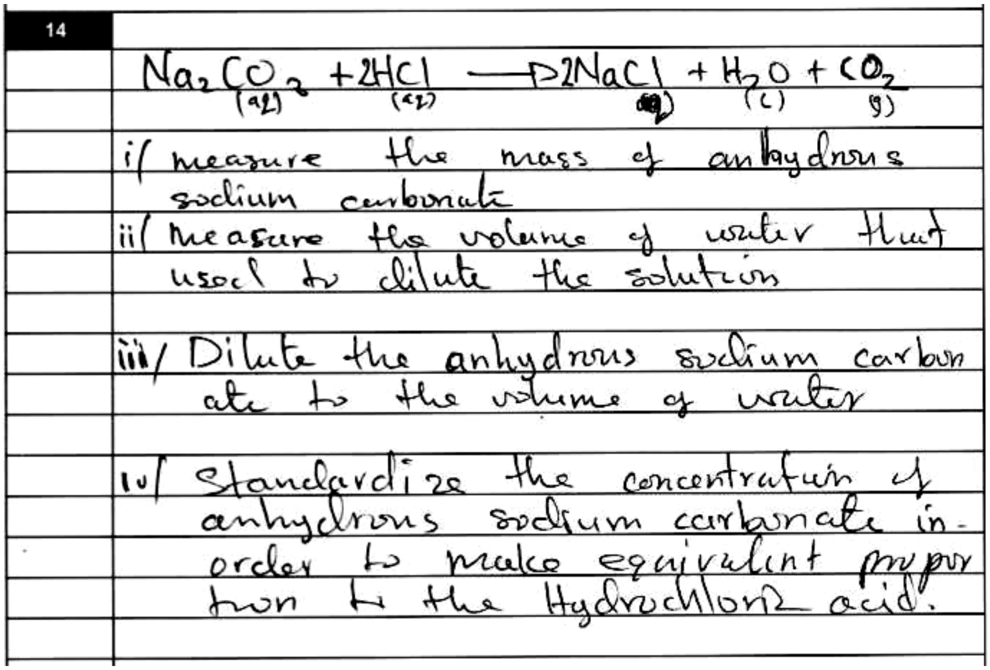


Figure 11: *Candidates' Performance on Question 14*

The analysis of data indicates that 300 (34.4%) of the candidates scored from 6.0 to 15.0 marks. Thus, their overall performance of candidates on this question was weak.

Analysis indicated furher that 65.6 percent of the candidates scored below the pass mark level of 02. The majority of the candidates did not address the key issues of question. For instance, one candidate mentioned *anhydrous sodium carbonate is used to react with acid to form salt and* *water*. This response was incorrect because the uses of anhydrous carbonate were not the requirement of the question. Likewise, another candidate incorrectly responded that *sodium carbonate is effective because it reacts with hydrochloric acid*. These responses implied that candidate had inadequate knowledge about the characteristics of primary reagents. Extract 14.1 shows a sample of an incorrect response from one of the candidates.



14

$Na_2CO_3 (aq) + 2HCl (aq) \rightarrow 2NaCl (aq) + H_2O (l) + CO_2 (g)$

i/ measure the mass of anhydrous sodium carbonate

ii/ Measure the volume of water that used to dilute the solution

iii/ Dilute the anhydrous sodium carbonate to the volume of water

iv/ Standardize the concentration of anhydrous sodium carbonate in order to make equivalent proportion to the Hydrochloric acid.

Extract 14.1: A sample of an incorrect response to question 14.

In Extract 14.1, the candidate wrote procedures for the standardization of HCl acid; however, these did not address the question.

Further analysis shows that the candidates who scored average marks on this question failed to explain the points thoroughly and exhaustively. Besides, these candidates lacked sufficient knowledge about the topic of volumetric analysis.

Analysis revealed that 34.4 per cent of those who scored high marks correctly explained the concept of primary standard reagents. They also correctly explained the effectiveness of anhydrous sodium carbonate by pointing out four features of primary standard reagents. For instance, one of the candidates indicated that anhydrous sodium carbonate could standardize hydrochloric acid because *it does not absorb water from the atmosphere* *and it has high percentage purity.* The candidate also correctly stated that anhydrous sodium carbonate *is thermally stable and therefore it cannot be affected by change of temperature*. These correct responses to this question indicates that the candidate had adequate knowledge of the features of standard reagent. Extract 14.2 shows a sample of correct responses to this question.

14 Effectiveness of anhydrous sodium carbonate in standardizing hydrochloric acid.

Sodium carbonate is the Primary standard solution which is made of sodium, carbon and three oxygen molecules. This can be used to standardize the concentration of hydrochloric acid due to the followings:-

The concentration of sodium carbonate does not change over time; This character fosters effectiveness of the substance towards the acid which is hydrochloric acid.

The anhydrous sodium carbonate has less impurity substances; This tendency suits its application towards standardizing the concentration of hydrochloric acid and reducing the level of impurities.

It is less volatile; This means can be applied and its concentration can be retained over the long period of time. Its molecules does not evokes or evaporates easily.

It is less harmful; This means the sodium ~~hydrox~~ carbonate is weaker base which is less corrosive to the solid materials ~~the~~ even in skin of the body compared to other bases like NaOH.

It has higher Molecular weight; This Molecules enables its exchanges and increase the reaction of the hydrochloric acid because increase in concentration increase the rate of the reaction.

14 Cont.

Can not easily loose ~~heat~~, water,
In low heat, hence It can. be
Used to standardize the Hydrochloric
acid.

It can not easily absorb water
or loose water. The Most properties
of Primary standard reagent is that.
They can not easily loose water or
gain water. hence It is used to
Standardize the secondary standard
reagent.

Generally: In preparation of
standard solution the great care is
needed.

Extract 14.2: A sample of a correct response to question 14.

In Extract 14.2, the candidate correctly presented the effectiveness of the features of anhydrous sodium carbonate, as the primary standard reagent does not change over time and has less impurities in standardizing HCl acid.

2.2 732/2 Chemistry 2: Practical Paper

This was a practical paper, which was in two equivalent alternatives, namely **732/2A Chemistry 2A** and **732/2B Chemistry 2B**. The candidates were required to sit for one of the two alternative papers. Each alternative paper consisted of three questions, which carried 50 marks. Question 1 weighed 20 marks, whereas Questions 2 and 3 carried 15 marks each. The candidates were assessed in the topic of *Volumetric Analysis*, *Chemical Kinetics* and *Qualitative Analysis* for Question 1, 2 and 3, respectively. The candidates were required to answer all questions. The pass mark for Question 1 was 8.0 while for Questions 2 and 3 was 6.0 marks. Results show that the overall performance was good as most of the candidates (88.56%) scored good marks in all three questions. The analysis of each question in the practical papers is as follows:

2.2.1 Question 1: Volumetric Analysis

Chemistry 2A and 2B

The question tested the candidates' competences in the use of volumetric analysis to determine the unknown element on the given base by titration.

Question 1 of 732/2A Chemistry 2A asked as follows:

"Your tutor meets you and your friend in the laboratory arguing about the name and atomic mass of a certain metal present in the metal hydroxide. She then decides to give both of you an experiment to identify the metal present in the hydroxide. For the smooth running of the experiment, the tutor provides you with the following solutions:

***A_1**: A solution containing metal hydroxide (MOH) where M is unknown metal.*

***B_2**: A solution of 3.65 g of pure hydrochloric acid in 1.00 dm^3 of aqueous solution.*

Methyl orange indicator.

Perform the experiment using the procedures given and answer the questions that follow.

Procedure

*(i) Pipette 20 cm^3 or 25 cm^3 of solution **A_1** into a conical flask.*

(ii) Add 2 to 3 drops of methyl orange indicator.

*(iii) Titrate solution **B_2** against solution **A_1** until a colour change is observed.*

(iv) Record up to four titre values.

Questions

(a) *(i) What is the volume of the pipette used?*
(ii) Present your results in a tabular form.

(b) What is the colour change of the indicator?

(c) Calculate the concentration of solution $\boldsymbol{B_2}$ *in mol* dm^{-3}.

(d) Calculate the concentration of $\boldsymbol{A_1}$ *in mol* dm^{-3}.

*(e) Calculate the atomic mass of metal **M** if the concentration of MOH is 5.6 g/*dm^3.

*(f) Identify the element **M** in MOH.*

Question 1 of 732/2B Chemistry 2B asked as follows:

*Sulphuric acid is hygroscopic and is an oxidizing agent; its concentration cannot be stable for a long time. You have decided to prove this fact by conducting an experiment using sulphuric acid solution labelled **SA** and primary standard solution made by dissolving 0.840 g of anhydrous sodium hydrogen carbonate in exactly 100 mL of solution. The primary standard solution was labelled **PS**. The titration indicator is methyl orange solution. Perform the experiment in the given procedures and answer the questions that follow.*

Procedure

(i) Pipette 20 cm^3 *or 25* cm^3 *of the solution **PS** and transfer it into the titrating flask.*
(ii) Add 2 to 3 drops of the indicator (MO) in the titrating flask.
*(iii) Transfer **SA** solution into the burette.*
*(iv) Titrate **PS** using **SA** until the end point is reached.*
(v) Repeat step (i) to (iv) three more times.

Questions

(a) (i) What is the volume of pipette used?
(ii) Draw and complete appropriate table of results.

*(b) (i) Calculate the average volume of **SA** used.*
*(ii) Calculate the molarity of sodium hydrogen carbonate in solution **PS**.*

(c) (i) Write the balanced chemical equation for the reaction that took place in this experiment.
(ii) Calculate the molarity of the standardized sulphuric acid.

A total of 872 (100%) candidates attempted this question. The analysis of the candidates' performance on this question shows that 639 (73.3%) scored from 14 to 20 marks, indicating good marks. Additionally, 196 (22.5%) of the candidates scored from 8.0 to 13.5 marks, indicating average scores and 37 (4.2%) of the candidates scored from 0 to 7.5 marks, indicating weak marks. Figure 12 illustrates the candidates' performance on this question.

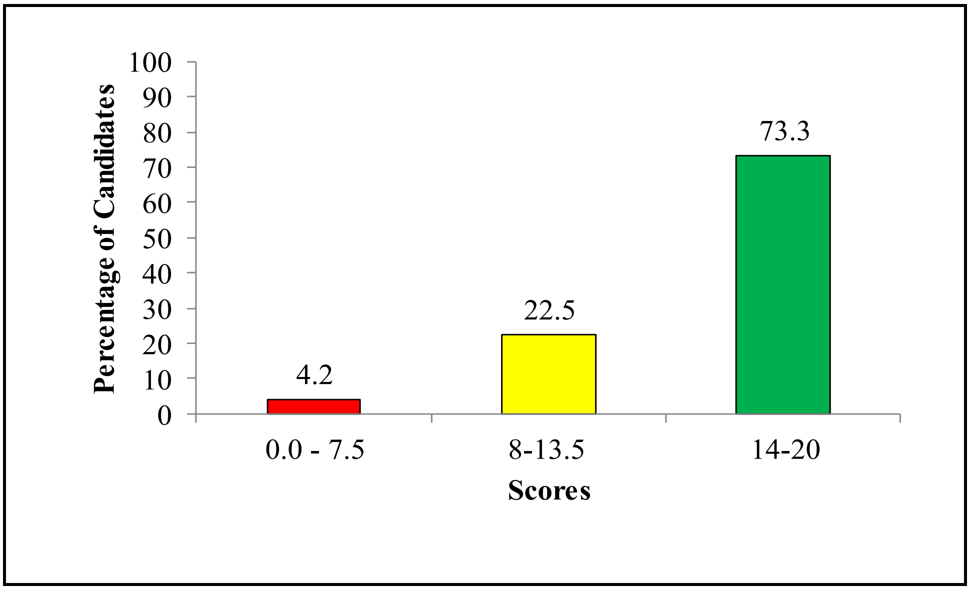


Figure 12: *Candidates' Performance on Question 1*

Generally, the majority of the candidates (95.8%) scored a pass mark or above, indicating good performance on this question.

The candidates who scored high marks on this question were 73.3 per cent. They had adequate knowledge about the standardization of solution using the titration method. In alternative practical A, these candidates correctly perform the experiment using standardized HCl acid with metal hydroxide in the formula MOH, and they used this information to calculate the atomic mass of metal **M** in the formula MOH. In alternative practical B, the candidates successfully standardized sulphuric acid using standard sodium hydrogen carbonate solution. Extracts 15.1 and 15.2 present samples of the correct responses to question 1 in the alternative practical, A and B, respectively.

1 Cont.

$$\text{Concentration} = \frac{3.65g}{1\,dm^3}$$

$$= 3.65g/dm^3$$

Concentration of $B_2 = 3.65g/dm^3$.

But,

from, $$\text{Molarity} = \frac{\text{Concentration}}{\text{Molar mass}}$$

$$= \frac{3.65g/dm^3}{(1+35.5)g/mol}$$

$$= \frac{3.65g/dm^3}{36.5g/mol}$$

$$= 0.1\,Mol/dm^3$$

∴ Concentration of $B_2 = 0.1\,Mol\,dm^{-3}$

d) From eqn. $MOH + HCL \rightarrow MCl_{(aq)} + H_2O_{(l)}$

Number of moles of HCl (n_a) = 1.

Number of moles of MOH (n_b) = 1.

Volume of HCl (V_a) = $20cm^3$

Volume of MOH (V_b) = $20cm^3$

Molarity of HCl (M_a) = 0.1M

Molarity of MOH (M_b) = ?

from

$$\frac{M_aV_a}{n_a} = \frac{M_bV_b}{n_b}$$

Since mole ratio = 1 : 1

$$\therefore M_aV_a = M_bV_b$$

$$M_b = \frac{M_aV_a}{V_b}$$

$$= \frac{0.1M \times 20cm^3}{20cm^3}$$

1 Cont.

$M_b = 0.1M$

∴ ~~Ab~~ Concentration of $A_1 = 0.1 Mol dm^{-3}$

e) Atomic mass of metal M = ?

Given that

Concentration of MOH is $5.6 g/dm^3$.

From,

$$\text{Molarity} = \frac{\text{Concentration}}{\text{Molar mass}}$$

Make Molar mass the subject of the formula

$$\text{Molar mass of MOH} = \frac{\text{Concentration of MOH}}{\text{Molarity of MOH}}$$

$$= \frac{5.6 g/dm^3}{0.1 Mol/dm^3}$$

$$= 56 g/mol.$$

Molar mass of MOH = 56 g/mol.

Then;

$MOH = 56 g/mol$

$M + 16 + 1 = 56$

$M + 17 = 56$

$M = 56 - 17$

$M = 39$

Molar mass of M in MOH = 39 g/mol

but

Molar mass of 39 g/mol is for Potassium element.

∴ The element M in MOH was Potassium (K)

Extract 15.1: A sample of a correct response to question 1 in Alternative Practical A.

In Extract 15.1, the candidate correctly recorded the experimental results in the table and gave the correct volumes in two decimal places as required.

Moreover, the candidate obtained the precise titre value falling within the expected range (i.e., ±0.5 cm^3). Additionally, the candidate correctly wrote the chemical reaction between the given metal hydroxide and hydrochloric acid. Furthermore, the candidate performed all the necessary calculations to identify Potassium as the unknown metal in the formula MOH.

1

a(i) Volume of pipette was 20 cm³

Table of results

(b)

Titrated ~~Volume used~~ (cm³)	PILOT	1	2	3
Final volume	20·50	40·30	20·10	20·40
Initial reading cm³	00·00	20·50	00·00	00·00
volume used (cm³)	20·50	19·80	20·10	20·40

(b)i, Average volume $= \frac{V_1 + V_2 + V_3}{3}$

$= \frac{19{\cdot}80 + 20{\cdot}10 + 20{\cdot}40}{3}$

$= 20{\cdot}1\ cm^3$

(ii) Molarity of $NaHCO_3$

Mass of $NaHCO_3$ = 0·840g

Volume of $NaHCO_3$ = 100mL = 0·1 L

Concentration $= \frac{Mass}{Volume}$

$= \frac{0{\cdot}840g}{0{\cdot}1\,dm^3}$

Concentration of $NaHCO_3$ = 8·4g/dm³

But

Molarity $= \frac{Concentration}{Molar\ mass}$

Molar mass of $NaHCO_3$ = 84g/mol

1 Cont.

$$\text{Molarity} = \frac{8.4\,g/dm^3}{84\,g/mol} = 0.1\,M$$

Molarity of sodium hydrogen carbonate $= 0.1\,mol/dm^3$

(d)(i) $2NaHCO_{3(aq)} + H_2SO_{4(aq)} \longrightarrow Na_2SO_{4(aq)} + 2H_2O_{(l)} + 2CO_{2(g)}$

(ii) Molarity of standardized sulphuric acid solution

Molarity of $NaHCO_3$ (mb) $= 0.1\,M$

Volume of $NaHCO_3$ (vb) $= 20\,cm^3$

Volume of H_2SO_4 (va) $= 20.1\,cm^3$

Molarity of H_2SO_4 (Ma) $= ?$

Number of mole of $NaHCO_3$ (nb) $= 2$

Number of mole of H_2SO_4 (na) $= 1$

From $\frac{ma\,va}{mb\,vb} = \frac{na}{nb}$

$$Ma = \frac{Mb\,vb\,na}{va\,nb}$$

$$Ma = \frac{0.1 \times 20 \times 1}{20.1 \times 2}$$

$$= \frac{2}{40.2}$$

$$= 0.0498 \approx 0.05\,M$$

1 Cont.

d(ii) The molarity of the standardized sulphuric acid $= 0.05\,mol/dm^3$

Extract 15.2: A sample of a correct response to question 1 in Alternative Practical B.

In Extract 15.2, the candidate correctly filled the table of results by observing the required two decimal places. The candidate correctly calculated the titre value which was within the acceptable range in comparison to the expected value (i.e., ± 0.5 cm^3). Furthermore, the candidate correctly gave the balanced chemical equation between the base and acid and thus identified the colour changes during titration. Additionally, the candidate skillfully utilized stoichiometric ratios from the equation to calculate the molarity of standardized sulphuric acid.

However, a small number of candidates 37 (4.2%) scored low marks, from 0–7.5 in Question 1. Their responses reflected a lack fundamental knowledge and skills in conducting volumetric analysis. Some candidates gave titration volumes, which deviated beyond or below the accepted value which fell out of the standard range (i.e., ± 0.5 cm^3). For instance, one candidate incorrectly wrote a reaction equation, leading to the use of improper stoichiometric coefficients for the reacting species as shown in the following equation: $2HCl + 2MOH \rightarrow MCl_2 + 2H_2O$. Thus, the candidate failed to recognize that the unknown metal M had a valence of +1, resulting in an incorrect formula MCl_2 instead of the correct formula MCl. Furthermore, some of the candidates incorrectly calculated the atomic mass of metal M in the compound MOH by using concentration instead of molecular mass. For instance, one of the candidate incorrectly used concentration ($5.6g/dm^3$) as the molar mass of the compound MOH to calculate the atomic mass of metal M in the following formula: $M + 16 + 1 = 5.6g/dm^3$.

Moreover, in alternative practical B, some candidates had limited knowledge of balancing chemical equation, calculating valence of metal or radical in a compound, providing correct products from chemical reaction and writing state symbols in chemical equations. For example, one candidate incorrectly wrote a chemical equation with the wrong product as follows:

$$2NaHCO_3 + 2H_2SO_4 \rightarrow Na_2SO_3 + 3H_2O + 2CO_2$$

Instead of giving sodium sulphate (Na_2SO_4), the candidate gave sodium sulphite (Na_2SO_3), resulting in an unbalanced chemical equation. In addition, other candidates wrote unbalanced chemical equations due to the lack of skills in determining the valence of a radical or metal in a compound, as shown in the equation:

$$Na_2HCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O + CO_2$$

Some candidates also confused the molecular mass of sodium hydrogen carbonate ($NaHCO_3$) with that of sodium carbonate when calculating the molarity $NaHCO_3$; for instance, one candidate wrote:

$$\text{Molarity} = \frac{\text{Conc (g/dm}^3)}{\text{Molar mass}} = \frac{8.4 \text{ g/dm}^3}{106 \text{ g/mol}}$$

This candidate used the molar mass of 106 g/mol of sodium carbonate instead of the correct molar mass of sodium hydrogen carbonate (84 g/mol). Extracts 15.3 and 15.4 further illustrate the incorrect responses to Question 1 in the alternative papers A and B, respectively.

1 a)i) The volume of the pipette used was 20cm³

ii) Table of results.

Experiment	PILOT	1	2	3
Final volume (cm³)	19.50	39.50	42.00	44.50
Initial volume (cm³)	00.00	19.50	20.00	22.00
Volume used	19.50	20.00	22.00	22.50

Volume used (cm³) = $\frac{19.50 + 20.00 + 22.00 + 22.50}{4}$

$= \frac{84}{4}$

∴ Volume used = 21 cm³

b) The colour change from yellow to pink.

c) Concentration of B_2 in mol dm⁻³

soln.

from

Concentration = $\frac{\text{Mass}}{\text{Volume}}$

= ~~1.00dm³~~ $\frac{3.65g}{1.00dm^3}$

= 0.27g/dm³

∴ Concentration of B_2 = 0.0027 mol dm⁻³

d) Concentration of A_1 in mol dm⁻³

soln.

Concentration = $\frac{\text{Mass}}{\text{Volume}}$

but concentration = Molarity x molar mass

1 Cont. d) $5.6 g/dm^3$ = ~~2ten~~

∴ Concentration of A_1 = $0.0056 mol dm^{-3}$

e) Atomic mass of M.

soln

$MOH = 5.6 g/dm^3$

$m(16+1) = 5.6 g/dm^3$

$\frac{17m}{17} = \frac{5.6 g/dm^3}{17}$

$m = 23.0 g/dm^3$

∴ The atomic mass of M is 23.

f) The element M is Sodium (Na)

Extract 15.3: A sample of an incorrect response to question 1 in Alternative Practical A.

In Extract 15.3, the candidate obtained incorrect data. Hence, the candidate calculated the wrong mean titre value which fell out of range. This indicates that the candidate did not know the fundamental principles of volumetric analysis. Furthermore, in parts (c), (d) and (e), one candidate used incorrect formulae to calculate molarity, leading to the wrong identification of metal **M** as Na.

1 (a). i/. the volume of pipette used is 25 cm³.

ii/. TABLE OF RESULTS:

	Pilot	1	2	3
Final volume	~~Pilot~~ 26.05	26.00	26.01	26.03
Initial volume	0.00	0.00	0.00	0.00
Volume Used	26.05	26.00	26.01	26.03

(b). i/. Avarage volume $= \frac{V_1 + V_2 + V_3}{3}$

$= \frac{26.00 + 26.01 + 26.03}{3}$

$= 26.04$

∴ the avarage volume of SA used is 26.04 cm³.

ii/. from: Molarity $= \frac{\text{Concentration}}{\text{Molar Mass}}$

but: concentration = Mass/volume

Concentration $= \frac{0.840g}{0.1}$

Concentration = 0.84 g/dm³

so. Molarity = Conc/Mr $= \frac{0.84}{84}$ = 0.01 M.

1 Cont

$NaHCO_3 = 23 + 1 + 12 + (16 \times 3)$

$NaHCO_3 = 84$ mol.

∴ Molarity = 0.01 mol.

c/. (i) $2NaHCO_3 + 2H_2SO_4 \rightarrow 2NaSO_3 + 3H_2O + 2CO_2$

ii/. from: $\frac{M_aV_a}{M_bV_b} = \frac{n_a}{n_b}$

so, $M_a = \frac{M_bV_b n_a}{V_a n_b}$

$M_a = \frac{0.01 \times 25 \times 2}{26 \times 2}$

$M_a = 9.62 \times 10^{-3}$

$M_a = 0.00962$ mol.

Extract 15.4: A sample of an incorrect response to question 1 in Alternative Practical B.

In Extract 15.4, the candidate wrote the reaction equation with an incorrect molecular formula of the base in part (c). Moreover, in part (c), the candidate wrote an incorrect chemical equation, chemical symbols and units. Additionally, the candidate used standard units *mol* the instead of using the unit of *mol/dm*^{3} for molarity.

2.2.2 Question 2: Chemical Kinetics and Energetic

Chemistry 2A and 2B

The question required the candidates to assess the effect of the rate of reaction by varying the concentration of sodium thiosulphate solution and to determine the effect of temperature on the rate of a chemical reaction.

Question 2 of 732/2A Chemistry 2A was as follows:

One of the factors that affect the rate of a chemical reaction is the concentration of the reactants. Therefore, in this experiment you are required to investigate the effect of concentration on the rate of reaction between sodium thiosulphate ($Na_2S_2O_3.5H_2O$) and hydrochloric acid (HCl).
You are given the following materials:
***AA**: A solution containing 0.25 M $Na_2S_2O_3.5H_2O$;*
***BB**: A solution containing 0.5 M HCl;*
Distilled water, stopwatch and a white paper with a cross "+".

Perform the experiment using the procedures given and answer the questions that follow.

Procedures
(i) Put an empty beaker (50 cm^3) on top of the mark "+" drawn on the given piece of paper. Make sure that the mark is clearly visible.
*(ii) Using a measuring cylinder, transfer 10 cm^3 of **AA** into a beaker positioned on top of the mark "+".*
*(iii) Using another measuring cylinder measure 5 cm^3 of **BB**.*
*(iv) Hold the measuring cylinder containing 5 cm^3 of **BB** in one hand and hold the stop watch in another hand.*
*(v) Simultaneously, pour 5 cm^3 of **BB** into the beaker positioned on top of the mark "+" and start the stop watch.*
(vi) Stir gently the contents in the beaker and record the time of disappearance of the mark "+".
*(vii) Repeat the procedure (i) to (vi) by using 8 cm^3, 6 cm^3, 4 cm^3 instead of 10 cm^3 of **AA** in procedure (ii) as tabulated below:*

Table of Results

Experiment	***Volume of Reactants (cm^3)***			***Time, t (s)***	***Rate (s^{-1})***
	AA	***Water***	***BB***		
1	*10*	*0*	*5*		
2	*8*	*2*	*5*		
3	*6*	*4*	*5*		
4	*4*	*6*	*5*		

Questions

(a) *Complete the Table of Results.*

(b) *Write the ionic equation representing the reaction between thiosulphate ion and an acid.*

(c) *Plot a graph of rate (1/t) of reaction as a function of a volume of sodium thiosulphate.*

(d) *With the aid of the graph obtained in (c), comment on the relationship between concentration of sodium thiosulphate and the rate of reaction.*

(e) *Use the data in (a) to find the value of a rate constant, k, given that rate of chemical reaction is expressed by* $\text{Rate} = k[S_2O_3^{2-}]^2[H^+]$.

Question 2 of 732/2B Chemistry 2B was as follows:

You are given a task to determine the effect of temperature on the rate of chemical reaction using sodium thiosulphate and nitric acid. During the experiment, you observe that sodium thiosulphate reacts with an acid to form white precipitates. However, the intensity of precipitation changes with change in temperature. You are asked to replicate the same experiment by using the following materials:

B1: *A solution of 0.05 M sodium thiosulphate;*
B2: *A solution of 0.1 M nitric acid;*
Stopwatch, thermometer and other relevant facilities.

Perform the experiment through the given procedures and then answer the questions that follow.

Procedures

(i) *Put an empty beaker (50 cm^3) on top of the mark "+" drawn on the given piece of paper. Make sure that the mark is clearly visible.*

(ii) *Pour about 200 cm^3 of water into a 250 or 300 cm^3 beaker. (Use this as your water bath).*

*(iii) Measure 10 cm^3 of **B1** and 10 cm^3 of **B2**, and pour into separate test tubes.*
*(iv) Put the two test tubes containing, **B1** and **B2**, into the water bath in (ii) and warm the contents to 50 °C.*
*(v) Pour the hot solutions of **B1** and **B2** in the beaker in (i) and immediately start the stopwatch.*
(vi) Using a glass rod, stir the reaction mixture and record the time taken for the letter + to disappear completely.
(vii) Repeat the procedure (iii) to (vi) by warming to temperatures, 60 ˚C, 70 ˚C and 80 ˚C instead of warming to 50 °C in procedure (iv).

Questions

(f) Complete the following table:

Table of Results

Temperature, T		***I/T (K^{-1})***	***Time, t (s)***	***Rate [$\frac{1}{t}(s^{-1})$]***	**$\log\left(\frac{1}{t}\right)$**
°C	*K*				
50					
60					
70					
80					

(g) From the table of results, give a conclusion with respect to the relationship between the temperature and the rate of reaction.

(h) Plot a graph of log (1/t) as a function of 1/T.

(i) Arrhenius equation can be presented by the relation, $\log\left(\frac{1}{t}\right) = \frac{-E_a}{2.303R}\frac{1}{T} + \log A$, *where* E_a *is the activation energy and* R *is the gas constant = 8.314 J mol^{-1} K^{-1}. With the aid of the graph obtained in (c), calculate the activation energy,* E_a, *in J mol^{-1}.*

The candidates who attempted this question were 872 (100%). The analysis done indicates 189 candidates (21.7%) scored from 10.5 to 15 marks, indicating good performance; 490 (56.2%) scored from 6.0 to 10.0 marks, indicating average performance; and 193 (22.1%) scored from 0 to 5.5 marks, indicating weak performance. Figure 13 illustrates the candidates' performance on this question.

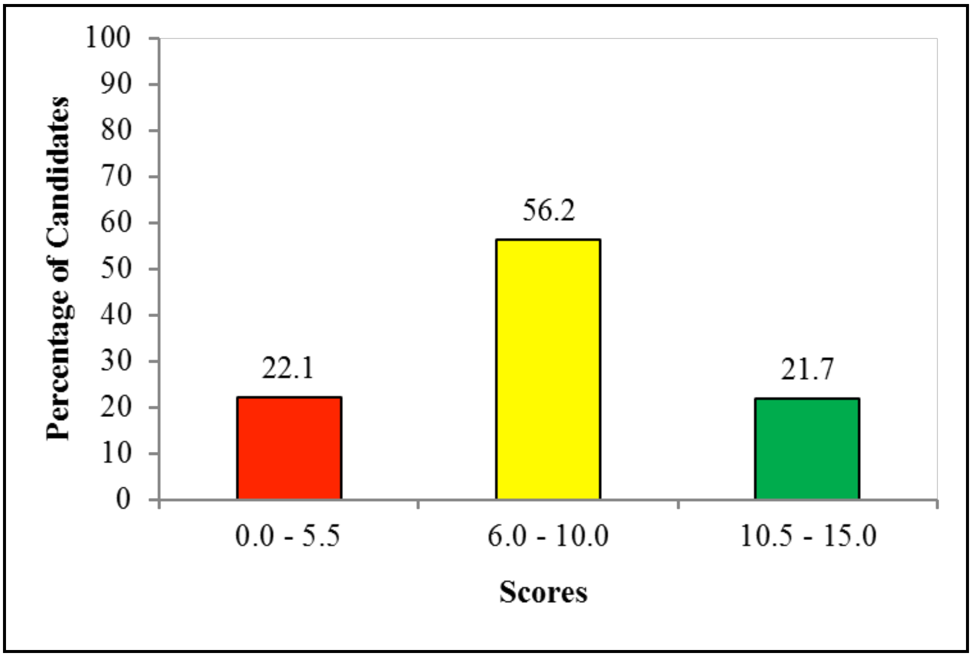


Figure 13: *Candidates' Performance on Question 2*

The analysis of the candidates' performance on this question shows that 679 (77.9%) scored from 6 to 15 marks, indicating good scores. Generally, the majority of the candidates (77.9%) had good performance on this question. These candidates had adequate knowledge about the rate of chemical reaction. They correctly determined the effect of the rate of reaction by varying the concentration of sodium thiosulphate solution in alternative practical 2A. Furthermore, they correctly determined the effect of temperature on the rate of the chemical reaction in alternative practical 2B. Extracts 16.1 and 16.2 show samples of the correct responses to Question 2 in alternative practical 2A and 2B, respectively.

2

(a) TABLE OF RESULTS

EXPERIMENT	Volume of the Reactant (cm^3)			Time t (sec)	Rate 1/t (Sec^{-1})
	AA	Water	BB		
1	10	0	5	21	0.04
2	8	2	5	2.5	0.04
3	6	4	5	27	0.03
4	4	6	5	35	0.02

(b) The balanced ionic equation between sodium thiosulphate and hydrochloric acid

$Na_2S_2O_{3(aq)} + 2HCl_{(aq)} \rightarrow 2NaCl_{(aq)} + SO_{2(g)} + S_{(s)} + H_2O_{(L)}$

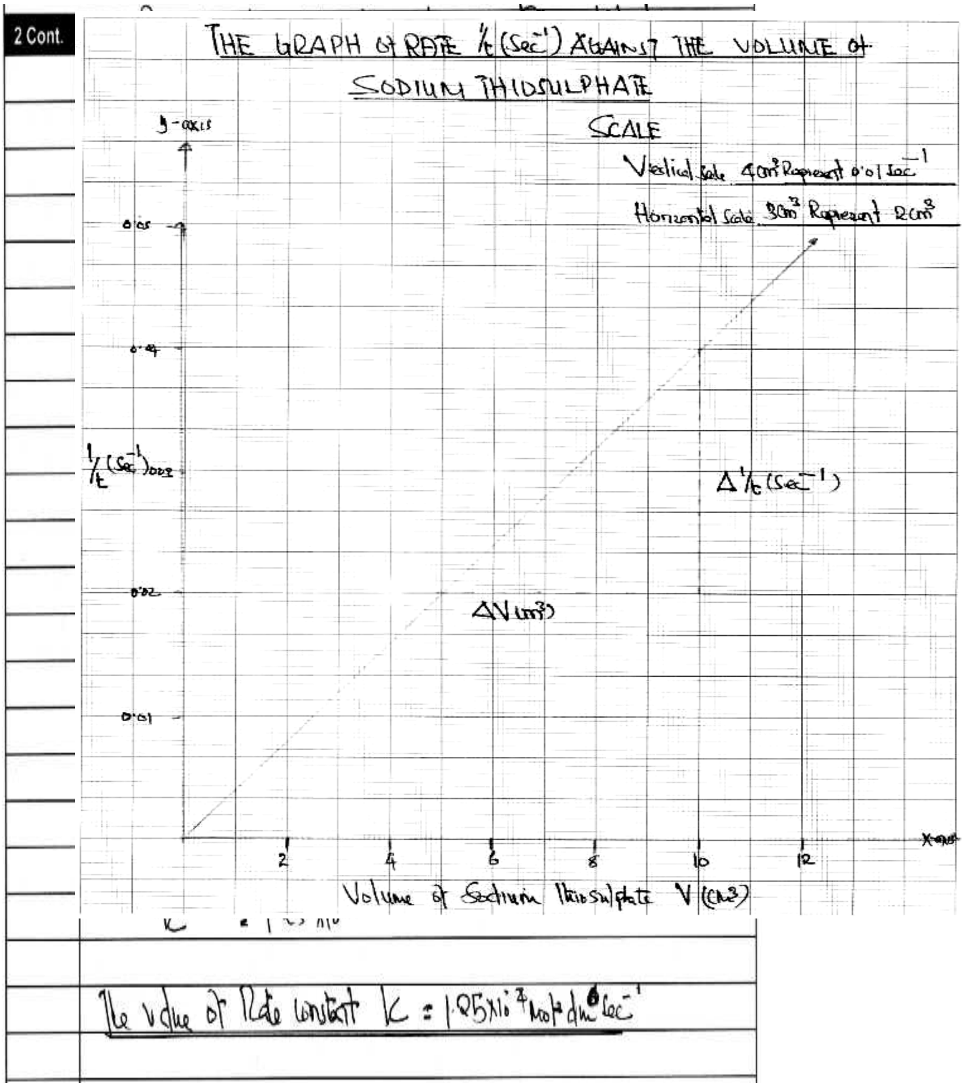
$2Na^+_{(aq)} + S_2O_3^{2-}{}_{(aq)} + 2H^+_{(aq)} + 2Cl^-_{(aq)} \rightarrow 2Na^+_{(aq)} + 2Cl^-_{(aq)} + SO_{2(g)} + S_{(s)}\ H_2O_{(L)}$

Then the spectator ions was canceled
The overall net ionic equation is

~~$2H^+_{(aq)} + S_2O$~~

$S_2O_3^{2-}{}_{(aq)} + 2H^+_{(aq)} \rightarrow SO_{2(g)} + S_{(s)} + H_2O_{(L)}$.

d) from the graph in 2c obtained the relationship between the concentration of sodium thiosulphate and rate of reaction is that As the concentration decrease the rate also decrease and the as the rate of reaction increase the volume is also increase. Hence the concentration of sodium thiosulphate is directly proportional to the rate of reaction i.e $V \propto 1/t$.



Extract 16.1: A sample of a correct response to question 2 of Alternative Practical A.

In Extract 16.1, the candidate correctly filled the experimental result in the table. In part (b), the candidate wrote the correct overall ionic equation for the reaction. Additionally, the candidate correctly plotted the graph as required per question in part (c), and commented on the relationship between the concentration of sodium thiosulphate and the rate of reaction in part (d). Lastly, the candidate correctly used the data in (a) to determine the value of the rate constant.

2 (a)

Table of results

Temperature, T		$\frac{1}{T}(K^{-1})$	Time t (s)	Rate $\left[\frac{1}{t}(sec^{-1})\right]$	$\log\left(\frac{1}{t}\right)$
°C	K				
50	323	~~2.893x10^-3~~ 3.095x10^-3	50	0.02	~~-1.6~~9
60	333	3.003x10^-3	24	0.04	-1.39
70	343	2.915x10^-3	18	0.05	-1.30
80	353	2.832x10^-3	10	0.1	-1

(b) The rate of reaction decrease with the Increase of temperature. hence the high temperature increase the rate of the reaction

$$Rate \propto \frac{1}{T}$$

$$\therefore t \propto \frac{1}{T}$$

(c) refer to the graph paper (G1).

d) Given

$R = 8.3143 J mol/k$

from

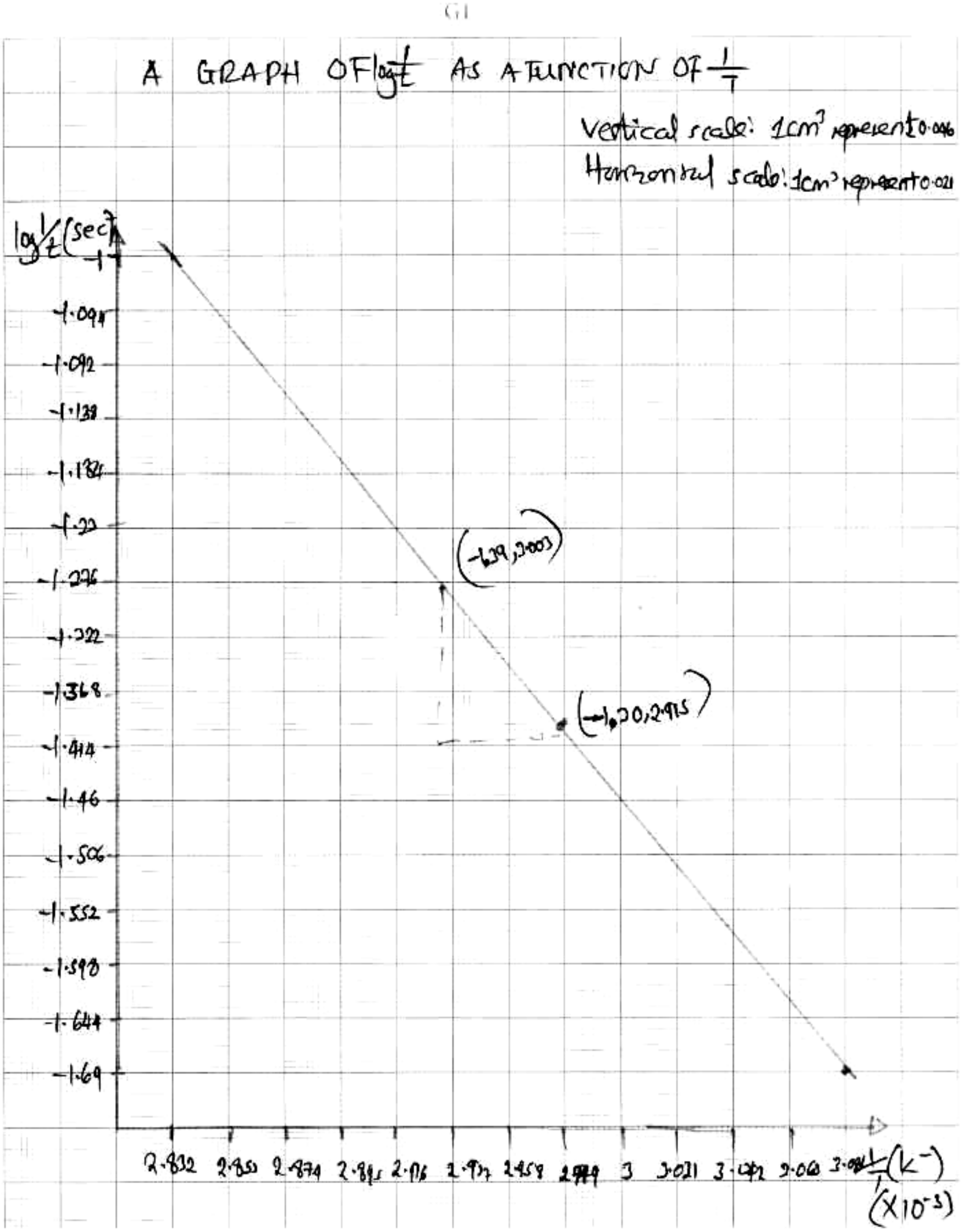
$$\log\frac{1}{t} = \frac{-Ea}{2.303RT}\frac{1}{} + \log A$$

$$m = \frac{-Ea}{2.303}$$

but from the graph

$$slope = \frac{\Delta \log\frac{1}{t}}{\Delta\frac{1}{T}}$$

2 Cont.	
	slope = $\frac{-1.29-(-1.20)}{2.003-2.915}$
	slope = -1.022 sec^{-1} k^{-1}
	then
	Ea = m × 2.303 × 8.314
	Ea = −1.022 × 2.303 × 8.314
	∴ Ea = −19.58 J mo^{-1}.
	~~Ea~~ =



Extract 16.2: A sample of a correct response to question 2 of Alternative Practical B.

In Extract 16.2, the candidate correctly recorded the required experimental data and plotted the graph of $\log\frac{1}{t}(\text{sec}^{-1})$ against $\frac{1}{T}(\text{K}^{-1})$ correctly, showing all points clearly and indicating an appropriate scale in part (b). Besides, the candidate correctly determined the activation energy of the reaction by using the Arrhenius equation. Lastly, the candidate clearly stated that the increase in temperature causes the decrease in the time for the reaction to be complete in part (c). This signifies the candidate knew that the rate of reaction is direct proportional to temperature.

In contrast, the candidates who scored low marks on this question had insufficient knowledge about rate of chemical reaction. Some of them recorded incorrect time for the completion of the reaction in the table of results. In part (c), some of the candidates plotted graphs with incorrect points due to inaccurate data collection and manipulation. Furthermore, the comments given by some candidates in part (d) on relationship of concentration to the rate of reaction were not correct; they confused time with the rate of reaction. For instance, one candidate responded that *when concentration decreases, the rate of reaction increases.* This comment is contrary to the literature. The correct response is that the rate of reaction decreases with the decrease in concentration. In part (e), some of the candidates wrongly calculated the order of reaction instead of the rate constant that the question required. An example response was: $k = \left(\frac{0.04}{0.03}\right) = \left(\frac{8}{6}\right)^n$ instead of using the rate law for calculating the rate constant, which is $\mathrm{k} = \frac{\text{rate}}{\left[S_2O_3^{2-}\right]^2\left[H^+\right]^1}$. The candidate failure to determine the rate constant using correct formulae led them to scoring low marks on Question 2 of alternative practical A.

Further analysis revealed that the candidates with low scores in alternative practical B indicates a lack graphing techniques. Although some candidates correctly completed the table in part (a), they failed to draw accurate conclusions of the relationship between temperature and the rate of reaction in part (b). For example, one candidate wrongly responded that *increase in temperature results to decrease the rate of chemical reaction*. Another candidate wrote: *The rate of reaction is inversely proportional to temperature that is increase in temperature decrease in rate of reaction*. Such incorrect responses were attributed to the candidates' insufficient knowledge of the subject matter. They failed to differentiate time from the rate of reaction. Additionally, in part (a) of the alternative B, some candidates did not include the title of the graph or labels of axis. Moreover, their choice of scale was poor. These candidates failed to understand that each coordinate axis of a graph should be labeled with the word or symbol for the variable plotted, and the graph should have a clear title indicating which variables are represented. Proper scales should be chosen to ensure that the data are easy to plot and read. These shortcomings affected the calculation of activation energy. Their low performance on this question indicated that candidates did not know the effect of temperature on the rate of reaction. Extracts 16.3 and 16.4 presents samples of the incorrect responses to Question 2 in alternative practicals A and B, respectively.

2 (a) Table of Results.

Experiment	Volume of Reactants (cm³)			Time, t (s)	Rate (s^{-1})
	AA	Water	BB		
1	10	0	5	30	0.033
2	8	2	5	40	0.025
3	6	4	5	50	0.02
4	4	6	5	60	0.016

(b) $Na_2S_2O_{3(aq)} + 2HCl_{(aq)} \rightarrow 2NaCl_{(aq)} + H_2O_{(l)} + SO_{2(g)} + S_{(s)}$

$2Na^+_{(aq)} + 2S^{2+}_{(aq)} + 3O^{2-}_{(aq)} + 2H^+_{(aq)} + 2Cl^-_{(aq)} \rightarrow 2Na^+_{(aq)} + 2Cl^-_{(aq)} + H_2O_{(l)} + SO_{2(g)} + S_{(s)}$.

$2Na^+_{(aq)} + 2S^{2-}_{(aq)} + 3O^{2-}_{(aq)} + 2H^+_{(aq)} + 2Cl^-_{(aq)} \rightarrow 2Na^+_{(aq)} + 2Cl^-_{(aq)} + H_2O_{(l)} + SO_{2(g)} + S_{(s)}$

$2S^{2-}_{(aq)} + 3O^{2-}_{(aq)} + 2H^+_{(aq)} \rightarrow H_2O_{(l)} + SO_{2(g)} + S_{(s)}$.

(d) As Volume of $Na_2S_2O_3$ decreases the rate of chemical reaction also decrease.
Hence $V \propto 1/t$.

(e) $Rate = K[S_2O_3^{2-}]^2[H^+]$

~~0.033 = K [10]² [~~

$0.025 = K[8]^2[2]$.

$0.025 = 128K$.

$\frac{0.025}{128} = \frac{128K}{128}$

2 Cont.

$K = \frac{0.025}{128}$

$K = 1.953 \times 10^{-4}$

∴ The rate constant $= 1.953 \times 10^{-4}$

Extract 16.3: A sample of an incorrect response to question 2 in Alternative Practical A.

In Extract 16.3, the candidate wrote the correct molecular equation but failed to write the ionic chemical equation in part (b). The candidate incorrectly used the volume of water and thiosulphate in the experiment to calculate the rate constant instead of the concentration of hydrochloric acid $[H^+]$ and thiosulphate $[S_2O_3^{2-}]$.

2 a) Table of result

Temperature, T		1/T (K⁻¹)	Time, t(s)	Rate [1/t (s⁻¹)]	log (1/t)
°C	K				
50	323	3.09×10^{-03}	64	0.0156	-1.806
60	333	3.00×10^{-03}	40	0.025	-1.602
70	343	2.91×10^{-03}	32	0.031	-1.508
80	353	2.83×10^{-03}	28	0.035	-1.447

b) As the temperature increase the rate of reaction decrease and when the temperature decrease the rate of reaction increase.

d). To calucate activation energy.

Given

R = 8.314 J mol⁻¹ K⁻¹

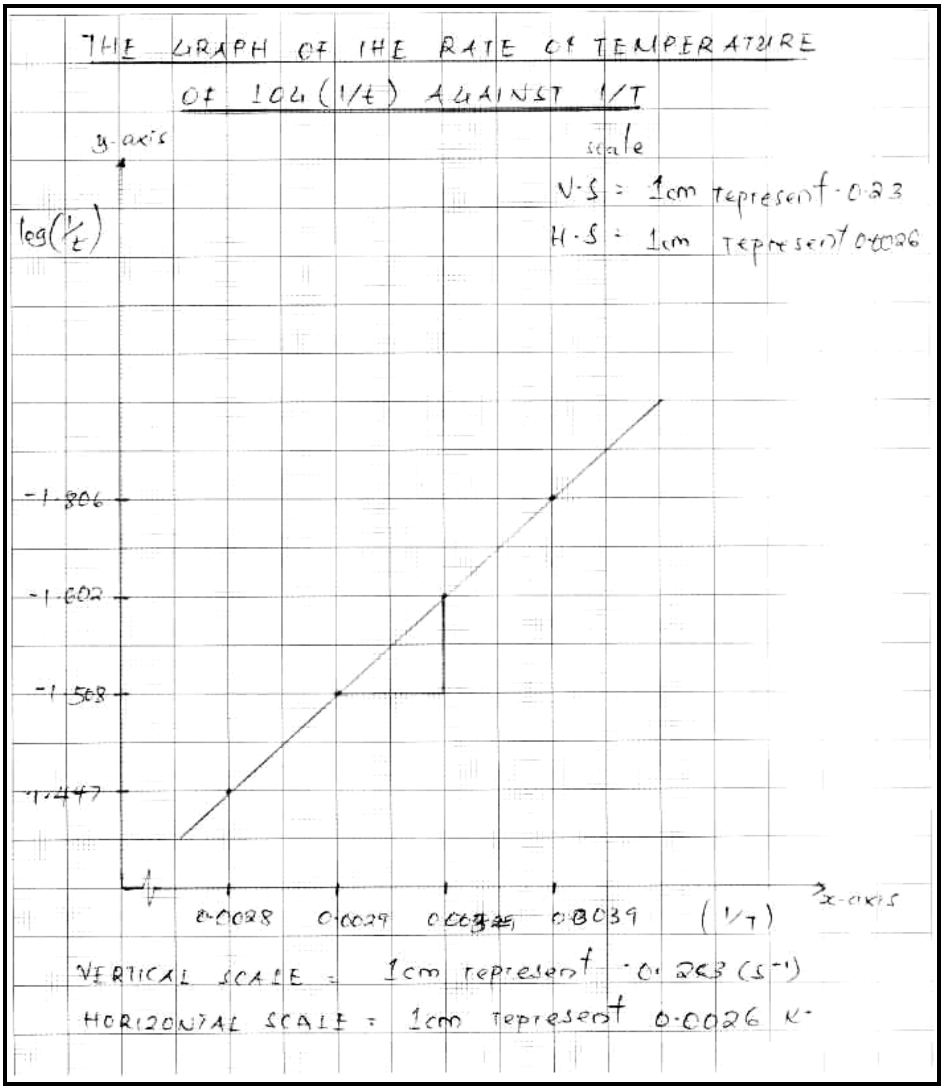
2.303

Ea = (m × 2.303 R)

Ea = (-3.70 × 10⁻³ × 2.303 × 8.413)

Ea = -71.68

∴ Activation Energy = 71.68 J mol⁻¹



Extract 16.4: A sample of an incorrect response to question 2 in Alternative Practical B.

In Extract 16.4, the candidate obtained correct data in part (a). However, the conclusion of the relationship between temperature and the rate of reaction was incorrect. Contrary to the established literature, the candidate wrongly stated that temperature and the rate of reaction are inversely related. Due to this incorrect conclusion, the candidate failed to plot the graph, significantly altering the nature of the graph. As a result, the incorrect slope was derived from the graph, leading to an erroneous calculation of the activation energy.

2.2.3 Question 3: Qualitative Analysis Chemistry 2A and 2B

The questions assessed the candidates' competence in carrying out practical activities and making informed observations and inferences of salts under investigation. The sample salts given were copper (II) sulphate ($CuSO_4$) in alternative 2A and iron (II) sulphate ($FeSO_4$) in alternative 2B.

In 732/2A Chemistry 2A, the question was as follows:
*Sample **K** is a simple salt in the laboratory, which contains one cation and one anion. Perform a systematic qualitative analysis experiment to identify the cation and the anion present in the sample based on the following tests and answer the questions that follow.*
*(i) Appearance of sample **K***
*(ii) Action of heat on sample **K** in a test tube*
(iii) Action of dilute sulphuric or hydrochloric acid on the solid sample
(iv) Action of concentrated sulphuric acid on the solid sample
(v) Flame test
(vi) Solubility of the sample
(vii) Confirmatory test for the anion
(viii) Confirmatory test for the cation

Questions

(a) Prepare a relevant Table showing the qualitative analysis results.
(b) What are the cation and anion present in the unknown sample?
(c) Write the reaction equation to indicate what took place in test (vii).

In alternative B, the question was as follows:
*John was complaining of stomach pains after drinking some tea. After diagnosis by the medical doctor, it was noted that the tea might have been contaminated with sample **L**.*
Perform the experiment to identify the cation and anion present in the tea sample based on the following tests and answer the questions that follow:
*(i) Appearance of sample **L***
*(ii) Action of heat on sample **L** in a test tube*
(iii) Action of dilute sulphuric or hydrochloric acid to solid sample
(iv) Action of concentrated sulphuric acid on solid sample
(v) Flame test
(vi) Solubility of the sample
(vii) Confirmatory test for the anion
(viii) Confirmatory test for the cation

Questions

(a) Prepare a relevant Table showing the qualitative analysis results.
*(b) Identify the ions in sample **L**.*
*(c) What is the name of sample **L**?*
(d) Write the reaction equation to indicate what took place in test (viii).
(e) Write the reaction equation to indicate what took place in test (iv).

All 872 candidates (100%) attempted the question. Among them, 625 (71.7%) scored from 10.5 to 15.0 marks; 177 (20.3%) scored from 6 to 10.5 marks; and 70 (8%) scored from 0 to 5.5 marks, as shown in Figure 14.

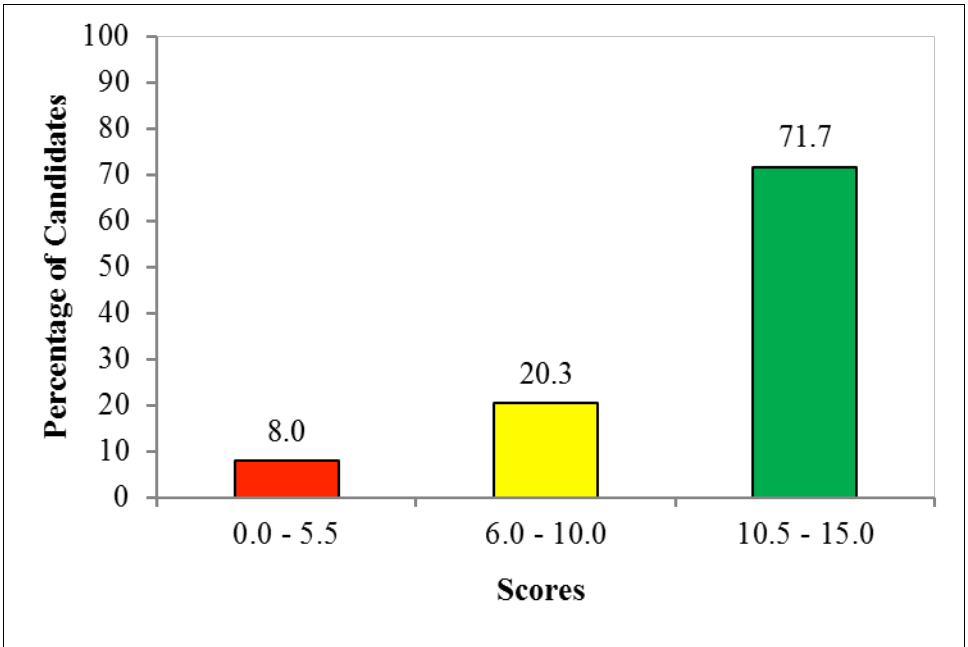


Figure 14: *Candidates' Performance on Question 3*

Figure 14 indicate that the candidates 'performance on this question was good, with 802 (92%) scoring from 6 to 15 marks.

Additionally, the majority of the candidates (92%) scored a pass mark or above. The candidates who had good performance (71.7%) mastered the topic of qualitative analysis and had proficiency in performing experiments in both alternative practicals A and B. Their responses show that those who scored high marks (10.5 to 15.0) in alternative practical A, presented clearly by giving correct observations and inferences in a standard table of results. These candidates correctly identified the cation which was Cu^{2+} and the anion which was SO_4^{2-}. Besides, most of these candidates wrote correct reaction equations to indicate what took place in the test in parts (vi) and (viii). Moreover, in alternative practical B, the candidates correctly identified the cation which was Fe^{2+} and the anion which was SO_4^{2-}. Furthermore, most of the candidates wrote the correct observations and inferences in most parts of the questions. Generally, the candidates were skilled in using qualitative analysis procedures to perform the experiment. Extracts 17.1 and 17.2 show samples of the correct responses to question 3 in alternative practicals A and B, respectively.

3	Experiment	Observation	Inference.
(a)	1) Appearance of sample K		
	i) Colour	Blue	Cu^{2+} may be present
	ii) Texture	Crystalline form	NO_3^-, SO_4^{2-}, Cl^- may be present.
	2) Action of heat on sample K in a test tube	Colourless gas with pungent smell evolves, which turns moist blue litmus paper red	SO_4^{2-} may be present
	3) Action of dilute HCl on a solid sample K	No gas evolves	SO_4^{2-}, NO_3^-, Cl^- may be present
	4) Action of concentrated H_2SO_4 on the solid sample	No gas evolves	SO_4^{2-} may be present.
	5) Flame test	Bluish - Green flame	Cu^{2+} may be present.
	6) Solubility of the sample	Soluble forming blue solution.	Cu^{2+} may be present
	7) Confirmatory test for the anion - A small volume of sample solution into the test-tube, then $BaCl_2$ was added followed by dilute HCl followed by dilute HNO_3	White precipitate insoluble in dilute HCl.	SO_4^{2-} confirmed
	8. Confirmatory test for the cation - A small volume of the sample solution in the		

3 Cont.	test tube, then ammonia solution added drop-wise until in excess	Pale blue precipitate soluble in excess of aqueous ammonia forming a deep blue solution	Cu^{2+} confirmed

(b) The cation is Cu^{2+} and anion is SO_4^{2-} present in the unknown sample.

(c) The reaction equation which took place in test (vii) is

$$CuSO_{4(aq)} + BaCl_{2(aq)} \longrightarrow CuCl_{2(aq)} + BaSO_{4(s)}$$

Extract 17.1: A sample of a correct response to question 3 in Alternative Practical A.

In Extract 17.1, the candidate properly followed the procedures given and gave correct observations, inferences, a balanced chemical equation. Finally, the candidate identified one cation (Cu^{2+}) and one anion (SO_4^{2-}) correctly.

3 (a)

No	PROCEDURE	OBSERVATION	INFERENCE
1	Appearance of sample L (i) colour	Green.	Fe^{2+} Ni^{2+}, Cr^{3+} Cu^{2+} may be present
	(ii) Deliquescence	Absorbs water from the atmosphere to form solution	NO_3^-, Cl^-, SO_4^{2-} may be present.
2.	The action of heat on sample L in a test tube	Reddish brown. residue	Fe^{2+}, Fe^{3+} may be. present.
3.	The action of dilute hydrochloric acid to solid sample. L	No gas evolves.	SO_4^{2-}, Cl^-, NO_3^- may be present
4	The action of concentrated sulphuric acid on a Sample L	Blue crystal turn white	SO_4^{2-} of hydrated Cu^{2+} may. be present.
5	Flame test of the Sample L	Yellow sparks	Fe^{2+}, Fe^{3+} was present.
6	The solubility of the sample L	Soluble in cold water	SO_4^{2-} was present except those of Ba^{2+}, Sr^{2+} Ca^{2+} and Pb^{2+}
7	The confirmatory test for the anion	White precipitate is formed insoluble in dilute HCl	SO_4^{2-} was present and confirmed.

3 Cont.

No	PROCEDURE	OBSERVATION	INFERENCE
8	The confirmatory test for the cation of the sample L	Dark blue precipitate is formed	Fe^{2+} was confirmed

(b) The ions in sample L is Fe^{2+} and SO_4^{2-}

(c) The name of sample L is iron II sulphate ($FeSO_4$)

(d) Required to write the equation that took place in test (viii)

$FeSO_4$ + Potassium hexanoferrate $\rightarrow$ Fe^{2+} confirmed

(e) Required to write the equation that took place in test (~~viii~~)(iv)

$FeSO_4 + H_2SO_4 \rightarrow SO_4^{2-}$ confirmed.

Extract 17.2: A sample of a correct response to question 3 in Alternative Practical B.

In Extract 17.2, the candidate provided correct observations and inferences from the tests performed. In addition, the candidate followed the procedures given and identified the presence of one cation Fe^{2+} and one anion SO_4^{2-} correctly. The candidate also wrote the correct molecular formulae ($FeSO_4$) for sample L.

In contrast, the candidates who scored low marks from (0 to 5.5) in alternative practical A, failed to write correctly in some stages of observations and inferences. For instance, one candidate responded to stage (i) on the appearance of sample K as *white in colour* instead of blue crystals. In stage (iii) and (iv), some candidates incorrectly inferred that the presence of CO_3^{2-} and HCO_3^{2-} theoretically showed that no gas evolved when dilute acid reacted with sulphates. These responses stemmed from incorrect observations and indicate a poor understanding of experimental procedures. Furthermore, some candidates demonstrated poor skills in testing the solubility of the salt. For instance, one candidate responded that *sample '**K**' was insoluble in cold water* while theoretically all sulphates salts are soluble except barium sulphates. In part (c), where the candidate were required to write the equation for the reaction in procedure (vii) some candidate provided incorrect and incomplete equations, indicating a lack of knowledge about the chemical processes taking place.

Similarly, the candidates who scored low marks from (0 to 5.5) in alternative practical B, struggled with performing tests and recording appropriately observations and inferences from the experiment. This led to an incorrect confirmatory test for iron (II) sulphate (sample **L**). For instance, one candidate responded: *Sample **L** was insoluble in cold water*. Another candidate reported that the *solubility of the sample **L** does not dissolve in hot or cold water*. The response was incorrectly stated because theoretically Iron II sulphate is soluble in water. The candidate lacked basic knowledge and competence in conducting salt analysis. Furthermore, in parts (d) and (e) the candidates were required to write the equation for the reactions in procedures (iv) and (viii), respectively. Some of them provided incorrect equations, indicating their lack of understanding of the chemical reaction involved. Other candidates failed to follow the instructions and tests given. This signifies that most of candidates lacked basic knowledge of the procedures for using a qualitative analysis sheet in analysing a salt sample. Extracts 17.3 and 17.4 show samples of the incorrect responses to

Question 3 in Alternative Practicals A and B, respectively.

3	S/N	EXPERIMENT	OBSERVATION	INFERENCE
a	(i)	Appearance of solid sample K	Pale or light green observed	Fe^{2+} may be present
	(ii)	Action of heat on a solid sample K	colourless gas evolves, which turns lime water milky and wet litmus paper from blue to red	CO_3^{2-}, HCO_3^- may be present
	(iii)	Action of dilute sulphuric or hydrochloric acid on the little amount of solid sample K in a test tube followed by 2 drop of HCl	Effervescence of a colourless gas evolves which turns lime water milky and wet litmus paper from blue to red	CO_3^{2-}, HCO_3^- may be present.
	iv	Action of concentrated sulphuric acid on the little amount of solid sample K in the test tube followed H_2SO_4	Effervescence of a colourless gas evolves. The gas turns lime water milky and wet litmus paper from blue to red	CO_3^{2-}, HCO_3^- May be present.
	v	Flame test	Yellow (orange) sparks	Fe^{2+}, Fe^{3+} may be present.

3 Cont.	S/N	EXPERIMENT	OBSERVATION	INFERENCE
	VI	Solubility of the sample K solution	Soluble forming pale green solution	Fe^{2+} may be present
		Solid sample K into test tube and followed cold distilled water		
	VII	Confirmatory test for the anion	white precipitate before warming the content	CO_3^{2-} confirmed
	VIII	confirmatory test for the cation	Deep blue precipitate	Fe^{2+} confirmed
b	Cation is Fe^{2+} Anion is CO_3^{2-}			
c	The reaction equation: $Fe^{2+} + CO_3^{2-} \longrightarrow FeCO_3$			

Extract 17.3: A sample of an incorrect response to question 3 in Alternative Practical A.

In Extract 17.3, most of the observations and inferences provided by the candidate are incorrect. For instance, in part (a) (ii), (iii), and (iv), the candidate wrote the effervescences of a colourless gas evolved which turns lime water milky on action of dilute and concentrated sulphuric acid on the solid sample **K**, instead of the expected observations "no gas evolved" which does not infer the presence of SO_4^{2-} ions. These discrepancies signify a lack of understanding of the test performed in the experiment.

3	S/N	Experiment	Observation	Inference.
(a)	(i)	Appearance of sample L		
		(a) Colour	Pail green	- Transition elements may be present.
		(b) Texture	Crystalline form	- NO_3^-, SO_4^{2-}, Cl^-, $C_2O_4^{2-}$, CrO_4^{2-}, NO_2^- and $Cr_2O_7^{2-}$ may be present.
		(c) Deliquescence	Doesn't absorbs water from the atmosphere	- NO_3^-, Cl^- and SO_4^{2-} are absent.
	(ii)	Action of heat on sample L. About 0.5 g of sample L was taken into dry test tube and ~~was~~ heated.	- Colourless vapour with a smell of vinegar evolves.	CH_3COO^- may be present.
	(iii)	Action of dilute sulphuric or hydrochloric acid. Small amount of sample L was taken followed by addition of dilute HCl,	- Effervescence of a colourless gas	CO_3^{2-}, HCO_3^- may be present.

3 Cont.	S/n	Experment	Observation	Inference.
	(V)	Action of concentrated H_2SO_4 on sample. about 0.5g of a sample L was taken into ~~test~~ dry test tube with the addition of conc. H_2SO_4.	Colourless vapour with vinegar smell evolves.	CH_3COO^- may be present.
	(k)	flame test. a nichrome wire was diped in concentrated HCL and heated in non-luminous flame	Blue grey	Pb^{2+} may be present.
	Vi	Solubility of sample L. A small amount of sample L was taken in a dry test tube followed by addition of distilled water.	insoluble in hot or cold water	CO_3^{2-} may be present
	Vii	Confirmatory test for the anion. about 1cm³ of the solution was transfered in a test tube		

3 Cont.				
	(vii)	with addition of BaCl$_2$. followed by dilute HCl.	White precipitate soluble in dilute HCl is formed	CO_3^{2-} confirmed.
	(viii)	confirmatory for cations. ·few drops of potassium ferro cynide was added in to the solution of the sample	Dark blue precipitate is formed!	Fe^{3+} confirmed.

(b) Cations is Fe^{3+}
Anions is CO_3^{2-}

(c) Sample L is $Fe_2(CO_3)_3$

(d) $Fe_2(CO_3)_3 + K_4Fe_2(CN)_6 \rightarrow Fe_2(CO_3)_3 + K_4(CN)$.

(e) $Fe_2(CO_3)_3 + H_2O \rightarrow 2Fe_2CO_3 + CO_2 + O_2$.

Extract 17.4: A sample of an incorrect response to question 3 in the Alternative Practical B.

In Extract 17.4, the candidate gave incorrect responses almost to all parts of the question. For example, in part (a) (iii) and (iv) the candidate incorrectly wrote the gas evolved during the action of dil. Hydrochloric acid and concentrated sulphuric acid on solid sample **L**. In part (a) (v), the blue grey observed in the flame test does not infer the presence of Fe^{2+} ion. The same applies to parts (a) (vii) and (viii); the confirmatory test does not infer the presence Fe^{2+} and SO_4^{2-} respectively.

3.0 ANALYSIS OF CANDIDATES' PERFORMANCE ON EACH TOPIC

3.1 Analysis of Candidates' Performance on Each Topic in Paper 1

A total of 10 topics were examined in paper 1. The topics covered included; *Analysis of O-level Chemistry Curriculum Materials; Planning and Preparation for Teaching; Environmental Chemistry; Assessment in Chemistry; Volumetric analysis; Chemical Kinetics, Energetics and Equilibrium; Transition Metal Chemistry; Electrochemistry; General Chemistry,* and *Organic Chemistry.*

Good performance was observed on the topics of *Environmental Chemistry* (99.3%), *Planning and Preparation for Teaching* (96.3%) and *Volumetric Analysis* (82.6%). The candidates attained average performance on the topics of *Analysis of O-level Chemistry Curriculum Materials* (69.3%), *Organic Chemistry* (50.1%) and *Transition Metal Chemistry* (45.2%). In contrast, the candidates had poor performance in the topics of *Assessment Procedures in Chemistry* (5.8%), *Electrochemistry* (9.4%), *General Chemistry* (24.8%), and *Chemical Kinetics, Energetics and Equilibrium* (39.9%). A summary of the candidates' performance on each topic in paper 1 has been presented in Appendix I.

Additionally, when comparing the performance in 2023 with that in 2022, there was an excellent improvement in the topic of *Planning and Preparation for Teaching* from (67.9%) in 2022 to (96.3%) in 2023. Other topics improved at an average performance level; *Organic Chemistry* (6.4%) in 2022 to (50.1%) in 2023 and *Transition Metal Elements* from (28.5%) in 2022 to (45.2%) in 2023. However, there was a decline in performance on the topics of *Assessment Procedures in Chemistry* from (87%) in 2022 to (5.8%) in 2023, *Analysis of O-level Chemistry Curriculum Materials* declined from (98.6%) in 2022 to (69.3%) in 2023, *Environmental Chemistry* declined from (95.3%) in 2022 to (89.8%) in 2023 and *Electrochemistry* declined from 23.8 percent in 2022 to 9.4 percent in 2023. Appendix III illustrate the comparison of the candidates' performance per topic for paper 1 in 2022 and 2023.

3.2 Analysis of Candidates' Performance on Each Topic in Paper 2

In each of the three alternatives of Chemistry Paper 2, three topics were assessed. The topics were *Volumetric Analysis*; *Chemical Kinetics, Energetics and Equilibrium*; and *Qualitative Analysis*. The candidates had good performance on all topics of *Volumetric Analysis* (95.8%), *Qualitative Analysis* (92%) and *Chemical Kinetics, Energetics and Equilibrium* (77.9%). A summary of the candidates' performance on each topic in paper 2 has been shown in Appendix II.

When comparing the performance in 2023 with that in 2022, there was a great improvement in *Volumetric Analysis,* from 74.7 per cent in 2022 to 95.8 per cent in 2023; *Qualitative Analysis* from 66.9 per cent in 2022 to 92 per cent in 2023; and *Chemical Kinetics, Energetics and Equilibrium*, from 49.1 per cent in 2022 to 77.9 per cent in 2023. A comparison of the candidates' performance per topic for paper 2 in 2022 and 2023 has been shown in Appendix IV.

4.0 CONCLUSION

The performance in the Chemistry subject on the Diploma in Secondary Education Examination (DSEE) was good since 99.4 per cent of candidates passed. Analysis shows that the candidates' good performance was attributed by their abilities to identify the needs of the questions, sufficient knowledge of the subject matter. However, the Assessment Procedures in Chemistry topic had very weak performance compared to other topics. This implies that many candidates did not develop the expected competences during the course.

5.0 RECOMMENDATIONS

This report makes the following recommendations in light of the findings from the analysis of the candidates' responses to the items in the 2023 DSEE in the Chemistry subject:

(a) Tutors should insist on participatory strategies, such as plenary discussions, role-plays, individual portfolio and critical reflections in the teaching and learning of the *Assessment in Chemistry* topic. This will enable students to apply the competences developed in responding to the questions asked in future examinations.

(b) In teaching the topic of *General Chemistry*, tutors should use models in displaying the atomic structure and scientific experiments behind the discovery of atomic models.

(c) Tutors should insist more on practical approaches/strategies such as demonstration, plenary discussions, individual portfolio and experiments in teaching and learning the topic of *Chemical Kinetics, Energetics and Equilibrium*. This will enable students to develop competences in the topic and apply them in real life situations.

(d) The topic of *Electrochemistry* should be taught by using practicals related to identified problems, activities oriented on different issues raised in the topic and critical reflections on various activities to build students competences in the topic.

APPENDIX I

Summary of Candidates' Performance on Each Topic in Paper 1 (Theory Paper)

S/N	Topic	Question Number	Performance on Each Question (%)	Performance on Each Topic (%)	Remarks
1	Planning and Preparation for Teaching	9	96.3	96.3	Good
2	Environmental Chemistry	11	99.3	89.8	Good
		13	80.3		
3	Analysis of O-level Chemistry Curriculum Materials	8	69.3	69.3	Average
4	Volumetric Analysis	4	82.6	58.5	Average
		14	34.4		
5	Organic Chemistry	7	68.5	50.1	Average
		12	31.7		
6	Transition Metal Chemistry	6	45.2	45.2	Average
7	Chemical Kinetics, Energetics and Equilibrium	2	45.4	39.9	Weak
		3	12.7		
8	General Chemistry	1	24.8	24.8	Weak
9	Electrochemistry	5	9.4	9.4	Weak
10	Assessment in Chemistry	10	5.8	5.8	Weak

APPENDIX II

Summary of Candidates' Performance on Each Topic in Paper 2 (Actual Practical)

S/N	Topic	Question Number	Performance on Each Question (%)	Performance on Each Topic (%)	Remarks
1	Volumetric Analysis	3	95.8	95.8	Good
2	Qualitative Analysis	1	92	92	Good
3	Chemical Kinetics, Energetics and Equilibrium	2	77.9	77.9	Good

APPENDIX III

Comparison of the Candidates' Performance per Topic in paper 1 2022 and 2023

APPENDIX IV

S/N	Topic	2022			2023		
		Number of Question	Performance on each Question (%)	Remarks	Number of Questions	Performance on each Question	Remarks
1	Analysis of O'level Chemistry Curriculum Materials	1	98.6	Good	1	69.3	Average
2	Environmental Chemistry	1	95.3	Good	2	89.8	Good
3	Assessment in Chemistry	1	87.0	Good	1	5.8	Weak
4	Planning and Preparation for Teaching	1	67.9	Average	1	96.3	Good
5	Volumetric Analysis	2	63.0	Average	2	58.5	Average
6	Chemical Kinetics, Energetics and Equilibrium	2	50.3	Average	2	39.9	Average
7	Transition Metal Chemistry	1	28.5	Weak	1	45.2	Average
8	Electrochemistry	1	23.8	Weak	1	9.4	Weak
9	General Chemistry	1	10.2	Weak	1	24.8	Weak
10	Fundamentals of Teaching and Learning Chemistry	1	8.9	Weak			
11	Organic Chemistry	2	6.4	Weak	1	50.1	Average

Comparison of the Candidates' Performance per Topic in Paper 2 DSEE 2022 and 2023

S/N	Topic	2022			2023		
		Number of Question	Performance on each Question (%)	Remarks	Number of Questions	Performance on each Question (%)	Remarks
1	Volumetric Analysis	1	66.9	Average	1	95.8	Good
2	Qualitative Analysis	3	79.7	Good	3	92	Good
3	Chemical Kinetics, Energetics and Equilibrium	2	49.1	Average	2	77.9	Good