THE UNITED REPUBLIC OF TANZANIA
MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY
NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

CANDIDATES' ITEM RESPONSE ANALYSIS REPORT ON THE CERTIFICATE OF SECONDARY EDUCATION EXAMINATION (CSEE) 2022

CHEMISTRY

THE UNITED REPUBLIC OF TANZANIA

MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

CANDIDATES' ITEM RESPONSE ANALYSIS REPORT ON THE CERTIFICATE OF SECONDARY EDUCATION EXAMINATION (CSEE) 2022

032 CHEMISTRY

Published by
The National Examinations Council of Tanzania,
P.O. Box 2624,
Dar es Salaam, Tanzania.

TABLE OF CONTENTS

FOREWORD

The Candidates' Item Response Analysis (CIRA) Report in Chemistry subject on the Certificate of Secondary Education Examination (CSEE) 2022 has been prepared to provide feedback to teachers, candidates, parents, policy makers and the public in general about the performance of the candidates and the challenges they experienced in attempting the examination.

The Certificate of Secondary Education Examination is a four-year summative evaluation, which among other things, shows the effectiveness of the education system in general and the education delivery system in particular. Essentially, candidates' responses to the examination questions is a strong indicator of what the education system was able or unable to offer to the candidates in their four years of secondary education.

The analysis presented in this report provides some insights on the performance of the candidates in Chemistry subject. The analysis indicates that the candidates who scored high marks had adequate knowledge of the tested concepts in Chemistry, and managed to apply mathematical skills in responding to some questions. However, those who scored low marks lacked adequate knowledge about the subject matter and failed to identify the demands of most of the questions. In addition, the candidates with low scores had insufficient mathematical skills and English language proficiency.

The feedback provided in this report will enable education administrators, school managers, teachers and candidates to identify proper measures to be taken to improve candidates' performance in future examinations administered by the Council.

The National Examinations Council of Tanzania appreciates the valuable contribution of all individuals who enhanced the preparation of this report in various capacities.

Dr. Said Ally Mohamed
EXECUTIVE SECRETARY

1.0 INTRODUCTION

This report analyses the performance of the candidates who sat for the Certificate of Secondary Education Examination (CSEE) 2022 in Chemistry subject. The Chemistry examination was set according to the 2019 CSEE format, which was developed from the 2007 Chemistry syllabus for ordinary level secondary education.

The examination consisted of two papers, namely 032/1 Chemistry 1 (Theory paper) and 032/2 Chemistry 2 (Actual practical paper). The theory paper comprised of sections A, B and C. Section A consisted of two objective questions. Question 1 consisted of ten multiple choice items, while question 2 consisted of five matching items. Each item in question 1 and 2 carried one mark, making a total of 10 marks for question 1, and 5 marks for question 2. Section B consisted of ten-short answer questions which carried 10 marks each. Section C comprised two essay questions which carried 10 marks each. The candidates were required to answer all the questions in sections A and B, and only one question from section C.

The practical paper had 3 alternative papers, namely 032/2A Chemistry 2A, 032/2B Chemistry 2B, and 032/2C Chemistry 2C. Each alternative paper consisted of two compulsory questions, carrying 25 marks each.

A total of 155,007 candidates sat for the Chemistry examination in CSEEE 2022. The overall candidates' performance was good as 93.68 per cent of the candidates passed the examination. The candidates' performance in 2022 has increased by 1.66 compared to the candidates' performance in 2021, which was 92.02 per cent (see the Appendix).

The analysis report comprises five sections. The first section provides the introduction which covers the background information, rubric and summary of the candidates' performance. The second section presents the analysis of the candidates' performance in each question. This section is supplemented with copies of actual scripts (extracts) showing sample of candidates' responses. The third section covers the analysis of candidates' performance topic-wise, while the fourth section offers conclusion and recommendations.

2.0 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION

Candidates' performance in this analysis has been categorized into the percentage of full marks in the intervals of 0 – 29, 30 – 64, and 65 – 100, which are classified as poor, average or good respectively, (see the Appendix).

2.1 032/1 CHEMISTRY 1

This paper had a total of 14 questions; two questions in section A, ten questions in section B and two questions in section C. In section A, question 1 carried a total of ten (10) marks, while question 2 carried five (05) marks. Each question in sections, B and C carried 7 marks and 15 marks, respectively. All questions in sections A and B were compulsory, however, the candidates were required to attempt only one question in section C.

2.1.1 Section A: Objective Questions

This section consists of two objective questions. The candidates were required to answer both questions in this section.

2.1.1.1 Question 1: Multiple Choice Items

The question consisted of 10 multiple choice items set from eight (8) topics, which were Water; Atomic Structure; Fuels and Energy; Matter; Organic Chemistry; Laboratory Techniques and Safety; Non-Metals and Their Compounds, and Air, combustion, Rusting and Fire fighting. In each item, the candidates were required to choose the correct answer from the given alternatives, A to E and write its letter beside the item number in the answer booklet provided.

This question was attempted by 155,437 candidates (100%). The analysis of the candidates' performance indicates that 5.18 per cent scored from 0 to 2 marks, 56.81 per cent scored from 3 to 6 marks, while 38.01 per cent scored from 7 to 10 marks. Generally, the performance in this question was good because 94.82 per cent of the candidates scored 3 marks or above. The candidates' performance in this question is summarized in Figure 1.

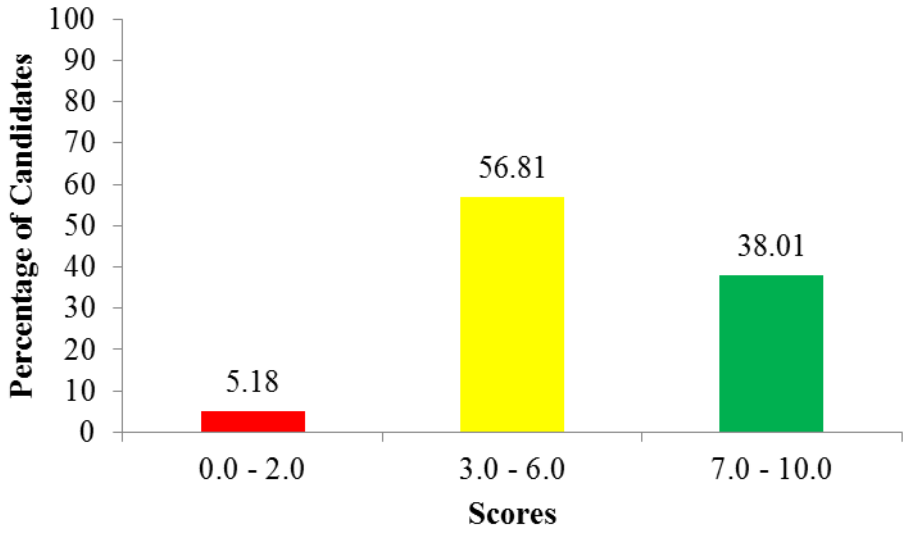


Figure 1: *Candidates' Performance in Question 1*

In item (i), the candidates were required to identify the property of water. The correct answer was *B, It is neither acidic nor basic.* Candidates who opted for the correct answer had adequate knowledge that the pH of water is neutral. The candidates who chose distractor *A, It is a very good solvent* did not realize that being solvent is not a chemical property. Those who opted for distractor *C, It has higher surface tension* did not realize that there are other liquids with much higher surface tension than water. Candidates who wrote distractor *D, It can exist in three states of matter* considered the existence of water in form of ice, liquid and vapour, as a chemical, instead of physical property. Similarly, those who chose distractor *E, It expands when it freezes* were not aware that the anomalous expansion of water is purely a physical property.

In item (ii), the candidates were required to identify the maximum number of electrons that could be accommodated by the innermost shell of atoms. The correct answer was *D, 2*. Candidates who chose the correct answer had enough knowledge that first shell can carry not more than two electrons (doublet rule). Those who opted for distractors *A, 3; B, 1* or C, *4* did not understand the rules that guide the filling of electrons in shells. Those who opted for distractor *E, 8* confused the doublet with octet rule which directs the filling of electrons in other shells rather than the innermost shell.

In item (iii), the candidates were required to identify the criterion for good fuel among others. The correct answer was *A, High speed of continous energy supply*. The candidates who chose the correct answer understood that a good fuel should supply energy continuously at a high rate once burnt. Similarly, the candidates who chose distractor *B, High energy value supplied*, were also correct bacause high energy value supplied means high caloric value which does not depend on the amount of mass. Candidates who opted for either distractor *C, Low carbondioxide supplied* or *D, High carbondioxide production* confused the main product of combustion (carbondioxide) with the qualities for a good fuel. The candidates in this category also considered that carbondioxide gas is useful, despite the fact that it pollutes the environment. The candidates who opted for *E, High content of non-combustable material* did not realize that a good fuel should have low content of non-combustible material.

In item (iv), the candidates were asked *What conclusion can be drawn from the random movement of pollen grains suspended in air?* The correct answer was *C, Matter is particulate in nature*. The candidates who got the correct answer had adequate knowledge about the kinetic nature of matter. The candidates who chose distractor *A, Matter is lighter in nature* incorrectly generalized all matter to be lighter in nature, where-as some matter is heavy. Those who chose distractor *B, Matter is solid in nature* had a misconception that matter exists only in one state (solid). This was, however, not correct because matter can exist in either of the three states depending on the conditions. The candidates who opted for distractor *D, Mattter is gaseous in nature* did not realize that the same matter can exist in solid or in liquid form. Similarly, the candidates who opted for distractor *E, Matter is wave in nature* had no adequate knowledge on the experiment used to verify that matter is made up of particles.

In item (v), the candidates were asked *Which energy source can be reused after being exploited?* The correct answer was *C, Renewable source*. The candidates who chose the correct answer had sufficient knowledge that renewable energy sources can be replenished after exploitation. The candidates were aware that these sources of energy are categorised as renewable sources. The candidates who chose distractor *A, Combustible source* confused the concept of combustion with types of

fuels. Those who chose distractor *B, Non renewable source* did not understand that non-renewable sources of energy such as fossils can not be reused after exploitation. The candidates were supposed to know that renewable sources of energy are those that can be replaced within a short period of time, and can be utilized again, for example wind and solar energy. The candidates who opted for either distractor *D, Synthetic Source* or *E, Natural source* lacked adequate knowledge about classification of energy based on the sources (synthetic and natural source).

In item (vi), the candidates were required to identify the formula for *prop-1-ene.* The correct answer was *E,* CH_3CHCH_2. The candidates who chose the correct answer had adequate knowledge that prop-1-ene is an alkene derived from the general formula C_nH_{2n}, and its number of carbon atoms (n) is 3. The candidates who opted for distractor *A,* C_3H_5*; B;* CH_3CCH*; C,* C_3H_4 or *D,* HCH_2CCH failed to determine the number of hydrogen atoms in propene. Basically, the candidates lacked adequate knowledge about homologous series.

In item (vii), the candidates were required to identify the instrument which was not a component of the First Aid Kit. The correct answer was C, *Knife*. The candidates who chose the correct answer had adequate knowledge about the items found in the First Aid Kit and their uses. The candidates who chose distractor *A, Goggles* were not aware that goggles are used for protection of eyes. The candidates who opted for distractors *B, Pair of scissors* or *E, Razor blade* failed to understand the function of scissor and razor blade is to cut dressing materials. Those who opted for distractor *D, Gloves* failed to understand that the function of gloves is to cover the hands of the person who administers first aid to avoid infection and direct contact with the victim's body fluid.

In item (viii) the candidates were required to identify the element which is oxidized in the reaction $2FeSO_4 + Cl_2 + H_2SO_4 \rightarrow Fe(SO_4)_3 + 2HCl$. The correct answer was distractor *E, Iron*. The candidates who gave the correct answer had good understanding of the concept of oxidation and reduction. Thus, they were able to notice that, iron was oxidized because its oxidation number changed from 2^+ to 3^+. Those who chose distractor *A, Chlorine* did not realize that oxidation number of chlorine decreased from 0 to -1 hence, it was reduced in that reaction. The candidates who

opted for either distractor *B, Hydrogen;* or *C Oxygen,* were not aware that these elements were neither oxidized nor reduced in the process.

In item (ix), the candidates were tasked to identify the components of fire. The correct answer was *E, Oxygen, fuel and heat*. The candidates who chose the correct answer had adequate knowledge about the basic requirements to start fire. The candidates who chose distractor *A, Match box, fire wood and kerosene* did not realize that it is impossible to make fire without oxygen and heat. Those who chose distractor *B, Match box, fire wood and oxygen* were not aware that heat was missing. The candidates who opted for distractor *C, Oxygen , fuel and fire wood* did not understand that fire-wood is a type of fuel, hence, since there is no heat fire will not start. Similarly, the candidates who opted for *D, Oxygen ,heat and match box* failed to understand that match box is not a component needed to start fire.

In item (x), the candidates were asked *Why is nitrogen formed first during fractional distillation of air?* The correct answer was *E, It has got low boiling point.* The candidates who chose the correct answer had good knowledge that air is a mixture of miscible components having close boiling points, and cannot be separated by simple distillation, but fractional distillation. In relation to other components of air, nitrogen gas has got lower boiling point, hence formed first during fractional distillation. The candidates who opted for distractor *A, It has got high boiling point* failed to understand that a component with high boiling point does not evaporate easily. Those who chose distractor *B, It has got low density* confused the term density with boiling point. Similarly, the candidates who wrote distractor *C, It has got low melting point* associated the fractional distillation with the parameter of melting instead of boiling point which was not correct. Distractor *D, It has got high density* was opted by the candidates who confused the property of heavy substances to settle at the bottom with the concept of boiling point in fractional distillation.

2.1.1.2 Question 2: Matching Items

The question was set from the topic of *Chemical Kinetics, Equlibrium and Energetics*, and it consisted of five premises in List A to be matched with seven responses,in List B as follows:

List A	***List B***
(i) Increases colliding particles per time	*A Increase in temperature*
(ii) Favours endothermic reaction	*B Increase in surface area*
(iii) Increases the speed to reach equilibrium	*C Increase in pressure*
(iv) Favours the side with fewer molecules	*D Increase in concentration*
(v) Favours more products on opposite side	*E Introducing a catalyst*
	F Decrease in temperature
	G Decrease in pressure

The question was attempted by 155,437 candidates (100%). 32.23 per cent scored from 0 to 1 mark while 47.03 per cent scored from 2 to 3 marks. The candidates who scored from 4 to 5 marks were 20.74 per cent, including 12.58 per cent who scored full marks. Generally, the candidates' performance in this question was good as 67.77 per cent of the candidates scored 2 marks or above. The summary of candidates' performance in this question is shown in Figure 2.

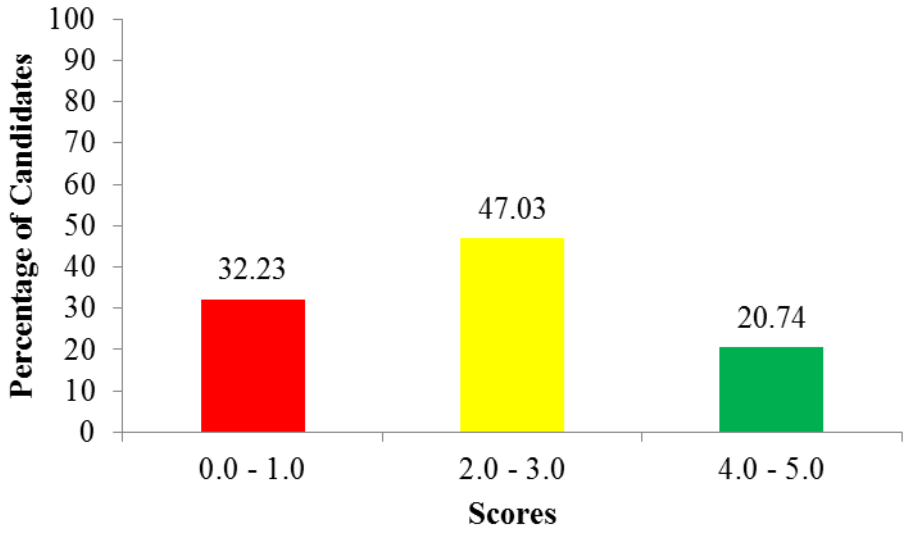


Figure 2: *Candidates' Performance in Question 2*

The candidates who scored high marks (20.74%) in this question matched the items given correctly. This indicates that they had adequate knowledge on the factors affecting the rate of chemical reaction. Extract 2.1 is a sample of correct responses from one of the candidates to this question.

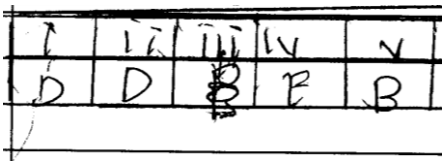
2	(i)	(ii)	(iii)	(iv)	(v)
	B	A	E	C	D

Extract 2.1: A sample of correct responses to question 2

In extract 2.1, the candidate correctly matched all the items in **List A**, which explained the effects on the rate of chemical reaction with their physical conditions in **List B**.

However, some of the candidates who scored low marks (32.23%) failed to attempt most of the items. They related the effects on the rate of chemical reaction with inappropriate physical conditions. For instance, there were candidates who incorrectly associated item *(i) Increases colliding particles per time* with response *F decrease in temperature* instead of response *B Increase in surface area*. Other candidates incorrectly related *(ii) Favours endothermic reaction* with *G Decrease in pressure* instead of *A Increase in temperature*. Also, in item *(iii), Increases the speed to reach equilibrium* matched with *E, Introducing a catalyst*, but some candidates wrote *C Increase in pressure*. Some of

them incorrectly identified *E, Introducing a catalyst* as the factor which favours the side with fewer molecules in item (iv). The candidates failed to understand that the role of catalyst is to alter the rate of chemical reaction. Others opted for *B, Decrease in temperature* , as a factor which favours a side with fewer molecules. The candidates also matched item *(v) Favours more products on opposite side* with response *E, Introducing a catalyst*, which was incorrect. Generally, in this category, the candidates had inadequate knowledge about factors affecting rate of chemical reactions and position of chemical equilibrium, thus performed poorly. A sample of incorrect responses is shown in extract 2.2



Extract 2.2: A sample of incorrect responses to question 2

In extract 2.2, the candidate matched all the items incorrectly.

2.1.2 Section B: Short Answer Questions

This section consisted of 10 questions. The candidates were required to answer all the questions.

2.1.2.1 Question 3: Matter

The question consisted of two parts, namely (a) and (b), as follows:

(a) How useful is mattter in our daily life? Give four points with an example for each.

(b) Why are the chemical symbols important in chemistry? Give three reasons.

A total of 155,437 candidates (100%) attempted this question in which 23.76 per cent scored from 0 to 2 marks. Candidates who scored from 2.5 to 4.5 marks were 37.53 per cent, while those who scored from 5 to 7 marks were 38.71 per cent. The general performance was good because 76.24 per cent of the candidates scored 2.5 marks or above. Figure 3 gives a summary of the candidates' performance in question 3.

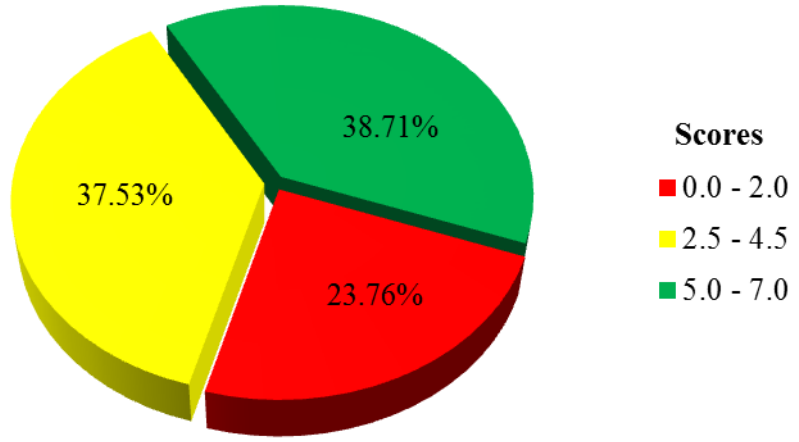
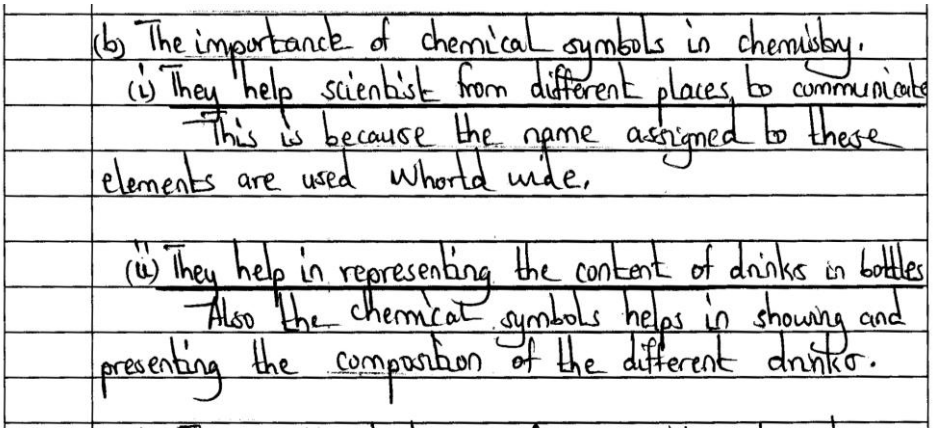


Figure 3: *Candidates' Performance in Question 3*

The candidates who scored high marks (38.71%) had adequate knowledge of the application of matter in daily life, in part (a). Most of the candidates cited uses of matter according to Chemistry and daily life experience. Likewise, they had appropriate skills on the concept of chemical symbols of elements, which enabled them to provide correct responses in part (b). Extract 3.1 shows a sample of correct responses from one of the candidates.

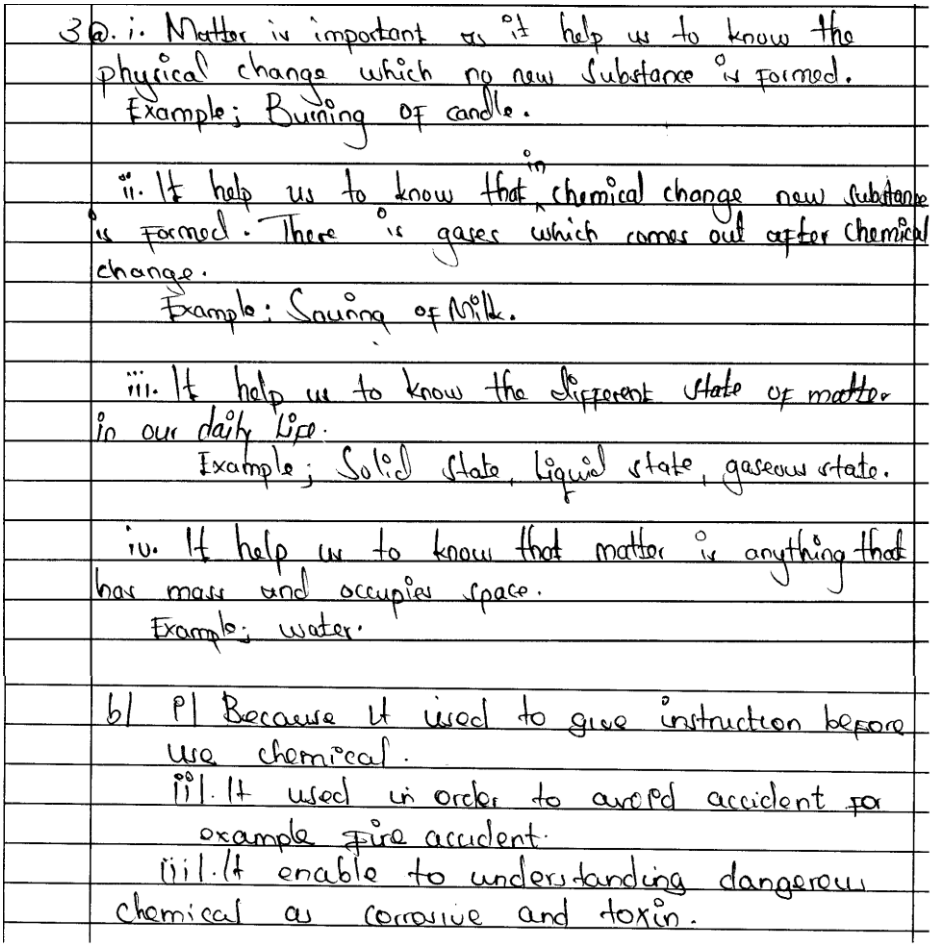
3 (a) The usefulness of matter in our daily life is as.
(i) Stones as matter helps in ~~and~~ construction of building. example stone for building foundations
(ii) Water as matter helps in conducting irrigation activities example Water,
(iii) Wood as matter helps in making furnitures and other goods. example Wood, chair
(iv) Air as matter enables us to breath and live example air, oxygen



Extract 3.1: A sample of correct responses to question 3

In extract 3.1, the candidate attempted all parts of the question correctly by stating four applications of matter in daily life in part (a). Also, in part (b), he/she wrote correctly three points on the importance of chemical symbols in Chemistry.

However, some candidates who scored low marks (23.76%) failed to attempt most parts of the question. For instance, in part (a), one candidate incorrectly wrote "matter changes from solid to liquid". Another candidate incorrectly wrote "Matter have both physical and chemical properties". Some of the candidates gave examples of matter without giving their uses. Other candidates gave the three states of matter with examples, contrary to the requirement of the question. This suggests that the candidates lacked adequate knowledge about the application of matter. Similarly, in part (b), some of the candidates wrote procedures of writing chemical equations instead of the importance of chemical symbols. Other candidates wrote chemical symbols for some of the first twenty elements of the Periodic Table. The candidates in this category lacked knowledge about the concept of chemical symbols and its significance. Extract 3.2 shows a sample of incorrect responses from one of the candidates.



Extract 3.2: A sample of incorrect responses to question 3

In extract 3.2, the candidates attempted all parts of the question but failed to write the correct application of matter in daily life in part (a). Furthermore, he/she failed to give reasons as to why chemical symbols are important in Chemistry.

2.1.2.2 Question 4: Chemical Kinetics, Equlibrium and Energetics

The question comprised parts (a), (b) and (c). The candidates were asked as follows

Zinc granules were placed in a beaker containing excess dilute sulphuric acid standing on a direct reading balance. The mass of a beaker and its contents were recorded after every two seconds as shown in Table 1"

Table 1

Time (s)	*0*	*2*	*4*	*6*	*8*	*10*
Mass (g)	*110.20*	*110.10*	*110.00*	*108.50*	*107.20*	*107.20*

Then, candidates were required to answer the following questions:

(a) *Why was there a loss in mass?*

(b) *Why did the mass remained constant after the eighth second?*

(c) *Briefly explain what would happen to the rate of reaction if zinc powder was used instead of granules.*

The question was attempted by 155,437 candidates (100%). 65.52 per cent scored from 0 to 2 marks, whereas 14.59 per cent scored from 2.5 to 4.5 marks. The analysis indicates that only 19.89 per cent scored from 5 to 7 marks. Generally, the performance of the candidates in this question was average as 34.48 per cent scored 3 marks or above. The candidates' performance is summarized in Figure 4.

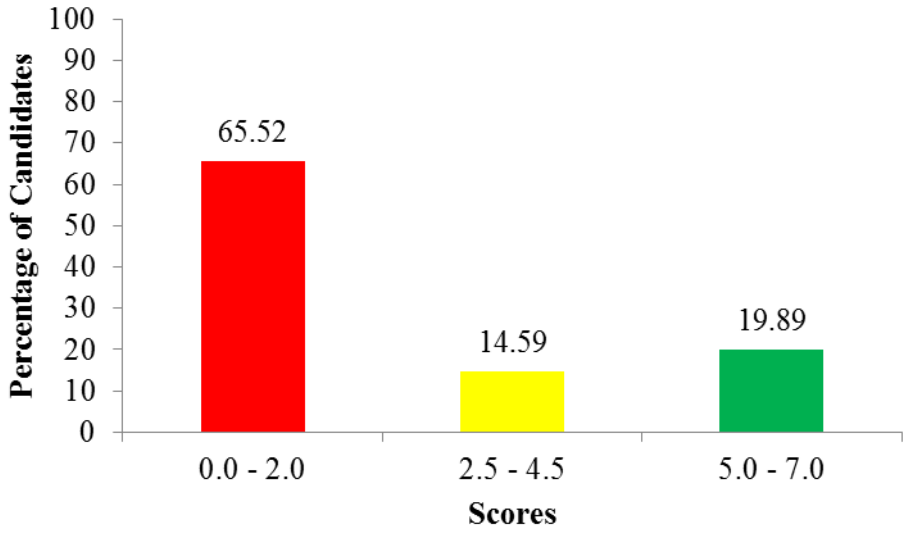
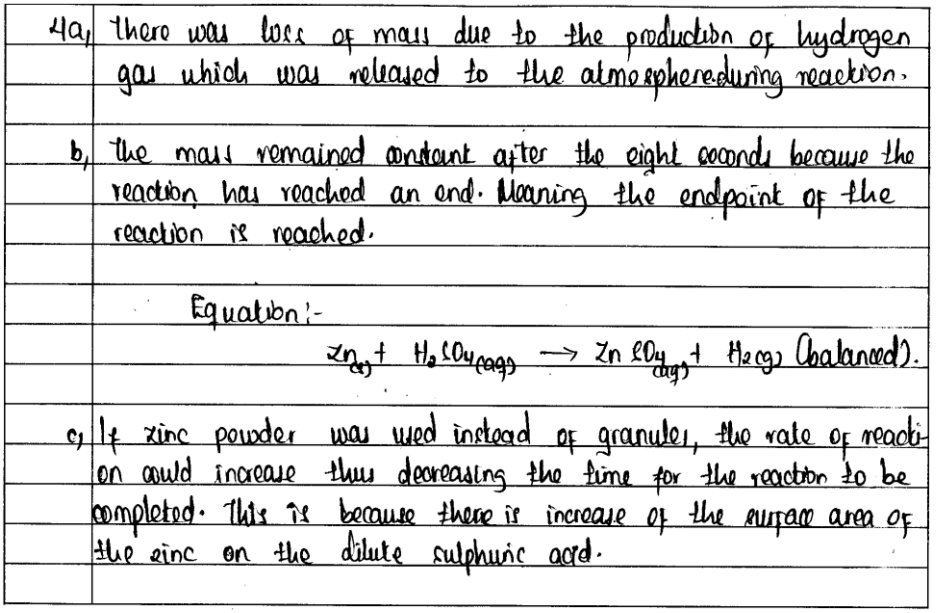


Figure 4: *Candidates' Performance in Question 4*

The candidates who scored high marks (19.89%) gave correct explanations about the observations, in part (a) – (c). They were able to clarify that zinc would displace hydrogen atom from sulphuric acid to liberate hydrogen gas, in part (a). Likewise, in part (b), the candidates associated the effect of concentration with the rate of chemical reaction. Moreover, in part (c), the candidates indicated that zinc powder had

large surface area which increases the rate of reaction by increasing number of particles available for the reaction with dilute sulphuric acid. Extract 4.1 shows a sample of correct responses from one of the candidates.


4a) There was loss of mass due to the production of hydrogen gas which was released to the atmosphere during reaction.

b) The mass remained constant after the eight seconds because the reaction has reached an end. Meaning the endpoint of the reaction is reached.

Equation:-

$Zn_{(s)} + H_2SO_{4(aqg)} \longrightarrow ZnSO_{4(aq)} + H_{2(g)}$ (balanced).

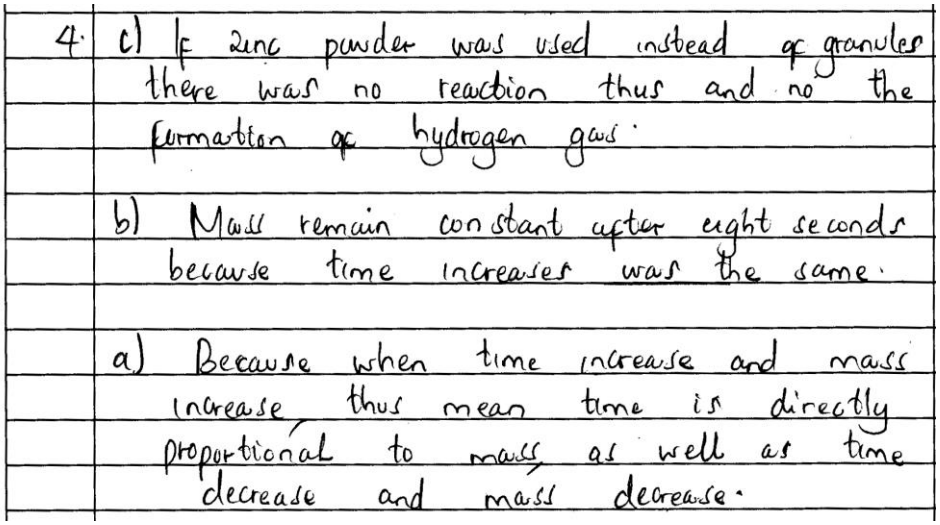
c) If zinc powder was used instead of granules, the rate of reaction would increase thus decreasing the time for the reaction to be completed. This is because there is increase of the surface area of the zinc on the dilute sulphuric acid.

Extract 4.1: A sample of correct responses to question 4

In extract 4.1, the candidate provided correct reasons for the decrease in mass of beaker and its contents, in part (a). Also, the candidate gave a reason for the mass of beaker and contents to remain constant after eight seconds of the reaction, in part (b). Lastly, he/she explained the effect of surface area on the rate of chemical reaction, in part (c), correctly.

On the other hand, the candidates who scored low marks (65.52%) did not attempt most parts of the question correctly. For example, in part (a), some of the candidates wrote “because sulphuric acid was dilute”. Others wrote that “the acid was not concentrated”. Those candidates failed to understand that zinc being on top of hydrogen in reactivity series, can displace hydrogen from dilute sulphuric acid to form hydrogen gas which escapes from the beaker and lead to the loss of mass of the contents. Also, in part (b), some candidates gave irrelevant reasons for the mass to remain constant, such as low temperature, and low concentration of the acid. Other candidates responded incorrectly that sulphuric acid was finished in the reaction. These candidates were

not aware that zinc was the limiting reagent, and that dilute sulphuric acid was in excess. Furthermore, in part (c), some of the candidates responded incorrectly that zinc powder was used because it is fine. Furthermore, other candidates had incorrect notion that zinc powder occupies small area or had reduced small volume. In general, the candidates failed to understand that zinc powder has a large surface area compared to unground zinc. Extract 4.2 shows a sample of incorrect responses from one of the candidates.


4. c) If zinc powder was used instead of granules there was no reaction thus and no the formation of hydrogen gas.

b) Mass remain constant after eight seconds because time increases was the same.

a) Because when time increase and mass increase, thus mean time is directly proportional to mass as well as time decrease and mass decrease.

Extract 4.2: A sample of incorrect responses to question 4

In extract 4.2, the candidate gave incorrect reasons to all parts of the question.

2.1.2.3 Question 5: Organic Chemistry

The question had two parts, namely (a) and (b). The candidates were asked as follows:

A certain compound with the molecular mass of 28 was analysed and found to be composed 0.6 g of carbon and 0.1 g of hydrogen.
(a) Workout its empirical formula and molecular formula.
(b) Classify the compound to its homologous series.

The question was attempted by 155,437 candidates (100%). 31.12 per cent of the candidates scored from 0 to 2 marks while 16.63 per cent scored from 2.5 to 4.5 marks. The analysis shows that 52.25 per cent scored from 5 to 7 marks. Generally, performance of the candidates in

this question was relatively good as 64.88 per cent of the candidates scored 5 marks or above. The performance of the candidates is summarized of in Figure 5.

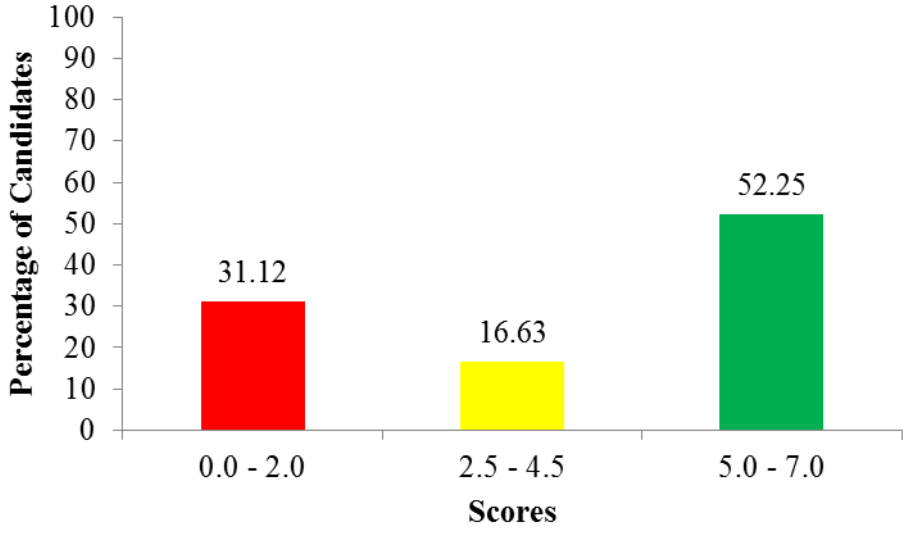


Figure 5: *Candidates' Performance in Question 5*

The candidates who scored high marks (52.25%) had adequate knowledge, and demonstrated necessary mathematical skills in the calculation of empirical and molecular fromula from the given masses. In part (b), the candidates correctly identified alkene as the homologous series to which the compound belonged. This implies that the candidates had sufficient knowledge on the properties of homologous series of hydrocarbons. Extract 5.1 shows a sample of correct responses from one of the candidates.

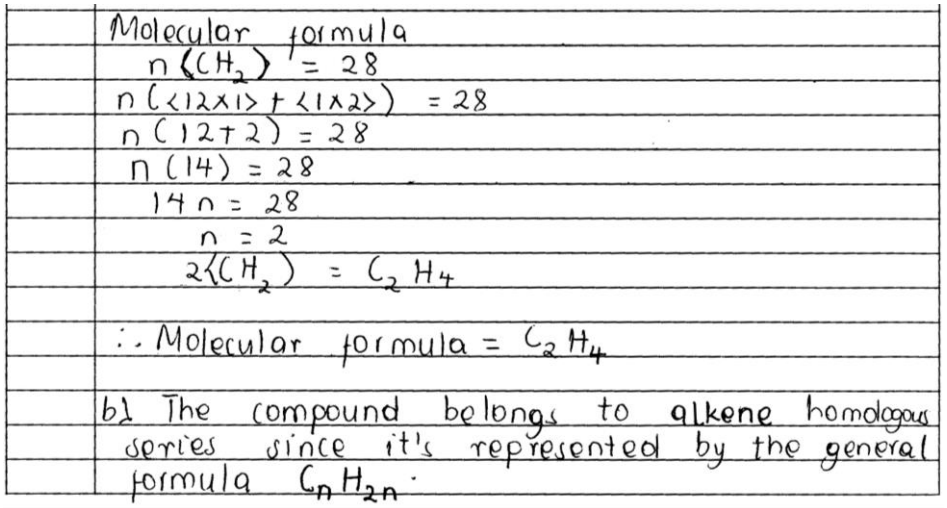
5- Required to: find empirical and molecular formula.

a) .

Solution.

Elements present	C	H
Mass composition (g)	0·6	0·1
Relative molecular mass	12	1
Divide mass composition with RMM	$0{\cdot}6/12 = 0{\cdot}05$	$0{\cdot}1/1 = 0{\cdot}1$
Divide both by the smallest number	$0{\cdot}05/0{\cdot}05 = 1$	$0{\cdot}1/0{\cdot}05 = 2$
	1	2

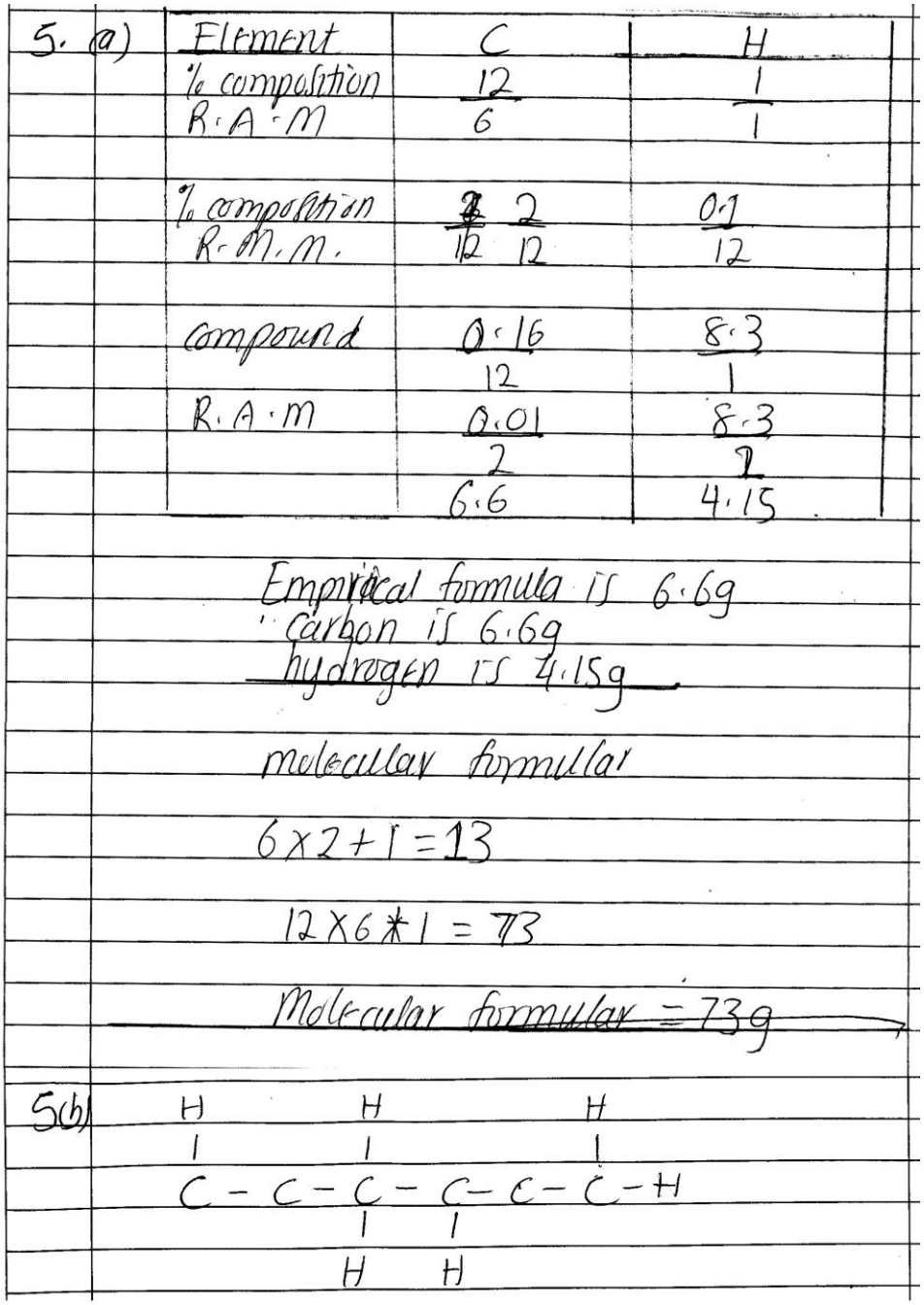
∴ Empirical formula = CH_2.



Extract 5.1: A sample of correct responses to question 5

In extract 5.1, the candidate calculated the empirical formula and molecular formula correctly in part (a). He/she correctly classified the compound by identifying its homologous series which is alkene in part (b).

However, the candidates who scored low marks (31.12%) in this question had poor mathematical skills on the steps to be followed while calculating empirical and molecular formula. Some candidates used molecular masses of the elements instead of atomic masses. Also, some candidates divided the atomic masses to the mass composition instead of dividing mass composition over atomic mass. In part (b), some of the candidates wrote incorrect homologous series, such as alkane and alkynes. The candidates had inadequate knowledge about organic compounds. Extract 5.2 shows a sample of incorrect responses in question 5.



Extract 5.2: A sample of incorrect responses to question 5

In extract 5.2, the candidate incorrectly regarded the atomic masses of the elements as percentage composition of carbon and hydrogen in part (a). He/she divided the values obtained in the first stage with atomic masses instead of dividing with the smallest value. Furthermore, the candidate wrote numbers, instead of empirical/molecular formula.

He/she gave structural formula instead of the homologous series, in part (b), thus failed to score marks in this question.

2.1.2.4 Question 6: Ionic Theory and Electrolysis

The question was asked as follows:

A Form Three student conducted an experiment to prepare a gas in the laboratory by decomposing a compound using electricity. A steady current was allowed to flow through the solution for 3 hours. At s.t.p 4.12 dm^3 of the gas which relighted the glowing splint was produced.

(a) What terminology is used to refer to such experiment set up?

(b) Work out the current flowing in the circuit.

A total of 155,437 (100%) candidates attempted this question. The candidates' performance indicates that 72.19 per cent scored from 0 to 2 marks, 17.69 per cent scored from 2.5 to 4.5 marks, whereas 10.12 per cent scored from 5 to 7 marks were. Generally, the performance in this question was weak because only 27.81 per cent of the candidates scored 2.5 marks or above. The summary of the candidates' performance is shown in Figure 6.

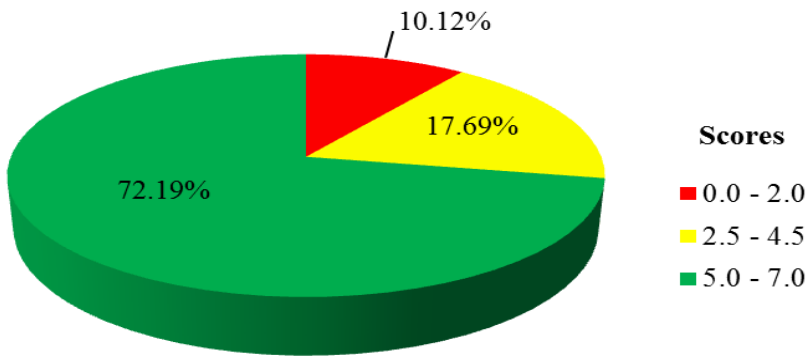
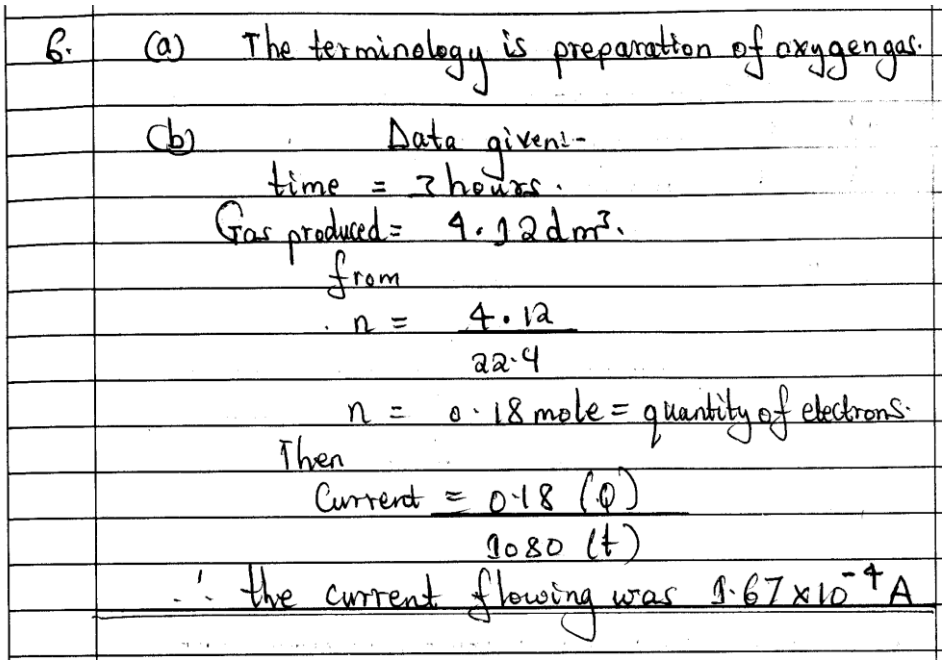


Figure 6: *Candidates' Performance in Question 6*

The candidates who scored low marks (10.12%) failed to attempt most parts of the question. For example, in part (a), some candidates wrote "electricity" instead of electrolysis. Other common responses due to candidates' misconceptions in this part were *decomposition, electrolytes*

and *electrodes*. Those candidates confused terms which are covered in electrolysis. This was attributed to insufficient knowledge about the concept of elctrolysis. The candidates were supposed to understand that electrolysis is the process in which a substance in acqueous solution or in molten state produce free ions by passing electric current through it. In part (b), most of the candidates carried the calculation wrongly. For, instance, some of them failed to convert minutes (time) given into seconds. Other candidates incorrectly multiplied the volume of oxygen gas with time, a step which was not appropriate. Also, the candidates failed to write a balanced chemical equation for the liberation of oxygen gas. As a result, they got wrong number of Farads required to liberate one mole of oxygen gas. additionally, there were candidates who applied incorrect formulae. For example, one candidate wrote that $Current = charge \times time$. Generally, the candidates failed to apply the Faraday's first law of electrolysis in calculating the current which was flowing through the circuit. Extract 6.1 shows a sample of incorrect responses in question 6.


6. (a) The terminology is preparation of oxygen gas.

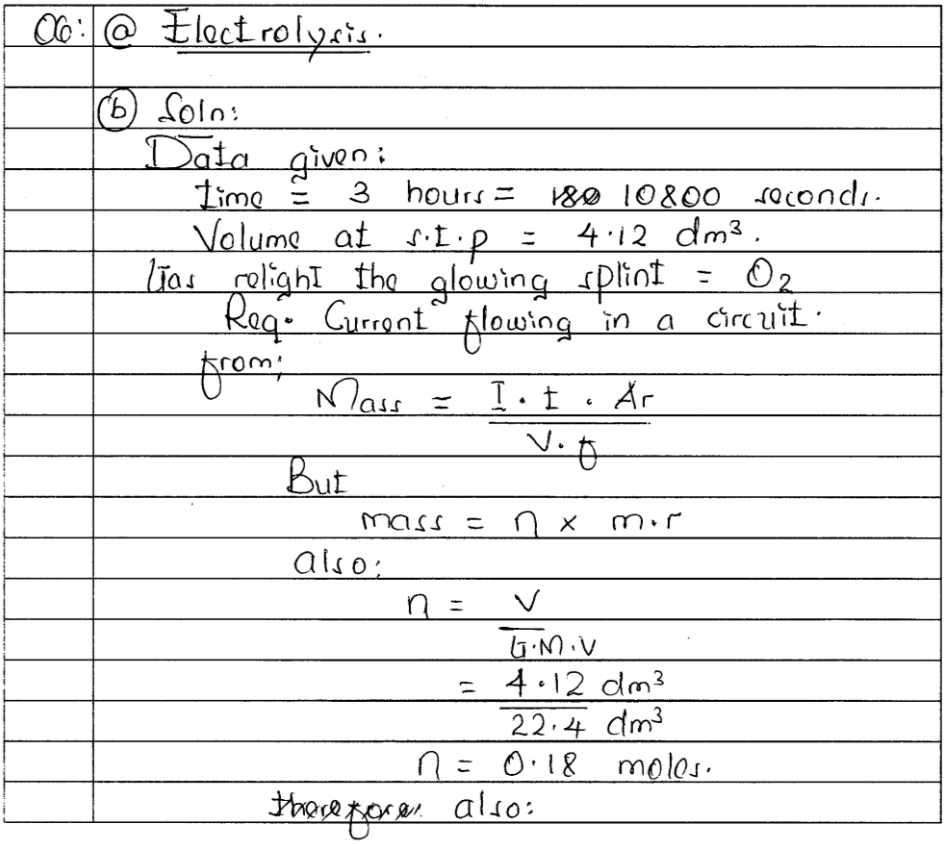
(b) Data given:-
time = 3 hours.
Gas produced = 4.12 dm³.
from
$n = \frac{4.12}{22.4}$
$n = 0.18$ mole = quantity of electrons.
Then
$Current = \frac{0.18\ (Q)}{1080\ (t)}$
∴ the current flowing was 1.67×10^{-4} A

Extract 6.1: A sample of incorrect responses to question 6

In extract 6.1, the candidate wrote aim of the experiment instead of the terminology reffering to the experimental set up, in part (a). He/she divided amount of substance instead of the quantity of electric charge

over time in part (b). Furthermore, the candidate converted minutesd incorrectly into 1,080 seconds instead of 10,800 seconds.

The candidates who scored high marks (10.12%) identified the terminology for the experimental set up as electrolysis, in part (a). This means that the candidates had adequate knowledge about electrolysis. In part (b), the candidates correctly calculated the current required through mathematical manipulation of the volume of gas evolved, and time taken at s.t.p. The candidates calculated mass of the gas and then applied Faraday's first law of electrolysis to calculate the amount of electric current. Extract 6.2 shows a sample of correct responses in question 6.


Qo: @ Electrolysis.

(b) Soln:

Data given:

Time = 3 hours = ~~180~~ 10800 seconds.

Volume at s.t.p = 4.12 dm^3.

Gas relight the glowing splint = O_2

Req. Current flowing in a circuit.

from;

$$Mass = \frac{I \cdot t \cdot Ar}{V \cdot f}$$

But

$$mass = n \times m.r$$

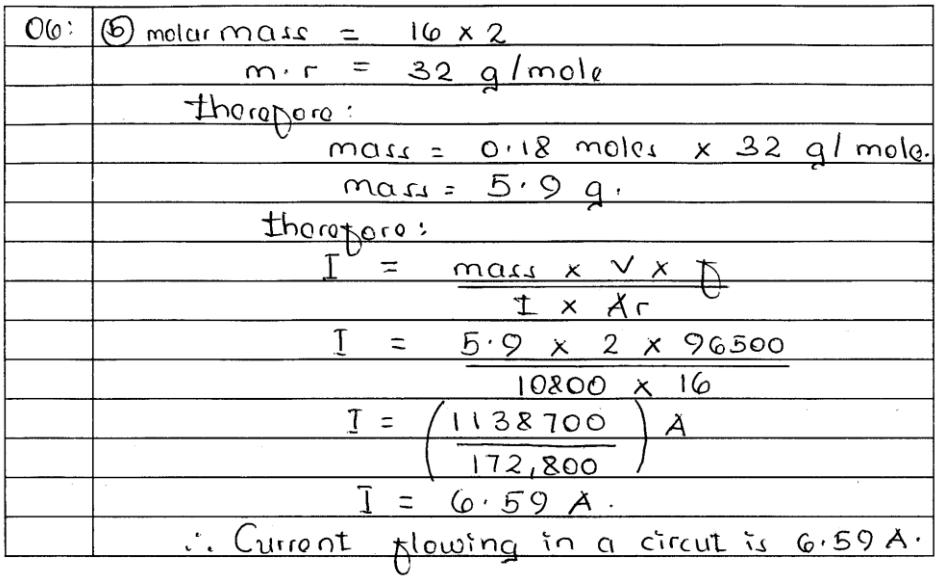
also;

$$n = \frac{V}{G.M.V}$$

$$= \frac{4.12\ dm^3}{22.4\ dm^3}$$

$$n = 0.18\ moles.$$

~~Therefore~~ also:



Extract 6.2: A sample of correct responses to question 6

In extract 6.2, the candidate gave the correct terminology, which was electrolysis, in part (a). In part (b), he/she followed clearly the steps to calculate the current flowing in the circuit.

2.1.2.5 Question 7: Acids, Bases and Salts

The candidates were required to classify the following salts based on solubility in water: *Sodium carbonate, Lead nitrate, Silver chloride, copper(II) silphate, Zinc chloride, Barium sulphate and Lead sulphate.*

A total of 155,437 candidates (100%) attempted this question. The analysis shows that 53.91 per cent scored from 0 to 2 marks, 20.95 per cent scored from 2.5 to 4.5 marks while 25.14 per cent scored from 5 to 7 marks. Generally, the performance of the candidates in this question was average because 46.09 per cent of the candidates scored 4.5 marks or above. The candidates' performance in this question is as shown in Figure 7.

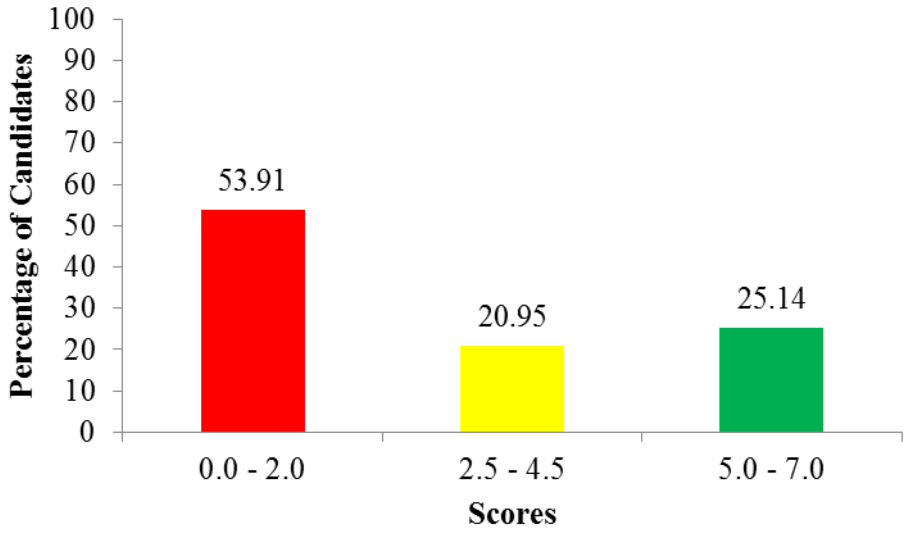


Figure 7: *Candidates' Performance in Question 7*

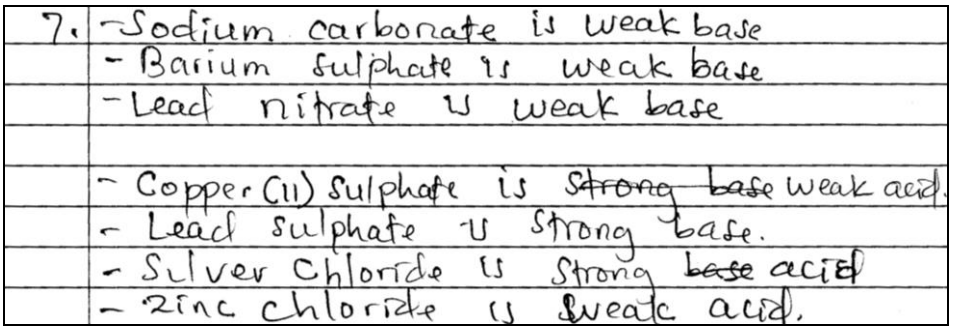
The candidates who scored high marks (25.14%) had good understanding that all carbonates are insoluble in water except sodium carbonate, potassium carbonate and ammonium carbonate. They were also aware that all sulphates are soluble in water except barium sulphate and lead sulphate. Similarly, the candidates were aware that all nitrates are soluble in water. Furthermore, the candidates knew that all chlorides are soluble in water with exception of silver chloride, mercury(II) chloride and Lead(II) chloride. Extract 7.1 shows a sample of correct responses in question 7.

7.	Solubility is the amount of solute dissolved in 100g of solvent a salt can either be soluble or insoluble.	
	Soluble salt	Insoluble salt
	Sodium carbonate	Barium sulphate
	Lead nitrate	Lead sulphate
	Copper (II) sulphate	Silver chloride.
	Zinc chloride	

Extract 7.1: A sample of correct responses to question 7

In extract 7.1, the candidate correctly classified the given salts on the basis of solubility in water.

Nonetheless, the candidates who scored low marks (53.91%) failed to attempt most parts of the question. For instance, some of the candidates categorised sodium carbonate as insoluble, while it is soluble. Other candidates classified lead nitrate as insoluble, while it is water soluble. Also, other candidates classified silver chloride and barium sulphate as soluble salts, while they are insoluble. There were also candidates who incorrectly classified the compounds as acidic salts and basic salts. Other candidates sorted the salts into chlorides, sulphates, nitrates and carbonates, contrary to the requirement of the question. These incorrect responses show that the candidates had insufficint knowledge about the properties of carbonates, chlorides, sulphates and nitrates. Extract 7.2 shows a sample of incorrect responses in question 7.



Extract 7.2: A sample of incorrect responses to question 7

In extract 7.2, the candidate incorrectly classified the salts into weak/strong bases and weak/strong acids.

2.1.2.6 Question 8: Hardness of Water

The candidates were given the following information "*Table 2 shows the volume of soap solution needed to form leather with three samples of water of equal volumes. Use the data from the table to answer the question that follow:*

Table 2

Water sample	***Volume of soap solution (cm^3)***
E	*6.5*
F	*0.2*
G	*3.7*

(a) Identify two things other than the volume of water that must be kept constant for such data to be meaningful.

(b) (i) Identify which water sample has the highest hardness. Give reason.

(ii) Give three causes of hardness of water.

The question was attempted by 155,437candidates (100%). 48.9 per cent of the candidates scored from 0 to 2 marks, 29.44 per cent scored from 2.5 to 4.5 were while 21.66 per cent scored from 5 to 7 marks. The analysis shows that 51.1 per cent of the candidates scored 2.5 marks or above, indicating average performance in overall. The candidates' performance in this question is summarized in Figure 8.

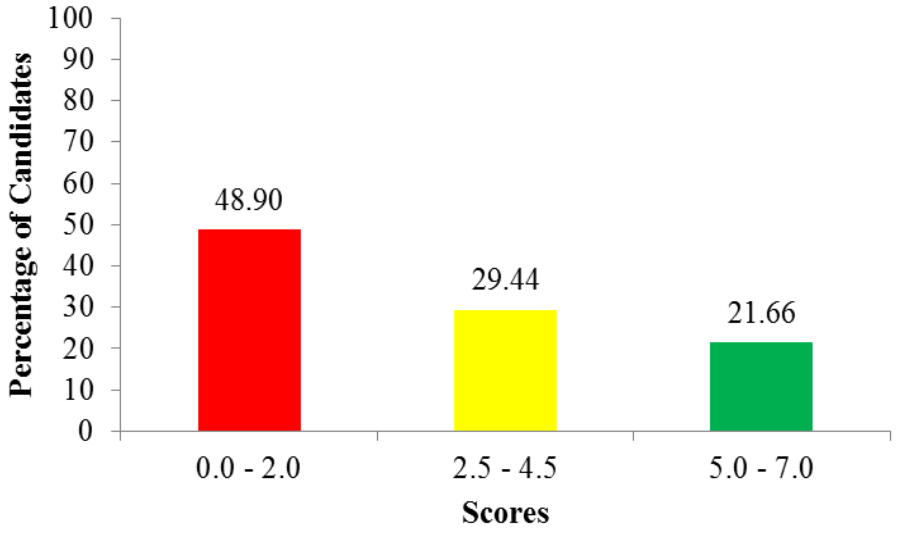


Figure 8: *Candidates' Performance to Question 8*

The candidates who scored high marks (21.66%) were knowledgeable about the salts which cause hardness of water. Likewise, the candidates had adequate knowledge about the methods required to remove hardness of water. The candidates understood that temporary hardness of water is caused by dissolved salts, such as calcium bicarbonate and magnesium bicarbonate, which are thermally unstable, and thus can be removed by boiling. Moreover, the candidates in this category had good mastery of the concept of variables. Thus, they were able to identify that temperature was a controled variable (temperature should be kept constant). Extract 8.1 shows a sample of correct responses in question 8.

8. a) Two thing to be kept constant are:
i) The temperature of the water. Water should not be boiled so as to prevent decompasition of the salts causing water hardness which could alter the results.

ii) The same amount of soap (volume) should be used so as to ensure correct value of the results needed to be obtained. By maintaining the same volume will help to give precise results.

8. b)
i) The Water sample E had the highest hardness.
Reason:
Because it required 6.5cm^3 of soap solution to form lather which is the highest volume needed compared to other samples.

8. b) ii) Causes of Water hardness are:
Presence of $Mg(HCO_3)_2$ and $Ca(HCO_3)_2$ in water causes water to be temporary hard. This is due to Acid rain which dissolves the limestone and dolomite rocks causing hardness.

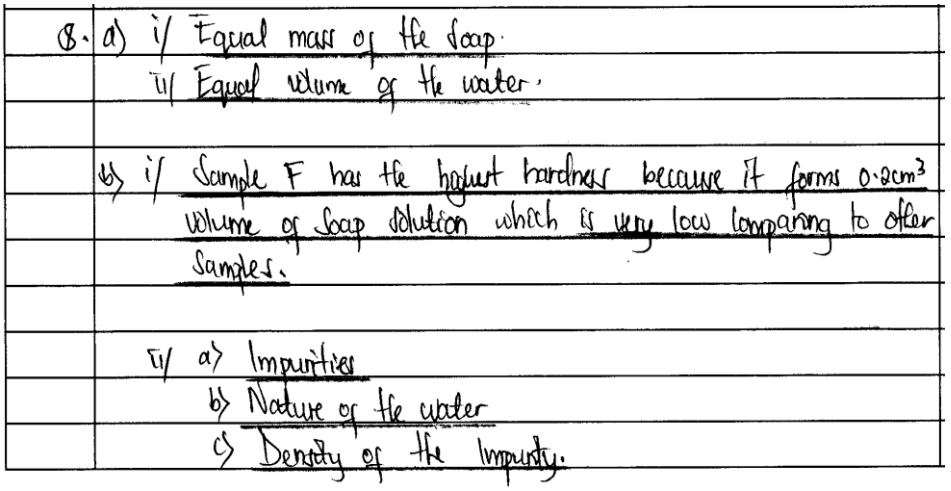
c) Presence of Calcium chloride ($CaCl_2$) and Magnesium Chloride ($MgCl_2$) in water also causes water hardness.

Extract 8.1: A sample of correct responses to question 8

In extract 8.1, the candidate managed to identify the factors to be kept constant during the experiment in part (a). Also in part (b), the candidate identified the sample with the highest hardness of water and their causes.

On the contrary, the candidates who scored low marks (48.90%) wrote incorrect responses, in part (a). Some of them responded by writing incorrect factors, such as density of water, duration of experiment and

pH of the water used. For example, one candidate wrote that the pH should be not acidic. Other candidates responded that the soap must form leather. Also there were candidates who had the notion that equal volume of the soap should be used for each sample of water. Others wrote sample F, instead of sample E, in part (b) (i), while in part (b) (ii), they mentioned sodium carbonate and potasium chloride as the causes of hardness of water, which was incorrect. Generally, the candidates in this category had inadequate knowledge about the concept of hardness of water, its causes and methods used to remove it. Extract 8.2 shows a sample of the incorrect responses to question 8.


8. a) i/ Equal mass of the soap.
ii/ Equal volume of the water.

b) i/ Sample F has the highest hardness because it forms 0.2cm³ volume of soap solution which is very low comparing to other samples.

ii/ a) Impurities
b) Nature of the water
c) Density of the impurity.

Extract 8.2: A sample of incorrect responses to question 8

In extract 8.2, the candidate wrote incorrect factors to be kept constant during the experiment, in part (a). In part (b) (i), he/she incorrectly identified sample F as the one with the highest hardness of water. Furthermore, in part (b) (ii), the candidate gave incorrect causes of hardness of water.

2.1.2.7 Question 9: Matter

In this question, the candidates were asked as follows:

Consider the following substances: milk, copper, soap, steel, chlorine and sugar.

(a) Identify the elements, compounds and mixtures from the list.

(b) Give four differences between the elements identified in 9 (a).

The question was attempted by 155,437 candidates (100%). 44.23 per cent of the candidates scored from 0 to 2 marks, 30.18 per cent scored from 2.5 to 4.5 marks, while 25.59 per cent scored from 5 to 7 marks. The general performance was average because 55.77 per cent of the candidates scored 2.5 marks or above. The summary of the candidates' performance is presented in Figure 9.

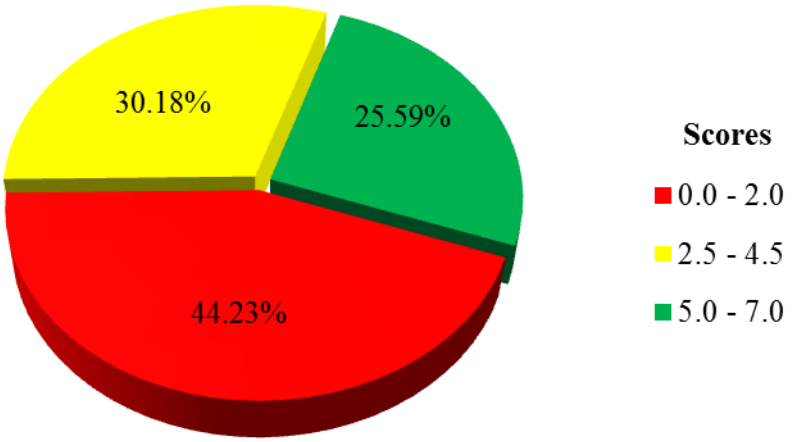


Figure 9: *Candidates' Performance in Question 9*

The analysis of the candidates' responses shows that, those who scored high marks (25.59%) had adequate knowledge on the properties of elements, mixtures, and compounds. As a result, they managed to identify elements, compounds, and mixtures, in part (a). Also in part (b), they differentiated copper (metal) from chlorine (non-metal) correctly. Extract 9.1 shows a sample of correct responses in question 9 from one of the candidates.

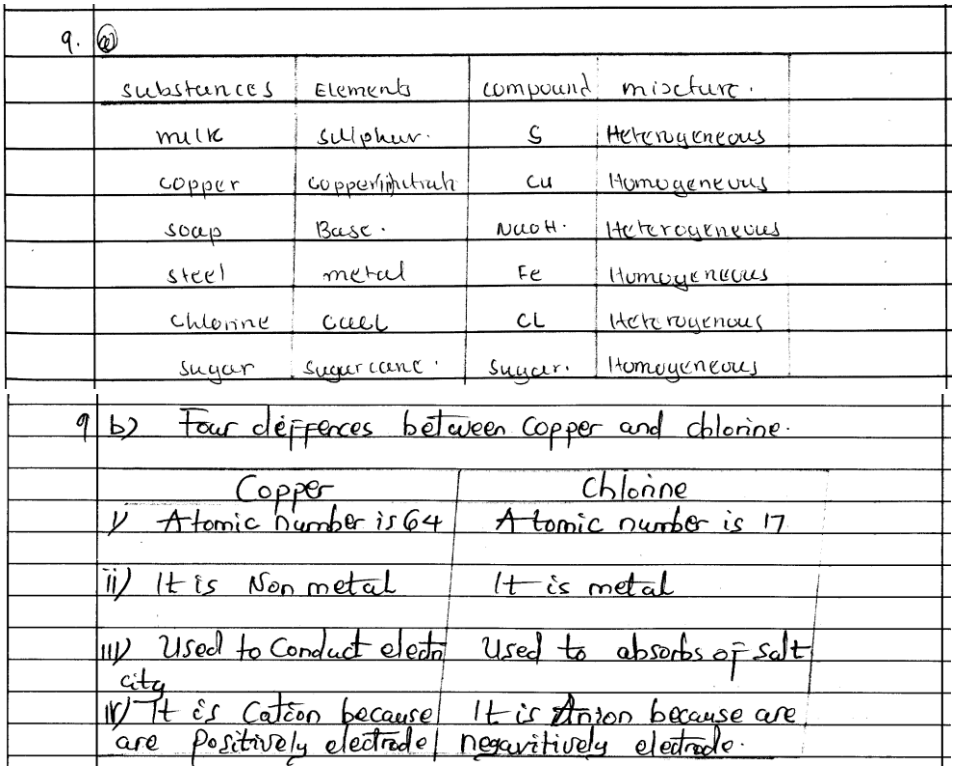
9 a)	Element	Compound	Mixture	
i)	Copper	Sugar	Steel	
ii)	Chlorine	Soap	Milk	

9 b)	Difference between element copper and chlorine	
	Copper - Metal	Chlorine - Non metal
i)	It is a good conductor of heat and electricity	It is a bad conductor of heat and electricity.
ii)	It is sonorous and ductile and malleable	It is non-sonorous and brittle
iii)	It loses electrons during reactivity process and acts as ~~oxidi~~ reducing agents.	It gains electrons during reactivity process and act as oxidizing agent.
iv)	Most metal exist in solid form except mercury which is in liquid state.	Most of them exist in gaseous state except carbon element which exist in solid form is diamond, graphite etc

Extract 9.1: A sample of correct responses to question 9

In extract 9.1, the candidate correctly identified the elements, compounds, and mixtures in part (a). Similarly, in part (b), he/she gave appropriate differences between copper and chlorine.

On the other hand, the candidates who scored low marks (44.23%) gave incorrect responses in all parts of the question. For instance, some of the candidates classified milk as a compound, and chlorine as a metal. Also, there were candidates who termed soap as a mixture, in part (a) which was incorrect. In part (b), the candidates correctly assigned properties of non-metals, such as poor conductor of heat to copper, contrary to the fact. Furthermore, some candidates termed steel as an element, instead of mixture which implies that the candidates considered iron and steel being synonimous. Consequently, they assigned incorrect properties to steel in part (b). The responses suggest that the candidates lacked adequate knowledge on the properties of elements, mixtures and compounds. Extract 9.2 shows a sample of incorrect responses in question 9.



9. (a)

substances	Elements	compound	mixture.
milk	sulphur.	S	Heterogeneous
copper	copper(II)nitrate	Cu	Homogeneous
soap	Base.	NaOH.	Heterogeneous
steel	metal	Fe	Homogeneous
chlorine	cucl	CL	Heterogeneous
sugar	Sugarcane.	Sugar.	Homogeneous

9 b) Four differences between copper and chlorine.

Copper	Chlorine
i) Atomic number is 64	Atomic number is 17
ii) It is Non metal	It is metal
iii) Used to Conduct electricity	Used to absorbs of salt
iv) It is Cation because are positively electrode	It is Anion because are negavitively electrode.

Extract 9.2: A sample of incorrect responses to question 9

In extract 9.2, the candidate gave incorrect examples of elements, compounds and mixtures in part (a). In part (b), he/she gave incorrect differences between copper and chlorine.

2.1.2.8 Question 10: Extraction of Metals

The question had two parts, namely (a) and (b). In part (a), the candidates were required to explain the function of coke and hot air in the extraction of iron from its ore. In part (b), they were required to account for the fact that aluminium is a vital element in our daily life by giving four points.

The question was attempted by 155,437 candidates (100%). Analysis indicates that 61.79 per cent scored from 0 to 2 marks, 26.49 per cent scored from 2.5 to 4.5 marks and 11.72 per cent scored from 5 to 7 marks. Generally, the performance in this question was average as 38.21 per cent of the candidates scored 2.5 marks or above. Figure 10 shows a summary of the candidates' performance in this question.

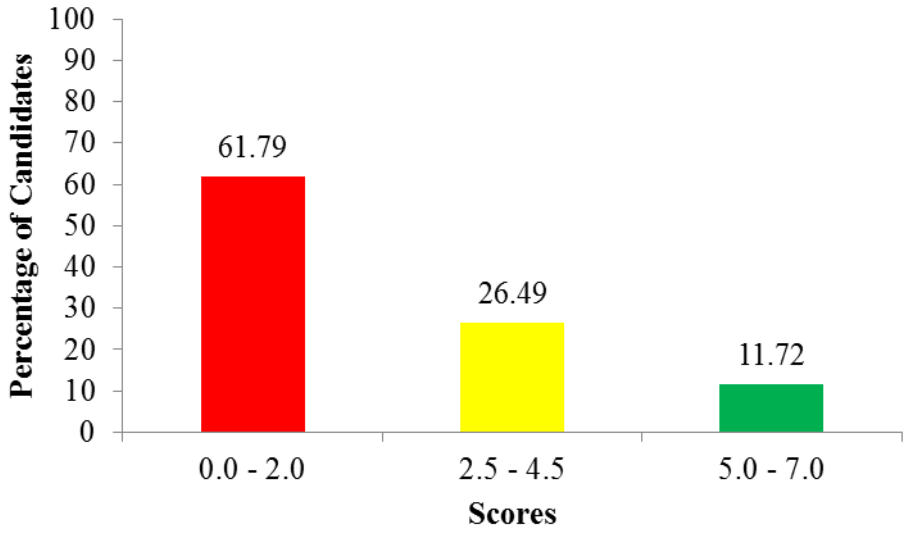


Figure 10: *Performance of Candidates in Question 10*

The candidates who scored high marks (11.72%) explained the function of both coke and hot air in the extraction of iron in part (a). They indicated that coke or carbon combines with oxygen to form carbon dioxide which is further reduced by carbon to form carbon monoxide. In part (b), the candidates gave four points to justify the importance of aluminium in our daily life. For instance, the candidates wrote that aluminium is used in making partition of offices and constructing bodies of airplanes. Extract 10.1 is a sample of correct responses in question 10.

10. a/ The function of coke and hot air in the extraction of iron from its ore is that they react to form Carbon dioxide gas which reacts with excess coke to form Carbon Monoxide gas

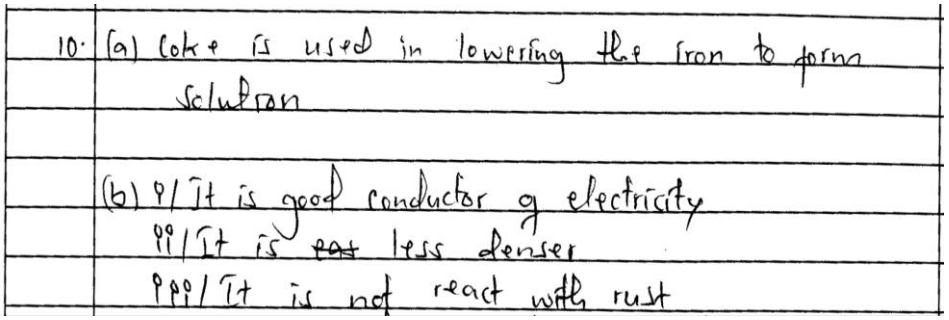
10: a/ reducing agent in the blast furnace.
ie: $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$.
$CO_{2(g)} + 2C_{(s)} \rightarrow 2CO_{(g)}$

b/ Uses of aluminium in our daily life.
- Used in making Overhead lines for electricity supply.
- Used in Making window frames.
- Used in Making aluminium foils.
- Used in Making water pipes.

Extract 10.1: A sample of correct responses to question 10

In extract 10.1, the candidate gave correct uses of coke and hot air in the extraction of iron, in part (a). In part (b), he/she gave four points on the importance of aluminium in our daily life.

However, the candidates who scored low marks (61.79%) gave incorrect function of both coke and hot air in the extraction of iron in part (a). These candidates lacked adequate knowledge about the steps involved during extraction of iron from its ore. For example, some candidates wrote that the function of coke is to remove impurities from slag. Others considered that hot air was intended to melt the impure iron. Also, there were candidates who associated the role of hot air with lowering the boiling of iron ore. In part (b), some of the candidates wrote incomplete sentences, while others gave inappropriate uses of aluminium. For instance, one candidate wrote "Aluminium is used in vulcanisation of ruber." Other candidates incorrectly associated uses of other metals with the uses of aluminium. For example, one candidate wrote "It is used to construct railway lines". Generally, the candidates had no adequate mastery of the concept of extraction, and the uses of the metals. Extract 10.2 is a sample of incorrect responses from one of the candidates in question 10.


10. (a) Coke is used in lowering the iron to form solution

(b) i/ It is good conductor of electricity
ii/ It is ~~eat~~ less denser
iii/ It is not react with rust

Extract 10.2: A sample of incorrect responses to question 10

In extract 10.2, the candidate gave incorrect function of coke and did not respond to the function of hot air in the extraction of iron, in part (a). In part (b), the candidate gave properties of of aluminium instead of its uses in daily life correctly.

2.1.2.9 Question 11: Compounds of Metals

The question was as follows:

An unkown green sample was mixed with dilute HNO_3 and gave a blue solution and a gas which precipitated lime water. The resulting solution was evaporated to dryness and upon further heating black residue was formed together with a brown gas which relighted a glowing splint.

(a) Identify the green sample, blue solution, black solid and two gases.

(b) Give balanced chemical equation for the reaction between the green sample and nitric acid, and the equation for the formation of balck residue.

The question was attempted by 155,437candidates (100%). The analysis of candidates' performance indicates that 88.18 per cent scored from 0 to 2 were, 5.77 per cent scored from 2.5 to 4.5 marks while 6.05 per cent scored from 5 to 7 marks. Generally, the performance of the candidates in this question was weak because only 11.82 per cent scored 2.5 marks or above. The summary of the performance is shown in Figure 11.

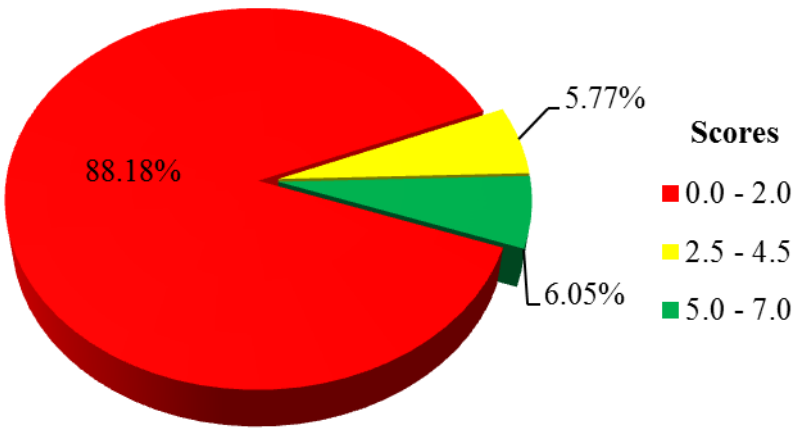
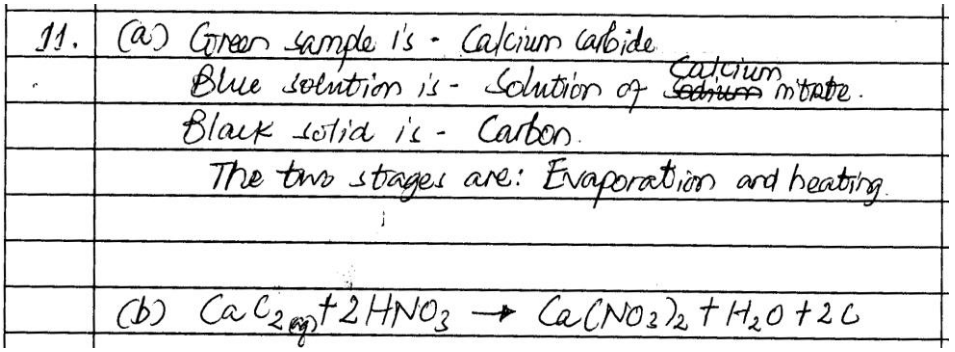


Figure 11: *Candidates' Performance in Question 11*

The candidates who scored low marks (88.18%) did not attempt correctly most parts of the question. For example, in part (a), some candidates incorrectly identified copper(II) sulphate as the green sample. Another candidate incorrectly wrote sodium carbonate as the green

sample. Other compounds which were incorrectly cited by candidates in this part were calcium carbonate, potassium hydroxide, sodium chloride, calcium hydroxide and calcium oxide. Also, some candidates incorrectly identified the blue solution to be copper carbonate, instead of copper nitrate. Furthermore, other candidates identified the black solid as calcium oxide or calcium hydroxide, instead of copper oxide. Similarly, candidates predicted the brown gas incorrectly by writing carbon dioxide instead of nitrogen dioxide. Basically, the candidates lacked adequate knowledge on the chemical properties of metal compounds, especially when treated with mineral acids. In part (b), the candidates wrote inappropriate chemical equations, indicating incorrect reactants and products. For instance, there were candidates who indicated oxygen, hydrogen and nitrogen gas among the products formed from the reaction between the green sample and dilute nitric acid. Similarly, some candidates incorrectly wrote chemical equation showing the decomposition of calcium carbonate, instead of copper(II) nitrate. Consequently, the candidates indicated calcium oxide instead of copper(II) oxide as the black residue. Basically, the candidates lacked adequate skills of interpreting chemical reactions with the aid of chemical equations. Extract 11.1 shows a sample of incorrect responses in question 11.

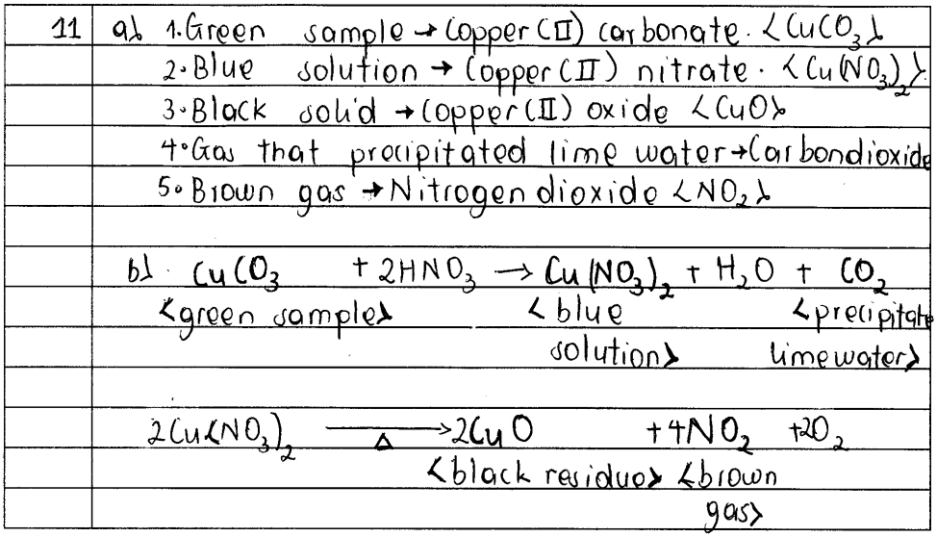

11. (a) Green sample is - Calcium carbide
Blue solution is - Solution of ~~Sodium~~ Calcium nitrate.
Black solid is - Carbon.
The two stages are: Evaporation and heating.
(b) $CaC_{2(s)} + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2O + 2C$

Extract 11.1: A sample of incorrect responses to question 11

In extract 11.1, the candidate wrote calcium carbide, calcium nitrate and carbon instead of copper(II) carbonate, copper(II) nitrate and copper oxide, respectively in part (a). He/she wrote incorrect chemical equation for the reaction between calcium carbide and nitric acid instead of $CuCO_3$ and dilute HNO_3 acid.

However, the analysis indicates that the candidates who scored high

marks (6.05%) wrote correct compounds in part (a). They also managed to identify the gas that precipitated lime water as carbon dioxide and the brown gas as nitrogen dioxide. In part (b), the candidates wrote the chemical equations for the reaction of copper carbonate with dilute nitric acid and the decomposition of copper nitrate. Generally, the candidates had adequate knowledge about properties of compounds of metals. Extract 11.2 is a sample of correct responses in question 11.



Extract 11.2: A sample of correct responses in question 11

In extract 11.2, the candidate correctly identified the green sample, blue solution, black solid and the two gases, in part (a). Also, he/she wrote a balanced chemical equation for the reaction of the green sample with nitric acid, and the equation for the thermal decomposition of copper(II) nitrate.

2.1.2.10 Question 12: Organic Chemistry

The question comprised parts (a) and (b). In part (a), the candidates were required to distinguish alkanes from alkenes by giving three points. In part (b), the candidates were required to give four reasons to justify the special attention given to carbon (rather than other elements) in organic chemistry.

A total of 155,437 candidates (100%) attempted this question, out of which, 72.73 per cent scored from 0 to 2 marks, 22.43 per cent scored

from 2.5 to 4.5 marks, while 4.84 per cent scored from 5 to 7 marks. The general performance in this question was weak as only 27.27 per cent of the candidates scored 2.5 marks or above. Figure 12 shows a summary of the candidates' performance in question 12.

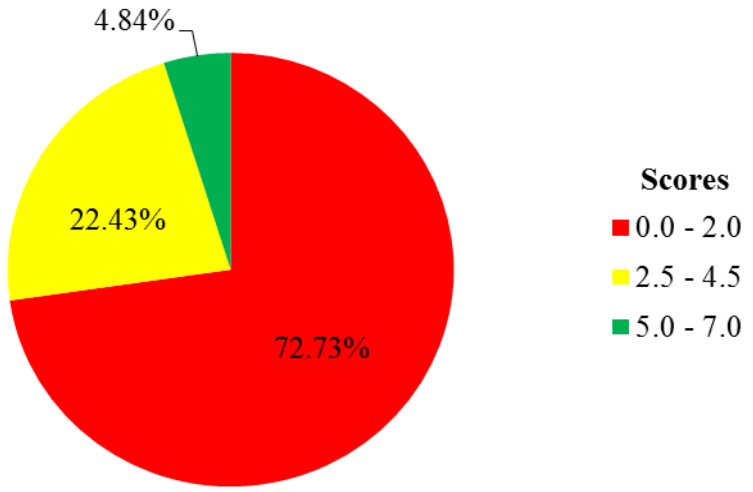
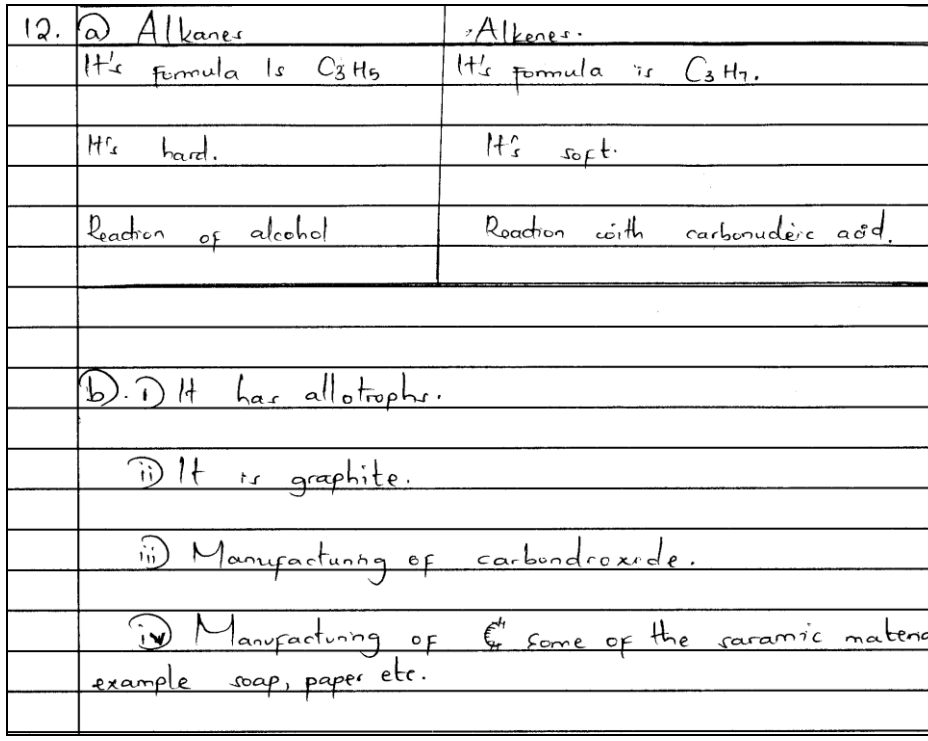


Figure 12: *Candidates' Performance in Question 12*

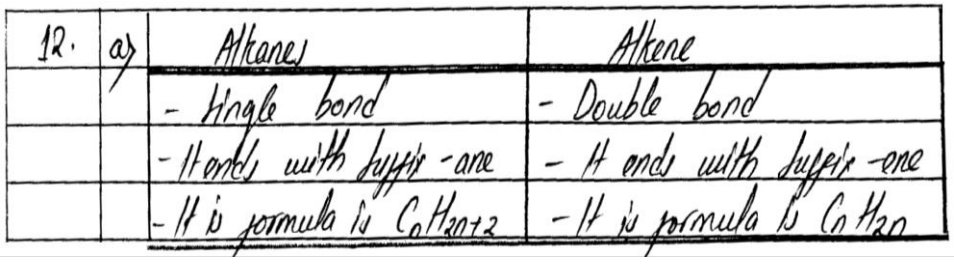
The candidates who scored low marks (72.73%) failed to distinguish alkane from alkene, in part (a). Some of them interchanged properties of alkanes with those of alkenes. For instance, one candidate wrote "alkanes are unsaturated, while alkenes are saturated". Another candidate wrote "alkane formula is C_nH_{2n}, but alkene is C_nH_{2n+2}". Similarly, some candidates wrote properties of alkynes, instead of alkenes. In part (b), the candidates gave incorrect reasons about carbon. For instance, one candidate responded "carbon is found high in the reactivity series", while carbon is not at high position in the reactivity series. Other candidates wrote incorrect compounds of carbon, such as carbon dioxide and carbonates, while others cited natural sources of carbon. Basically, the candidates with low scores had inadequate knowledge about the properties of hydrocarbons. Extract 12.1 shows a sample of incorrect responses in question 12.

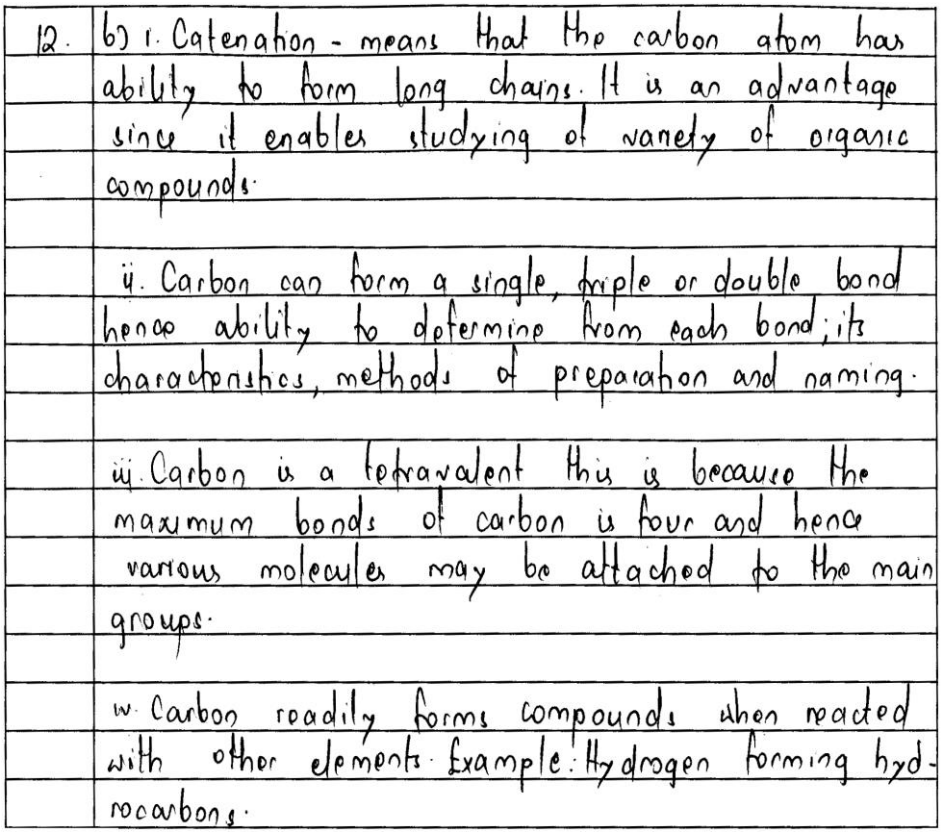


Extract 12.1: A sample of incorrect responses to question 12

In extract 12.1, the candidate gave incorrect differences between alkanes and alkenes, in part (a). Similarly, in part (b), he/she gave inappropriate responses, thus lost all the marks allotted to this question.

The candidates who scored high marks (4.84%) differentiated alkanes from alkenes based on their chemical and physical properties. For instance, one of the candidates wrote that the first member in alkane is methane, while the first member in alkene is ethane. In part (b), the candidates gave correct reasons to justify the special attention given to carbon (apart from other elements) in organic chemistry. Extract 12.2 shows a sample of correct responses in question 12.





Extract 12.2: A sample of correct responses to question 12

In extract 12.2, the candidate distinguished correctly alkanes from alkenes, in part (a). Also, he/she gave appropriate characteristics which qualify carbon to be given a special attention in chemistry.

2.1.3 Section C: Essay Questions

This section comprised two questions. The candidates were required to answer only one question.

2.1.3.1 Question 13: Pollution

In this question, the candidates were required to explain six effects of water pollution in Tanzania.

A total of 155,437 candidates (100%) attempted this question. The analysis of the candidates' performance indicates that 8.14 per cent scored from 0 to 4 marks, 41.89 per cent scored from 4.5 to 9.5 marks, while 49.97 percent scored from 10 to 15 marks. The general

performance was good because 91.86 per cent of the candidates scored 4.5 marks or above. Figure 3 summarizes candidates' performance in question 13.

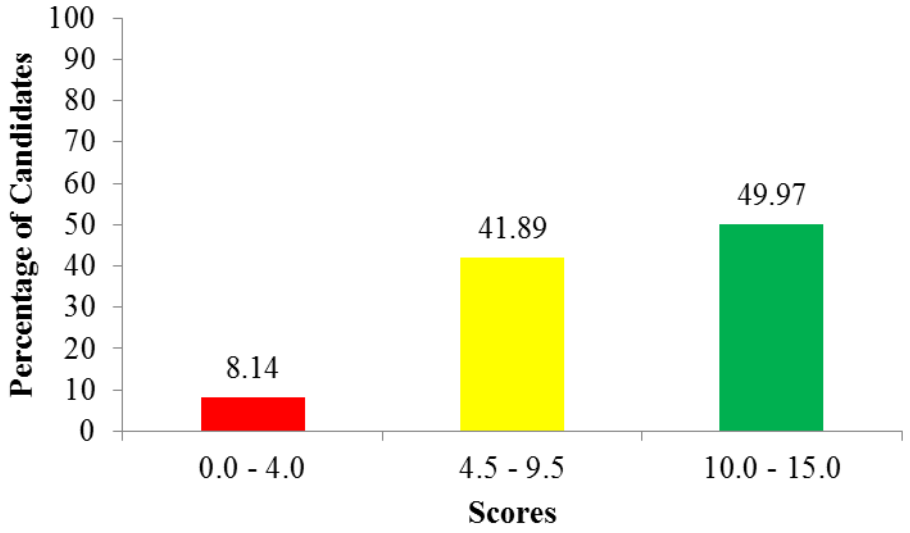


Figure 13: *Candidates' Performance in Question 13*

The candidates who scored high marks (49.97%) explained six effects of water pollution in Tanzania correctly. To mention the few, some of the points given include loss of biodiversity, accumulation of toxic materials in the bodies of animals, erruption of water borne diseases, algal blooms, and obstraction to water transport. The correct answers given indicate that the candidates had adequate knowledge about pollution, specifically acquatic pollution. Extract 13.1 shows a sample of correct responses from one of the candidates in question13.

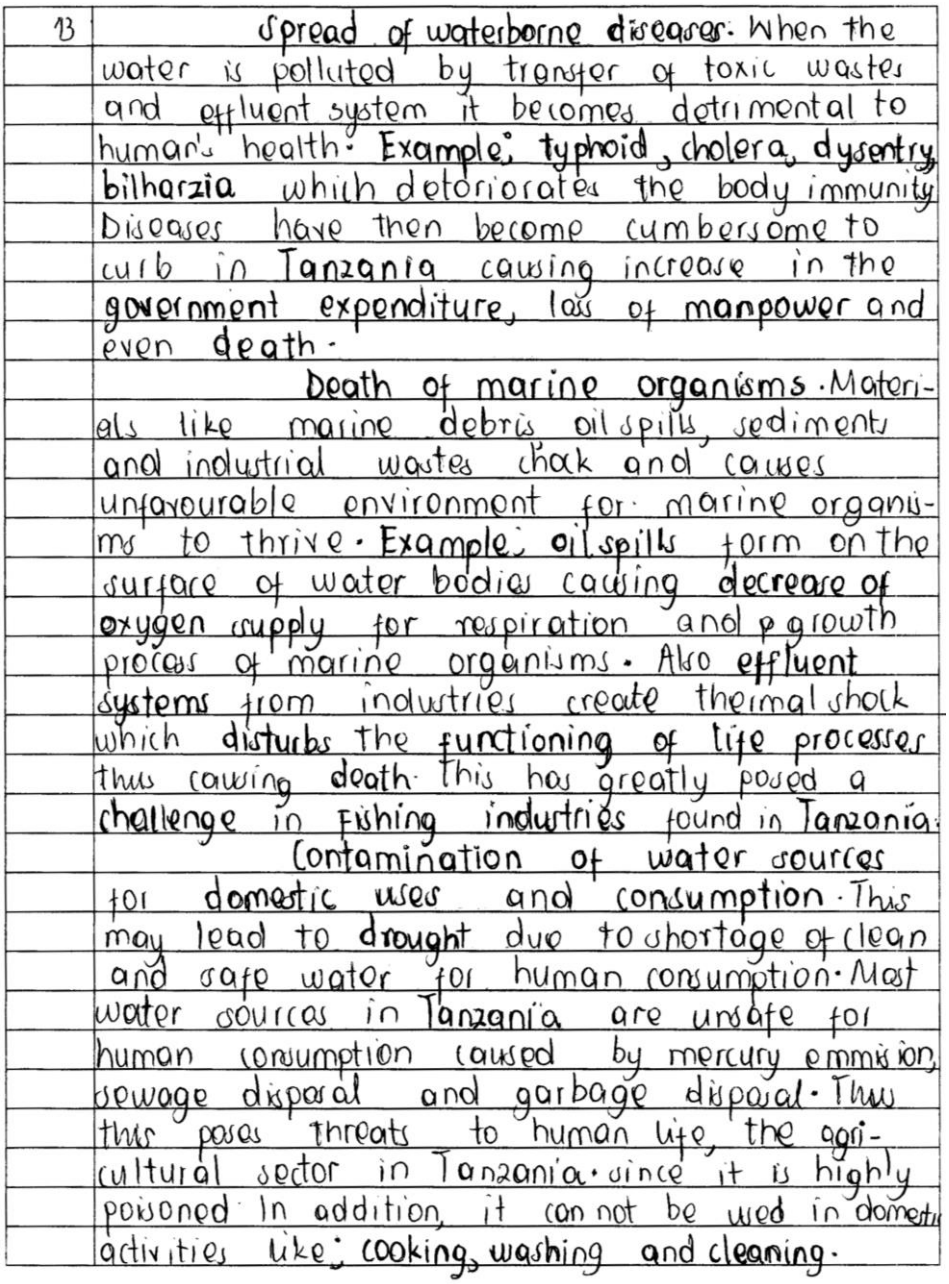
13 Water pollution is the introduction of unwanted materials in water source. The causes of water pollution can be identified from sources namely **point source** which is the direct ejection of materials (wastes) in water sources and **non-point source** which is the indirect pollution of water sources. The causes of water pollution include; use of agrochemicals, oil spills, acid rain, sewage disposal and industrial effluent system. The following include effects of water pollution in Tanzania;

Eutrophication. This is the proliferation of algae on the surface of water bodies. When farm fertilizers find their way in water they act a food nutrients to micro-organisms. This results to the multiplication of algae on the surface of water which leads to blockage of sunlight underneath. This in turn cause death of photosynthetic marine plants resulting to biological oxygen demand (BOD) since decomposers also use oxygen on dead organisms thus marine organism die due to shortage of oxygen forming dead zones. This poses a great challenge of navigation in Tanzania.

13. Blockage of sewage systems. The wastes accumulated in water such as plastic bags, bottles and non-biodegradable materials may cause blocking of sewage systems to the discharge ways. This may cause overflowing of sewage systems which emit foul smells and cause uncomfortability of people living near the area. This is evident in most areas of Tanzania in suburbs of Arusha, Dar es salaam and Mwanza.

Emmision of foul smell and causes thermal shock thus disrupting the ecological systems. Wastes discharged in water are decomposed upon releasing foul smells. Example; garbage, sewage and industrial effluents. Thermal shock refers to sudden increase in temperature in water bodies. This may lead to disruption of the marine ecological systems. Thus, Tanzania faces a dwindling diversity in marine organisms and residence uncomfortabilities in some areas.

Conclusively, water pollution in Tanzania can be mitigated in the following ways; Enactment of policies and strict laws to promote marine conservation, reduce use of agro-fertilizers and pesticides, inspection of oil tankers, neutralization of industrial wastes before discharge in waterbodies, promoting coastal development and regulating industrial emmisions which causes formation of acid rains.


13

Spread of waterborne diseases. When the water is polluted by transfer of toxic wastes and effluent system it becomes detrimental to human's health. Example; typhoid, cholera, dysentry, bilharzia which deteriorates the body immunity. Diseases have then become cumbersome to curb in Tanzania causing increase in the government expenditure, loss of manpower and even death.

Death of marine organisms. Materials like marine debris, oil spills, sediments and industrial wastes chock and causes unfavourable environment for marine organisms to thrive. Example; oil spills form on the surface of water bodies causing decreare of oxygen supply for respiration and growth proces of marine organisms. Also effluent systems from industries create thermal shock which disturbs the functioning of life processes thus causing death. This has greatly posed a challenge in Fishing industries found in Tanzania.

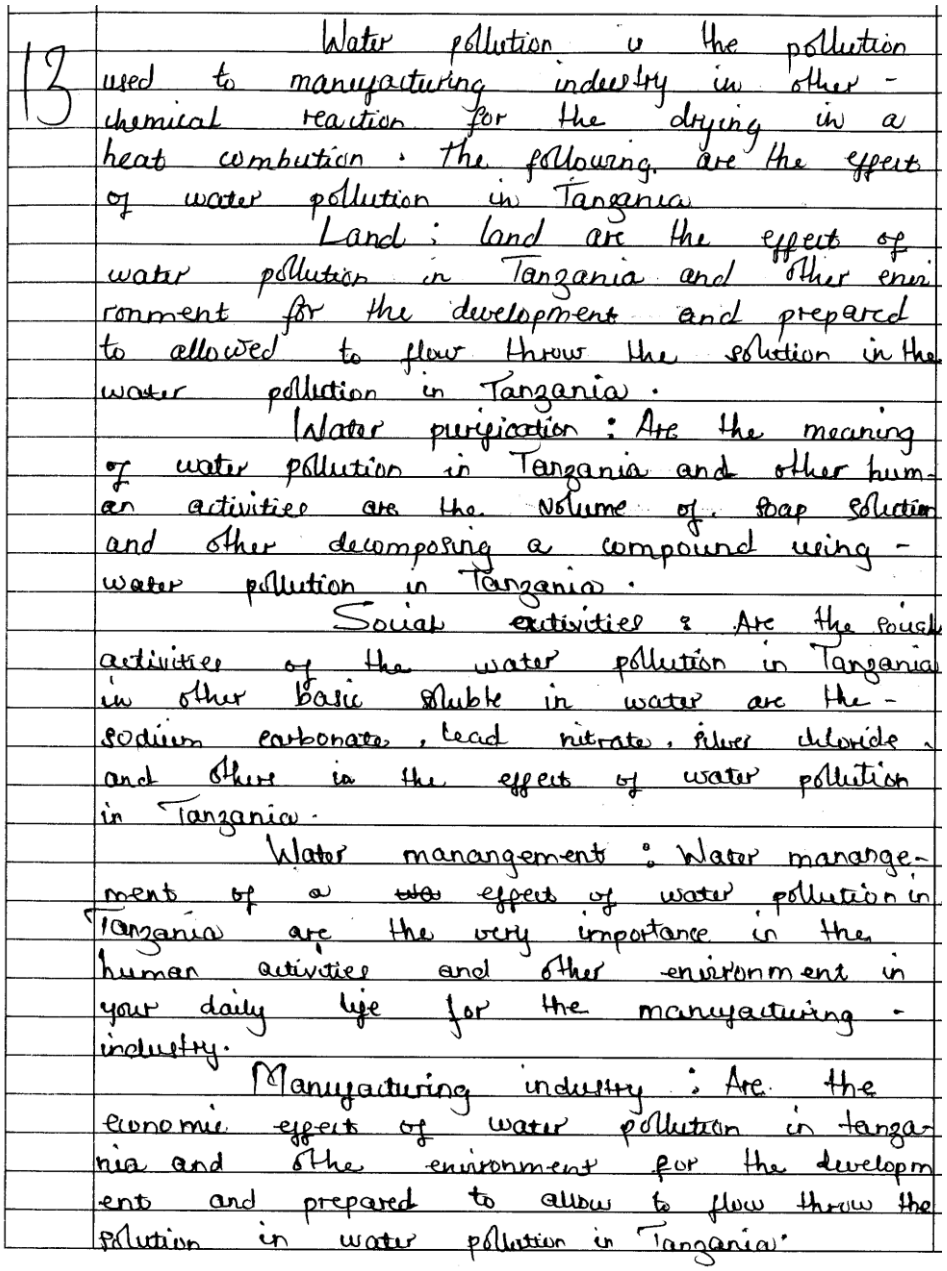
Contamination of water sources for domestic uses and consumption. This may lead to drought due to shortage of clean and safe water for human consumption. Most water sources in Tanzania are unsafe for human consumption caused by mercury emmision, sewage disposal and garbage disposal. Thus this poses threats to human life, the agricultural sector in Tanzania since it is highly poisoned. In addition, it can not be used in domestic activities like; cooking, washing and cleaning.

Extract 13.1: A sample of correct responses to question 13

In extract 13.1, the candidate correctly explained the effects of water pollution. He/she followed the appropriate rules required in essay writing.

Nevertheless, the candidates who scored low marks (8.14%) gave incorrect points about the effects of water pollution. Some of them explained the three types of pollution, which are air pollution, terrestrial

pollution and aquatic pollution. For instance, one of the candidates described air pollution as "the introduction of harmful materials in air." Another candidate gave sources of water pollution, such as oil spills, pesticides, fertilizers and uncontrolled disposal of industrial wastes into water channels/bodies. Generally, the candidates lacked adequate knowledge about the effects of water pollution. Extract 13.2 shows a sample of incorrect responses in question 13.



13

Water pollution u the pollution used to manufacturing industry in other - chemical reaction for the drying in a heat combution. The following are the effects of water pollution in Tanzania

Land : land are the effects of water pollution in Tanzania and other environment for the development and prepared to allowed to flow throw the solution in the water pollution in Tanzania.

Water purification : Are the meaning of water pollution in Tanzania and other human activities are the volume of soap solution and other decomposing a compound using - water pollution in Tanzania.

Social activities : Are the social activities of the water pollution in Tanzania in other basic soluble in water are the - sodium carbonate, lead nitrate, silver chloride, and there is the effects of water pollution in Tanzania.

Water manangement : Water manangement of a ~~was~~ effects of water pollution in Tanzania are the very importance in the human activities and other environment in your daily life for the manufacturing - industry.

Manufacturing industry : Are the economic effects of water pollution in tanzania and the environment for the developments and prepared to allow to flow throw the solution in water pollution in Tanzania.

Extract 13.2: A sample of incorrect responses to question 13

In extract 13.2, the candidate provided irrelevant responses, contrary to the demand of the question.

2.1.3.2 Question 14: Soil Chemistry

In this question the candidates were required to describe six ways that can be adopted by the farmers to mantain soil fertility in Tanzania.

A total of 155,437 candidates (100%) attempted this question. The candidates' performance analysis indicates that 3.24 per cent scored from 0 to 4 marks, 14.17 per cent scored from 4.5 to 9.5 marks and 82.59 per cent scored from 10 to 15 marks. These data show that 96.76 per cent of the candidates scored 4.5 marks or above, indicating good performance. The summary of the candidates' performance is shown in Figure 14.

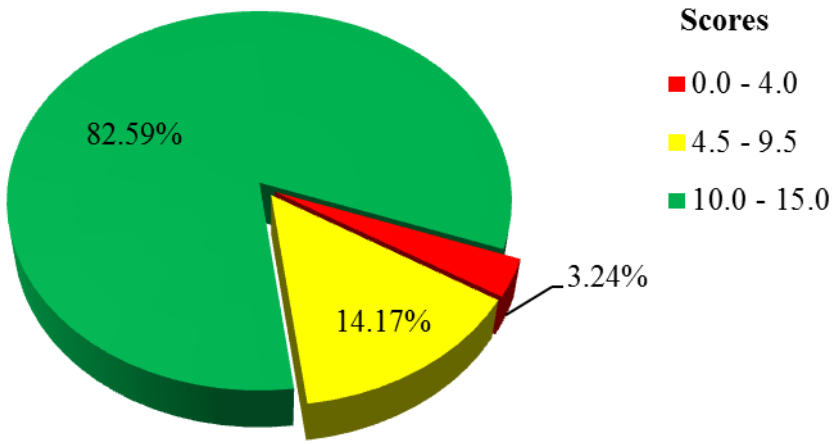


Figure 14: *Candidates' Performance in Question 14*

The analysis of candidates' responses indicates that, those who scored high marks (82.59%) explained the meaning of soil fertility in the introduction. In the main body, they explained appropriate ways of maintaining soil fertility of a particular area. The responses given suggest that the candidates understood the requirements of the question, and had adequate knowledge about the application of the concept of soil fertility in real life. Extract 14.1 shows a sample of correct responses to question 14.

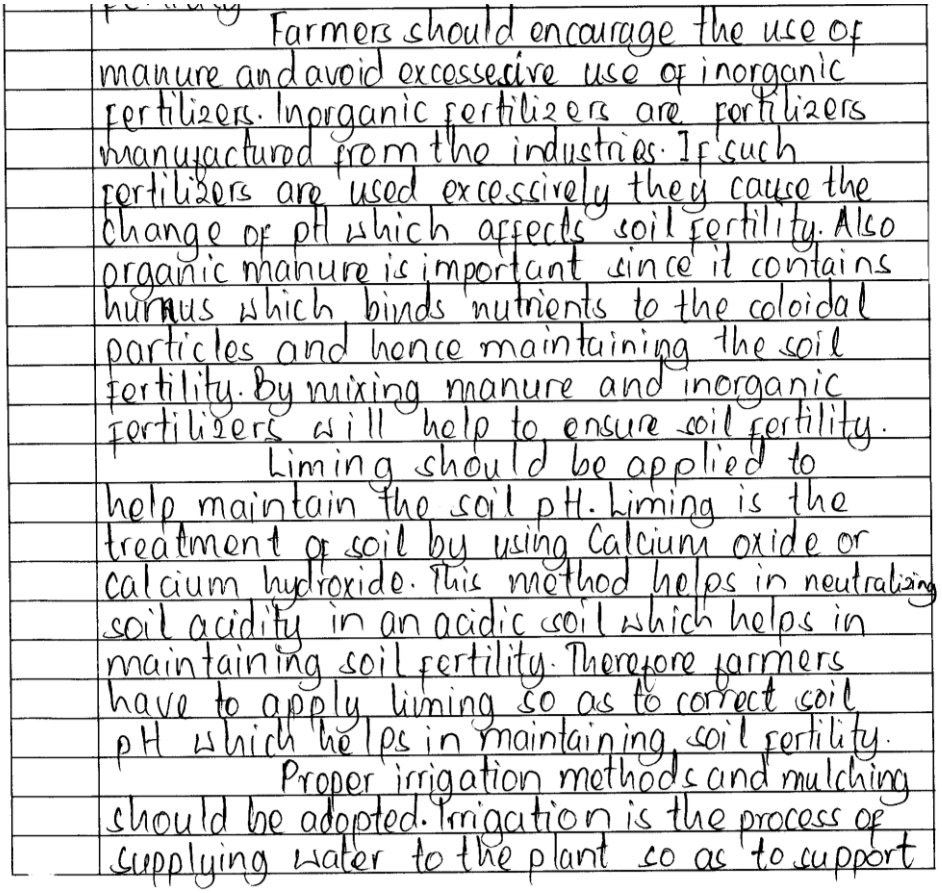
SECTION C:

14.: Soil fertility is the ability of the soil to provide adequate amount of nutrients in correct propotions to support the life of plants. Soil fertility is important in plant growth since it helps in providing necessary nutrients which are required by plants. Examples of such nutrients are Calcium, Nitrogen, Potassium and Phosphorous which are present in the soil as Ions. Soil fertility can be affected by excessive use of fertilizers and poor farming methods which affects its fertility. There are various ways in which farmers have to adopt so as to maintain soil fertility in Tanzania which are as follows:

Proper farming methods. Farmers have to adopt proper ways of farming which can help to maintain the soil fertility. Example crop rotation and growing leguminous plants and other main crops a process known as intercropping. This will help to maintain the soil fertility and availability of minerals.

Avoid excessive use of agricultural chemicals (Agrochemicals). Agrochemicals are chemicals which are used by farmers to kill insects and pests. If such chemicals are used in a large amount they may cause the change of soil pH which affects the availability of minerals and plant nutrients. Therefore it is vital for farmers to reduce the use of agrochemicals so as to ensure soil fertility in the land of Tanzania which helps to improve the yields.

14. By preventing soil erosion through practising Agroforestry. Agroforestry involves the system of agriculture whereby trees (forests) along together with crops are grown in the same farm. This will help to maintain soil fertility by preventing soil erosion which could erode the top part of the soil which contain nutrients which affects its fertility. Therefore agroforestry is very important in maintaining the soil fertility.


Farmers should encourage the use of manure and avoid excessive use of inorganic fertilizers. Inorganic fertilizers are fertilizers manufactured from the industries. If such fertilizers are used excessively they cause the change of pH which affects soil fertility. Also organic manure is important since it contains humus which binds nutrients to the coloidal particles and hence maintaining the soil fertility. By mixing manure and inorganic fertilizers will help to ensure soil fertility.
Liming should be applied to help maintain the soil pH. Liming is the treatment of soil by using Calcium oxide or calcium hydroxide. This method helps in neutralizing soil acidity in an acidic soil which helps in maintaining soil fertility. Therefore farmers have to apply liming so as to correct soil pH which helps in maintaining soil fertility.
Proper irrigation methods and mulching should be adopted. Irrigation is the process of supplying water to the plant so as to support

Extract 14.1: A sample of correct responses to question 14

In extract 14.1, the candidate explained appropriate ways of maintaining soil fertility.

Nonetheless, the candidates who scored low marks (3.24%) failed to explain ways of maintaining soil fertility. Others explained ways through which land degradation occurs or soil fertility is lost. For instance, some candidates wrote about leaching and deforestation as methods of maintaining soil fertility. Such responses imply that the candidates did not understand the requirement of the question. Other candidates wrote on the nutrients available in the soil such as organic matter, humus, and minerals. This is an indication that the candidates had insufficient knowledge about soil fertility. Extract 14.2 shows a sample of incorrect responses in question 14.

14 Soil pertility: Is the process of getting nutrient in the Soil; The ways that can be adopted by the ~~the~~ permers to maintain Soil pertility in the ~~Sot~~ Tanzania as follow:-

Ways of Bending: This way lead and production of Soil in the nutrient and lead the growth will improve in the Soil in Tanzania

Ways of Broadcasting: This way to protect Soil nutrient in the production of nutrient pertilizer where the cause of microorganism in the Soil and lead growth permers in Tanzania and Agriculture.

Drip way: This ~~method~~ ways It lead to produce Soil pertility in the permers production and lead improve in Tanzania By Using Drip ways - per Soil pertility in Tanzania.

Foliyer Spraying: This ways lead to improve Soil pertility per permers growth in Tanzania and a good economic per Agriculture in Tanzania

Side dressing Application: This way is a Source of production of ~~permes~~ Agriculture per permer in Tanzania and lead Soil pertility because of Using pertilizer per production in Tanzania.

... Tway lead to improve Soil per getting nutrient in the production of Agriculture in Tanzania as a Source of getting Soil pertility.

The Conclude the Soil pertility and has many way per production of Agriculture in Tanzania, So to make pertilizer will improve nutrient in the Soil.

Extract 14.2: A sample of incorrect responses to question 14

In extract 14.2, the candidate provided incorrect responses on the ways to maintain soil fertility.

2.2 032/2 CHEMISTRY 2 (PRACTICALS)

There were three alternative papers of Actual Practical, namely 032/2A Chemistry 2A, 032/2B Chemistry 2B, and 032/2C Chemistry 2C.
Each paper consisted of two questions, weighing 25 marks each. Question 1 was derived from the topic of Volumetric Analysis, while question 2 was derived from the topic of Chemical Kinetics, Equilibrium and Energetics.

2.2.1 Question 1: Volumetric Analysis

The question was attempted by 155,437 candidates (100%). The analysis indicates that 9.84 per cent of the candidates scored from 0 to 7 marks, 40.60 per cent scored from 7.5 to 16.5 marks and 49.56 per cent scored from 17 to 25. Generally, the candidates' performance in this question was good because 90.16 per cent scored 7.5 marks or above. The summary of the performance is shown in Figure 15.

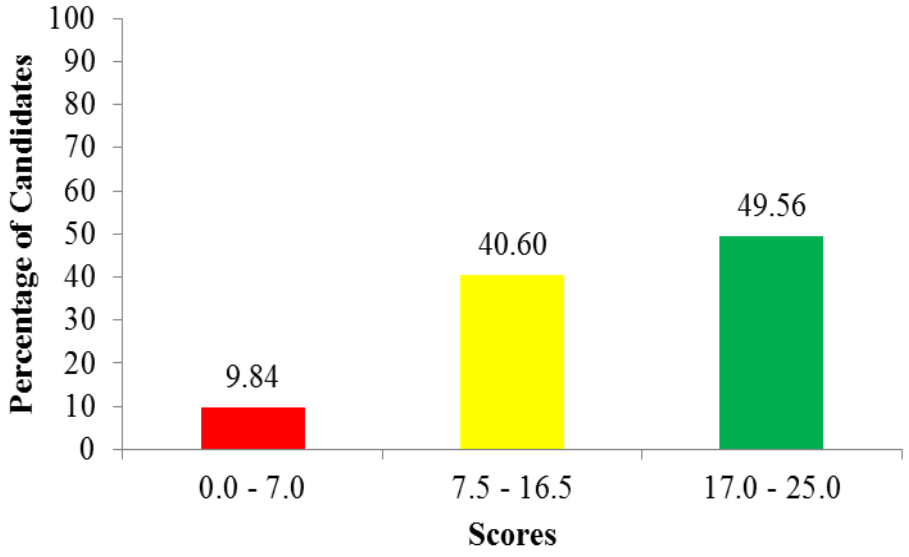


Figure 15: *Candidates' Performance in Question 1*

2.2.1.1 Alternative 2A

The candidates were provided with solutions **A** and **D**. One of those was acidic, and the other was a basic solution. The basic solution was made by dissolving 3.5 g of impure sodium hydroxide (NaOH) in a distilled water, making up a solution of one litre. The acidic solution was 0.03 M sulphuric acid (H_2SO_4). The candidates were required to perform the following procedures, and then answer the questions that follow:

The candidates were provided with the following procedures:

*(i) Pour about 1 cm^3 of solution **A** into a test tube and use litmus paper to a test if it is an acid or a base.*

(ii) Discard the content and wash the test tube.

*(iii) Repeat the procedures (i) and (ii) using a solution **D**.*

*(iv) Titrate the acid solution (in a burrete) against the base solution (in a titration flask) using methyl orange (**MO**) as an indicator up to the end point.*

(v) Repeat the step (iv) to obtain three more readings and record the results in a tabular form.

Questions

(a) (i) What was the volume of the pipette used?

(ii) What was the colour change at the end point?

(iii) Calculate the average volume of the acid used to neutralize the base.

*(b) Write a balance chemical equation for the neutralization reaction between solution **A** and **D**.*

(c) Calculate the percentage purity of sodium hydroxide.

The candidates who scored high marks in this question filled correctly the table of results by considering two decimal places, and accuracy of the data. This means that they followed correctly titrating procedures to obtain correct readings. Similarly, the candidates read the volume of pipette used and recorded it correctly. More-over, the candidates wrote balanced chemical equation for the chemical reaction between sodium hydroxide (NaOH) and sulphuric acid (H_2SO_4). The candidates applied

the concept of mole and stochiometry to calculate the molarity of pure sodium hydroxide with its appropriate SI unit. Similarly, the candidates calculated the mass concentration of pure and impure sodium hydroxide. Finaly, the candidates used the mass concentration of impure and pure sodium hydroxide to calculate the percentage purity of sodium hydroxide. Extract 15.1 shows a sample of correct responses in question 1 (Alternative 2A).

1. (a) (i) The volume of pipette used was $25cm^3$.

(ii) The colour changes from orange into red at the end point

(iii) TABLE OF RESULTS

Titration	Pilot	1	2	3
Final volume (cm^3)	38.10	47.60	42.60	37.40
Initial volume (cm^3)	0.00	10.00	5.00	0.00
Volume used (cm^3)	38.10	37.60	37.60	37.40

$$\text{Average volume} = \left(\frac{V_1 + V_2 + V_3}{3}\right) cm^3$$

$$= \left(\frac{37.60 + 37.60 + 37.40}{3}\right) cm^3$$

$$= 37.53\ cm^3$$

Average volume of acid used to neutralie the base was $37.53cm^3$

(b) The balanced chemical equation between solution A and D.

$$2NaOH_{(aq)} + H_2SO_{4(aq)} \longrightarrow Na_2SO_{4(aq)} + 2H_2O_{(l)}$$

c. Data given.

Molarity of acid (Ma) = 0.03 M

Volume of acid used (Va) = $37.53\ cm^3$

Volume of base used (Vb) = $25\ cm^3$

From balanced chemical equation

Number of moles of acid (na) = 1 mole

Number of moles of base (nb) = 2 mole.

required. Molarity of base (Mb) = ?

1. (c) From Mole ratio formula.

$$\frac{Ma\,Va}{na} = \frac{Mb\,Vb}{nb}$$

$$Mb = \frac{Ma\,Va\,nb}{na\,Vb}$$

$$Mb = \frac{0.03M \times 37.5cm^3 \times 2moles}{1mole \times 25cm^3}$$

$$Mb = 0.09\ M$$

Molarity of base = 0.09M

then

From Concentration of Impure = $\frac{mass}{volume}$

$$Concentration = \frac{3.5g}{1dm^3}$$

$$Concentration = 3.5g/dm^3$$

But

Concentration of pure is given by

$$Molarity = \frac{Concentration}{Molarmass}$$

$$Concentration = Molarity \times Molarmass$$

now

Molarmass of NaOH = 23(1) + 16(1) + 1(1)

= 23 + 16 + 1

= 40g/mol.

Recall Concentration = Molarity x Molar mass

= 0.09M x 40g/mol

= 3.6 g/dm³

then, from,

$$Percentage\ purity = \frac{Concentration\ of\ pure}{Concentration\ of\ impure} \times 100\%$$

$$Percentage\ purity = \frac{3.6g/dm^3}{3.5g/dm^3} \times 100\%$$

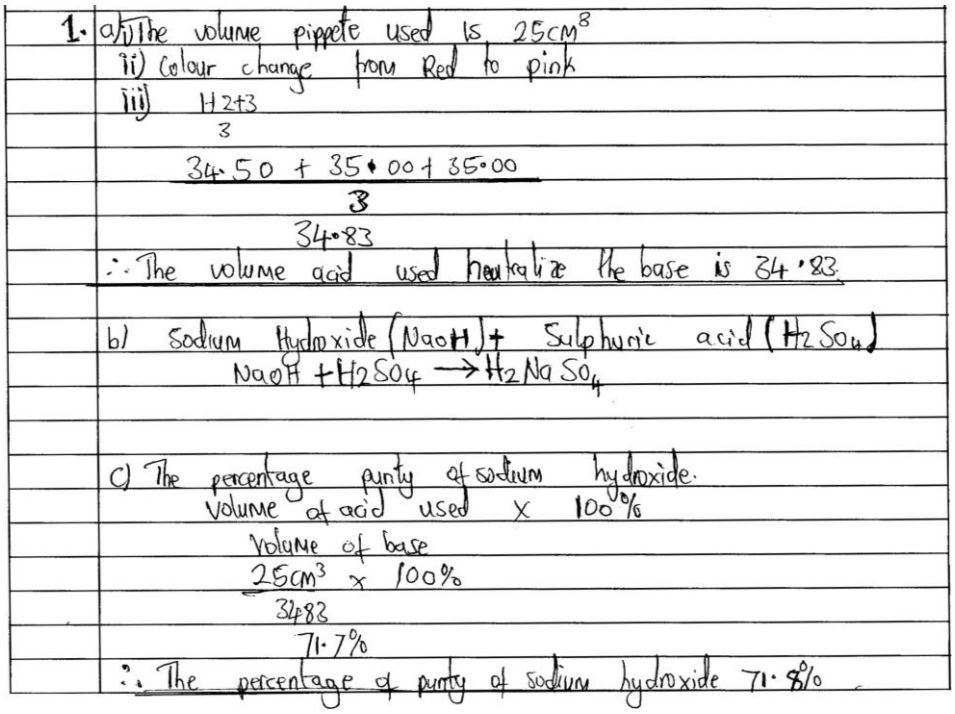
c. Percentage purity = 102%

Percentage purity of NaOH was 102%.

Extract 15.1: A sample of correct responses to question 1, paper 2A

In Extract 15.1, the candidate filled the table of results correctly, carried out the subsequent calculations and finally, determined the correct value of the percentage purity of sodium hydroxide.

Conversely, the candidates who scored low marks failed to fill the table of results correctly. Some of them got incorrect volumes of the acid solution used. Similarly, they failed to take into consideration the 2 decimal places, accuracy, and left some gaps in the table of results. Some of them did not indicate the volume of pipette used. Likewise, The candidates failed to write well balanced chemical equation between H_2SO_4 and NaOH. As a result, the candidates obtained incorrect mole ratio of acid to base. Also, they used wrong formulae in the successive calculations in an attempt to determine the percentage purity of sodium hydroxide. For instance, some candidates used the formula $MaVana = MbVbnb$ instead of $MaVanb = MbVbna$. Generally, the candidates in this category had insufficient knowledge about the concept of laboratory apparatuses, chemical equation, mole concept and volumetric analysis. Extract 15.2 shows a samples of incorrect responses in this question.


1. a) i) The volume pippete used is $25cm^3$
ii) Colour change from Red to pink
iii) H2+3 / 3
$\frac{34.50 + 35.00 + 35.00}{3}$
34.83
∴ The volume acid used heutralize the base is 34.83

b) Sodium Hydroxide ($NaoH$) + Sulphuric acid (H_2SO_4)
$NaOH + H_2SO_4 \rightarrow H_2NaSO_4$

c) The percentage purity of sodium hydroxide.
$\frac{\text{Volume of acid used}}{\text{Volume of base}} \times 100\%$
$\frac{25cm^3}{34.83} \times 100\%$
71.7%
∴ The percentage of purity of sodium hydroxide 71.8%

Extract 15.2: A sample of incorrect responses to question 1, paper 2A

In Extract 15.2, the candidate skipped the table of results, and wrote incorrect colour change in part (a). In part (b), he/she gave incorrect chemical equation, and in part (c), he/she used volume instead of mass concentration to calculate the percentage purity, instead of percentage impurity of sodium hydroxide. However, the candidate indicated correct volume of the pipette used.

2.2.1.2 Alternative 2B

The candidates were provided with solutions **BB** and **CC**. One solution was acidic, while the other solution was basic. The acidic solution contained 3.06 g/dm^3 sulphuric acid (H_2SO_4), while the basic solution contained 2 g of impure sodium hydroxide (NaOH) in 500 cm^3 of distilled water. The candidates were required to perform the following procedures, and then answer the questions that follow:

The candidates were provided with the following procedures:

*(i) Pour about 2 cm^3 of solution **BB** into a test tube and use litmus paper to test if it is acidic or a basic.*

(ii) Discard the content and wash the test tube.

*(iii) Repeat the steps (i) and (ii) using solution **CC**.*

*(iv) Titrate the acid solution (in the burrete) against the base solution (in the titration flask) using methyl orange (**MO**) as an indicator up to the end point.*

(v) Repeat the step (iv) to obtain three more readings and record the results in a tabular form.

Qestions

(a) (i) What was the volume of the pipette used?

(ii) Calculate the average volume of the acid used to neutralize the base.

(iii) What was the colour change at the end point?

*(b) Write a balanced chemical equation for the the reaction between solutions **BB** and **CC**.*

(c) Calculate the percentage of impurity of sodium hydroxide.

The candidates who scored high marks filled the table of results correctly considering two decimal places and within accuracy of the data. They correctly followed the titration procedures to obtain correct readings. Also, they managed to read the volume of pipette used and recorded it correctly. These candidates were able to write balanced chemical equation regarding the chemical reaction of the two sample solutions (NaOH and H_2SO_4). The candidates had adequate knowledge on the concept of mole and related calculations. Thus, they wrote correct formulae, calculated mass concentration and molarity of sodium hydroxide. Finally, the candidates calculated percentage impurity of sodium hydroxide. Extract 16.1 shows a sample of correct responses in question 1 (Alternative 2B) from one of the candidates.

Q1. Data given.

Solution BB ; concentration = 3.06 g/dm³ of H_2SO_4.

Solution CC ; mass = 2g NaOH.

Volume = 500 cm³ → 0.5 dm³.

Table of value.

Titration	Pilot	I	II	III
Final reading (cm³)	30.00	31.00	30.10	31.60
Initial reading (cm³)	0.50	1.60	0.80	2.30
Total volume (cm³)	29.50	29.40	29.30	29.30

Questions.

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

(ii) To calculate the average volume of Acid

$$\text{A.V acid} = \frac{V_1 + V_2 + V_3}{3}$$

$$= \frac{29.40 + 29.30 + 29.30}{3}$$

$$= \frac{88}{3} = 29.3 \text{ cm}^3$$

∴ The average volume used is 29.3 cm³.

(iii) The colour change at the end point is from Yellow colour to Pink colour.

(b) The balanced chemical equation between BB and CC is

$$H_2SO_{4(aq)} + NaOH_{(aq)} \longrightarrow Na_2SO_{4(aq)} + H_2O_{(l)}$$

Balanced :: $H_2SO_{4(aq)} + 2NaOH_{(aq)} \longrightarrow Na_2SO_{4(aq)} + 2H_2O_{(l)}$

Balanced

(c) Percentage impurity of NaOH.

Data given.

Concentration Acid = 3.06 g/dm3

Molar mass (H_2SO_4) = 98 g/mol.

Then, Molarity of acid = $\frac{Conc}{mr}$

$$M_a = \frac{3.06}{98} = 0.03M$$

Then, from

$$\frac{n_a}{n_b} = \frac{M_a V_a}{M_b V_b}$$

$$\frac{1}{2} = \frac{0.03M \times 29.3\ cm3}{M_b \times 20\ cm3}$$

$$M_b = \frac{1.829}{20} = 0.091M.$$

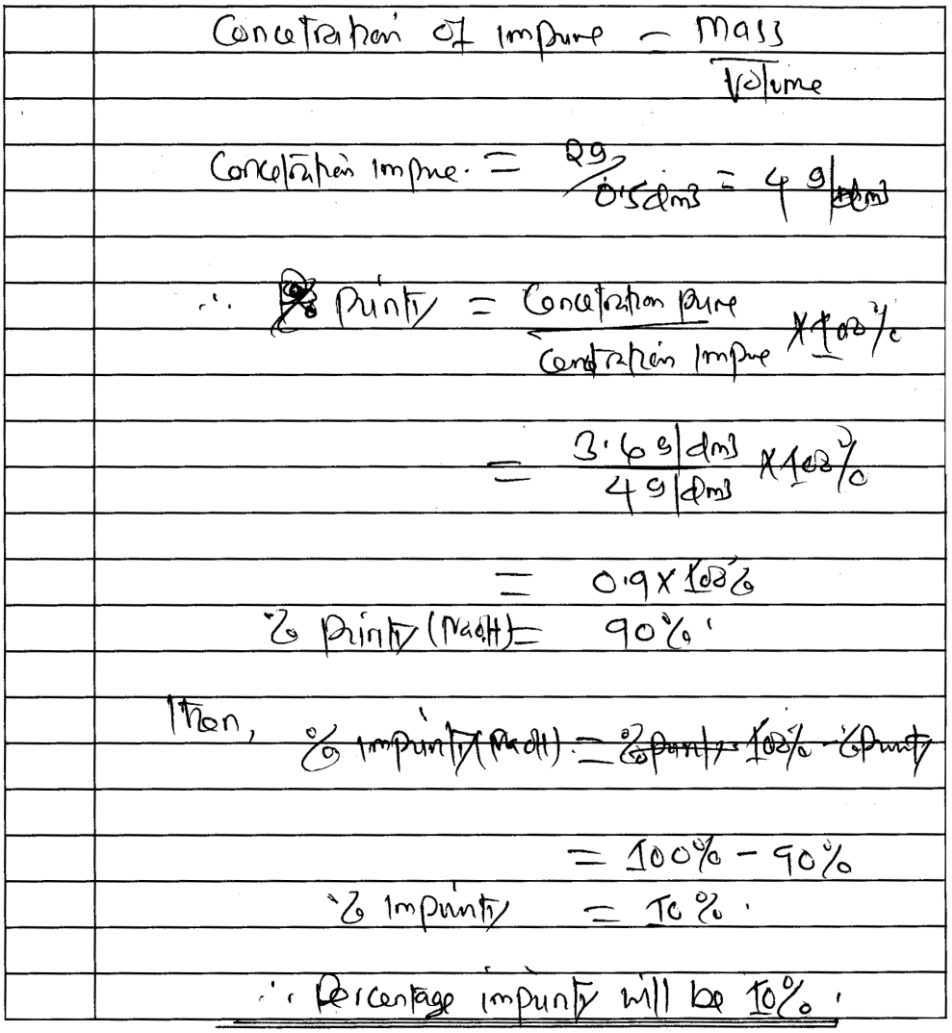
∴ Molarity of base of pure is 0.09m

Then,

$$M = \frac{Conc}{pw}$$

Concentration pure = 0.09 x 40

∴ Concentration of pure is 3.6 g/dm3.

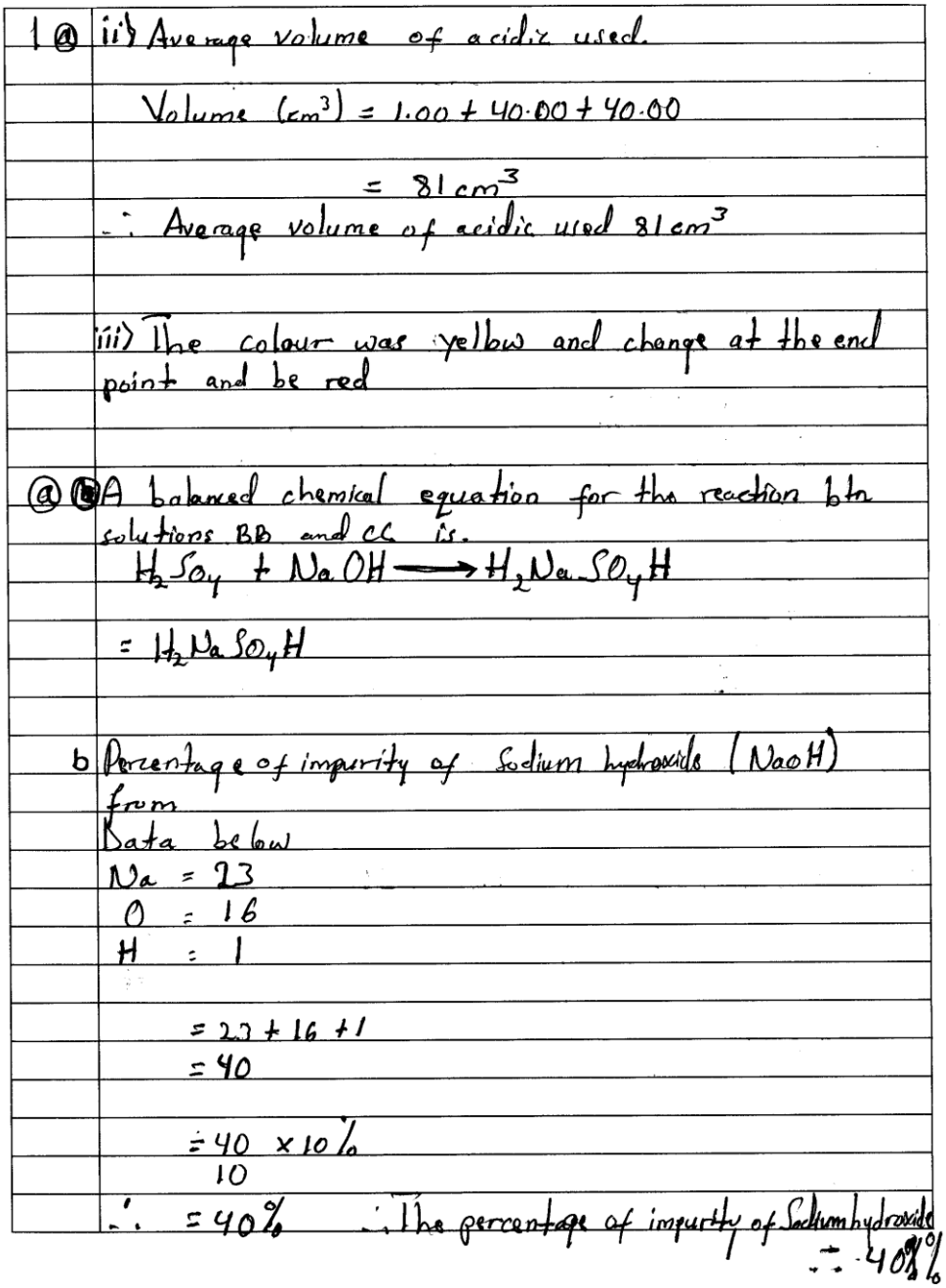


Extract 16.1: A sample of correct responses to question 1, paper 2B

In Extract 16.1, the candidate filled the table of results correctly, and used appropriate formulae to calculate the percentage impurity of sodium hydroxide.

However, the candidates who scored low marks failed to fill the table of results correctly by not adhering to 2 decimal places and accuracy. Some of them did not indicate the volume of the pipette used to measure the volume of the base. Likewise, the candidates failed to write the balanced chemical equation between H_2SO_4 and NaOH. For example one candidate wrote $H_2SO_4 + NaOH \longrightarrow NaSO_4 + H_2O$. Hence, he/she obtained acid base mole ratio of 1:1 instead of 1:2. Also, the candidate used incorrect formulae in the successive calculations.

Thus, they obtained incorrect values of percentage impurity of sodium hydroxide. Generally, the candidates falling under this category lacked adequate knowledge about the chemical equation, mole concept, and volumetric analysis. Extract 16.2 shows a sample of incorrect responses in question 1 (Alternative 2B).


1 @ ii) Average volume of acidic used.

Volume (cm^3) = 1.00 + 40.00 + 40.00

= 81 cm^3

∴ Average volume of acidic used 81 cm^3

iii) The colour was yellow and change at the end point and be red

@ (a) A balanced chemical equation for the reaction bth solutions BB and CC is.

$H_2SO_4 + NaOH \longrightarrow H_2NaSO_4H$

= H_2NaSO_4H

b Percentage of impurity of Sodium hydroxide (NaoH) from

Data below

Na = 23

O = 16

H = 1

= 23 + 16 + 1

= 40

÷ 40 × 10%
10

∴ = 40% ∴ The percentage of impurity of Sodium hydroxide ÷ 40%

Extract 16.2: A sample of incorrect responses to question 1, paper 2B

In Extract 16.2, the candidate calculated total volume of the acid used instead of titre (average) volume in part (a). Similarly, the candidate wrote incorrect chemical equation for the neutralization reaction. In part (b), the candidate calculated the molar mass of sodium hydroxide instead of the percentage impurity of sodium hydroxide. He/she failed to construct a table of results and gave incorrect answers to the remaining parts of the question.

2.2.1.3 Alternative 2C

The candidates were provided with solutions **UU** and **VV,** and were required to proceed as follows:
*Pour about 2 cm^3 of solution **UU** into a test tube; add 2 to 3 drops of methyl orange **(MO)** indicator to test whether it is an acidic or basic solution. Empty the test tube and wash it. Repeat the procedure using solution **VV**.*

*The acidic solution you have identified is a solution of 0.1 M nitric acid. The basic solution was made by dissolving 2.65 g of Na_XCO_3 in a 0.5 dm^3 of a solution. Titrate the acid solution (from the burrete) against the base solution (in titration flask) using methyl orange **(MO)** as an indicator up to the end point. Repeat the procedure to obtain three more burrete readings. Record your results in a tabular form.*

Questions

(a) (i) What was the volume of the pipette used?
(ii) Calculate the average titre volume.

(b) If the mole ratio between the base and acid for the reaction is 1:2 respectively, determine the following:
(i) Concentration of Na_XCO_3 in mol/dm^3 and g/dm^3
(ii) Molecular mass of Na_XCO_3
(iii) The value of x and hence replace it in the formula Na_XCO_3.

*(c) Write a balanced chemical equation for the reaction between **UU** and **VV**.*
(d) What is the significance of the indicator in this experiment?

The candidates who scored high marks in this question correctly filled the table of results, gave the volume of pipette used, and wrote well

balanced chemical equation for the reaction between Na_XCO_3 and HNO_3. Also, they followed the correct procedures, and used appropriate formulas in calculating the molarity of Na_XCO_3. Similarly, the candidates calculated the mass concentration of pure Na_XCO_3, finally, determined the value of x in Na_XCO_3. Generally, the candidates had adequate knowledge about neutralization reactions, and the mole concept. Extract 17.1 shows a sample of correct responses in question 1 (Alternative 2C).

1. UU → Acidic solution
VV → Basic solution.

1a (i) Volume of the pipette used was 25 cm^3.

(ii) Volume of acid.

	PILOT	I	II	III
Initial reading (cm^3)	00.00	00.00	00.00	00.00
Final reading (cm^3)	24.5	25.00	25.10	24.90
Volume used (cm^3)	24.5	25.00	25.10	24.90

Average titre volume = $\frac{V_1 + V_2 + V_3}{3}$

$= \frac{(25 + 25.1 + 24.9)\,cm^3}{3}$

$= \frac{75\,cm^3}{3}$

∴ Average titre volume is 25 cm^3.

b. Soln:
Given; $n_a = 2$
$n_b = 1$.
$M_a = 0.1M$
2.65 g of Na_xCO_3 → 0.5 dm^3.
$V_a = 25cm^3$
$V_b = 25\,cm^3$

i) Concentration of Na_xCO_3 in mol/dm³ and g/dm³

Soln.

From;

$$\frac{M_a V_a}{M_b V_b} = \frac{n_a}{n_b}$$

$$\Rightarrow \frac{0.1m \times 25dm^3}{M_b \times 25dm^3} \times \frac{2}{1}$$

$$M_b = \frac{0.1m}{2}$$

$$M_b = 0.05m = 0.05mol/dm^3.$$

∴ Concentration of Na_xCO_3 in mol/dm³ is 0.05mol/dm³.

=> From;

$$\text{Concentration} = \frac{\text{Mass (g)}}{\text{Volume } (dm^3)}$$

Mass = 2.65

Volume = 0.5 dm³

$$\text{Concentration} = \frac{2.65g}{0.5dm^3}$$

$$= 5.3\ g/dm^3$$

∴ Concentration of Na_xCO_3 in g/dm³ is 5.3 g/dm³.

ii) Molecular mass of Na_xCO_3.

Soln:

From;

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

16 iii) ⇒ concentration = $5.3 g/dm^3$

⇒ Molarity = $0.05 mol/dm^3$

Molar mass = $\frac{\text{concentration}}{\text{Molarity}}$.

~~⇒ Mr = $0.05 mol/dm^3$~~

⇒ Mr = $\frac{5.3 g/dm^3}{0.05 mol/dm^3}$ = $106 g/mol$

∴ Molecular mass of Na_xCO_3 is $106 g/mol$.

iii. Value of x

Sol;

Chemical formula; Na_xCO_3

Molar mass of Na_xCO_3 = $106 g/mol$

Also,

Mr of Na_xCO_3 = $23 \times x + 12 + 16 \times 3$

= $23x + 12 + 48$

⇒ $23x + 60$

Since;

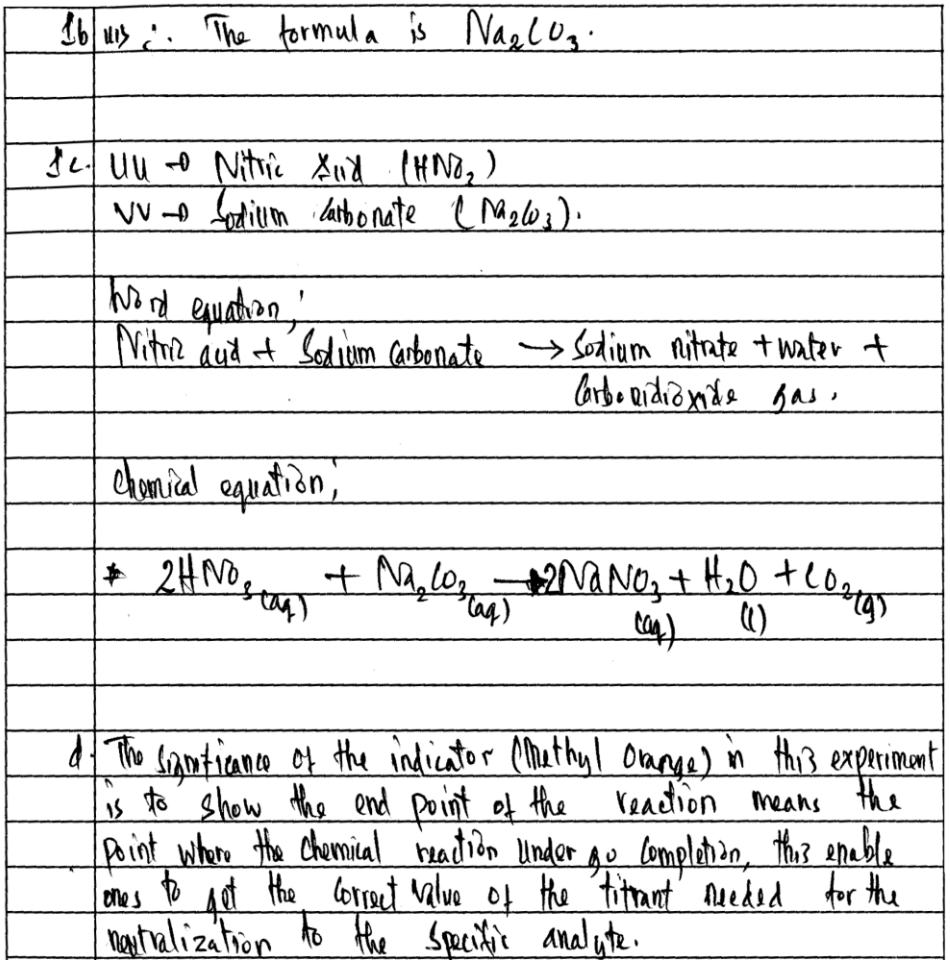
$23x + 60 = 106$.

$23x = 106 - 60$

$23x = 46$

$x = \frac{46}{23} = 2$.

∴ $x = 2$.



Extract 17.1: A sample of correct responses to question 1, paper 2C

In Extract 17.1, the candidate correctly identified the acid and base in the unlabeled beakers. He/she filled the table of results with correct data, which implies that the candidate performed correct procedures in the titration. Furthermore, the candidate performed the subsequent calculations and determined the value of **X** being 2, in the substance Na_XCO_3. Thus, the correct formula of the compound was Na_2CO_3. Also, the candidate gave the significance of the indicator, in part (d).

On the contrary, the candidates who scored low marks failed to attempt most parts of the question. For instance, in filling the table of results, some of the candidates recorded the data with one decimal places instead of two. Also, they did not indicate the volume of the pipette used and most of the data recorded in the table deviated much from the expected

volume. Similarly, the candidates wrote incorrect/unbalanced chemical equations between HNO_3 and Na_XCO_3, which led to wrong mole ratios. In the calculation, they used incorrect formulae and followed inappropriate mathematical steps in determining the value of **X**. Extract 17.2 shows a sample of incorrect responses in this question (Alternative 2C).

Q1

SOLUTION	UU	INDICATOR
SOLUTION	UU	Red / pink
	VV	Yellow colour

TABULAR FORM

Volume Reading	Pilot	i	ii	iii
Final Reading	22.50	23.00	22.50	21.00
Initial reading	0.00	0.00	0.00	0.00
Volume use	22.50	23.00	22.50	21.00

A:

i 20 ml

ii

$$\frac{23.0 + 22.5 + 21.0}{3}$$

$Va = 22.16 cm^3$

∴ The volume of Acid is $22.16 cm^3$

B. $na = 1$ and $nb = 2$

i

$= Na_xCO_3$

DATA

$Na = 0.1 M$

$mass = 2.650$

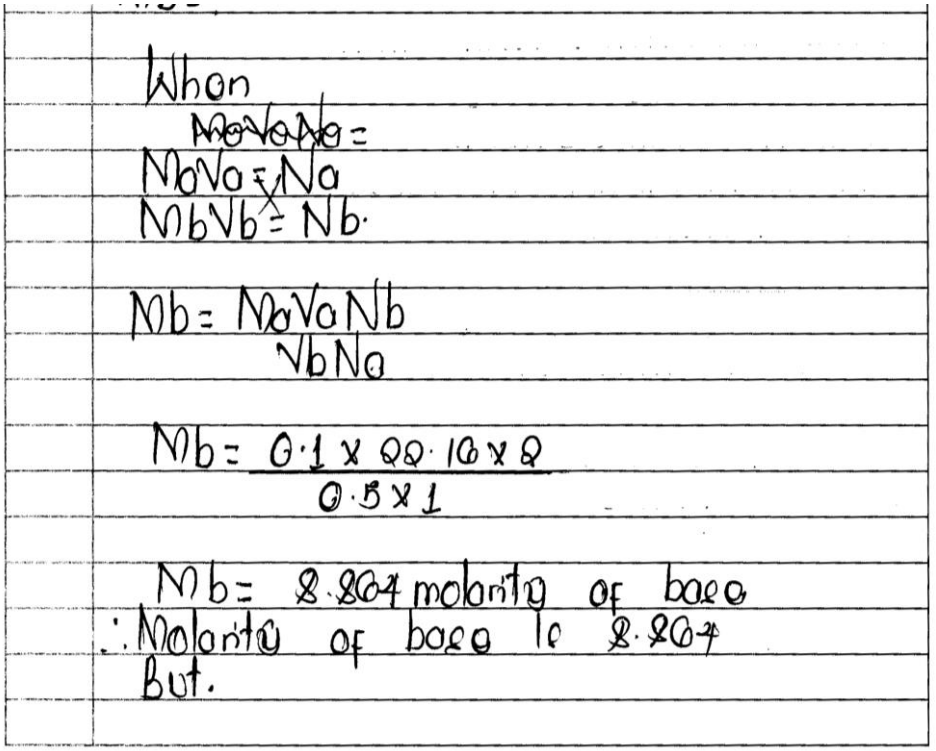
$Vb = 0.50 m^3$

$Va = 22.16 cm^3$

$na = 1$

$nb = 2$

$Mb = ?$



Extract 17.2: A sample of incorrect responses to question 1, paper 2C

In Extract 17.2, the candidate identified the acid and base incorrectly in the beakers. He/she also incorrectly performed titration, and the calculations in determining the value of **X** in the formula Na_XCO_3. This led to the incorrect value of **X** in the formula Na_XCO_3.

2.2.2 Question 2: Chemical Kinetics, Equilibrium and Energetics

The question was attempted by 155,437 candidates (100%). The analysis shows that 10.94 per cent of the candidates scored from 0 to 7 marks, 37.26 per cent scored from 7.5 to 16.5 marks and 51.80 per cent scored from 17 to 25 marks. Generally, the candidates' performance in this question was good because 89.06 per cent scored 7.5 marks or above. The summary of the candidates' performance is shown in Figure 16.

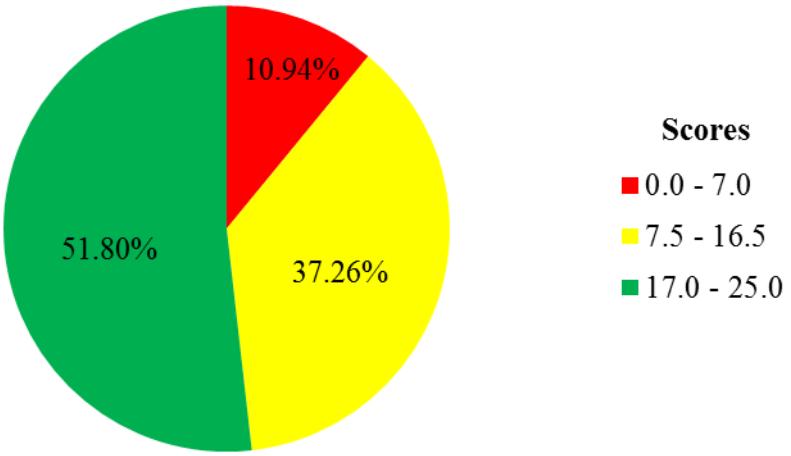


Figure 16: *Candidates' Performance in Question 2*

2.2.2.1 Alternative 2A

The aim of the experiment was to determine the effect of concentration on the rate of chemical reaction. The candidates were required to study the reaction between sodium thiosulphate and hydrochloric acid. The chemicals provided were labeled as **LL** and **NN**, containing 0.13 M sodium thiosulphate and 2 M nitric acid, respectively. Also, each candidate was given distilled water, stopwatch or stop clock, and a sheet of white paper marked **X**.

The candidates were provided with the following procedures:

*(i) Measure 20 cm^3 of solution **LL** and put it into a 100 cm^3 beaker.*

*(ii) Place the beaker containing solution **LL** on the top of letter **X** drawn on a sheet of paper.*

*(iii) Measure 10 cm^3 of solution **NN**; put it into a beaker containing solution **LL** and immediately start the stopwatch. Swirl the beaker with contents twice.*

*(iv) Look down vertically through the mouth of the beaker so as to see the cross at the bottom of the beaker. Stop the clock when the letter **X** is invisible.*

*(v) Record the time taken for the letter **X** to dissapear completely.*

(vi) Repeat the experiment using the data shown in the following table.

Table: Experimental Data

Experiment No.	Volume of NN (cm^3)	Volume of LL (cm^3)	Volume of distilled water (cm^3)	Time (sec)	$\frac{1}{t}$ (sec^{-1})
1	10	20	0		
2	10	15	5		
3	10	10	10		
4	10	5	15		

(a) *Complete filling the experimental table.*

(b) *What does* $\frac{1}{t}$ *represent in the experimental table?*

(c) *Write a balanced chemical equation for the reaction between* ***LL*** *and* ***NN***

(d) *How was the factor of concentration varied in this experiment?*

(e) *Plot a graph of volume solution* ***LL*** *against* $\frac{1}{t}$

(f) *Use the graph you have drawn in (e) above to explain how the variation of concentration affects the rate of chemical reaction.*

The candidates who scored high marks in this question were able to fill the table by using volume of **NN**, **LL** and distilled water in part (a). In part (b), they had enough knowledge about the concept of rate of chemical reaction that is; rate of reaction $= \frac{Change\ in\ concentration}{Change\ in\ time}$.

In part (b), the candidates interpreted that $\frac{1}{t}$ represented the rate of reaction in the table. The candidates correctly wrote a balanced chemical equation for chemical reaction between sodium thiosulphate and dilute hydrochloric acid, in part (c). Likewise, the candidates explained that the addition of water (dilution) was done technically to vary the concentration, in part (d). Moreover, the candidates plotted the graph (to obtain the best fit line) as required in part (e). In part (f), these candidates appropriately pointed out that the rate of the reaction was direct proportional to the concentration. Other candidates specified that the reaction took more time because the concentration of sodium

thiosulphate was decreased through dilution. Extract 18.1 shows one of the correct responses in question 2 (Alternative 2A).

2. (a) Experimental data.

Experiment Number	Volume of NN (cm^3)	Volume of LL (cm^3)	volume of distilled water (cm^3)	Time (sec)	1/t (sec^{-1})
1	10	20	0	40·72	0·025
2	10	15	5	66·56	0·015
3	10	10	10	145·90	0·007
4	10	5	15	240·00	0·004

(b) 1/t in experimental table represent the rate of reaction.

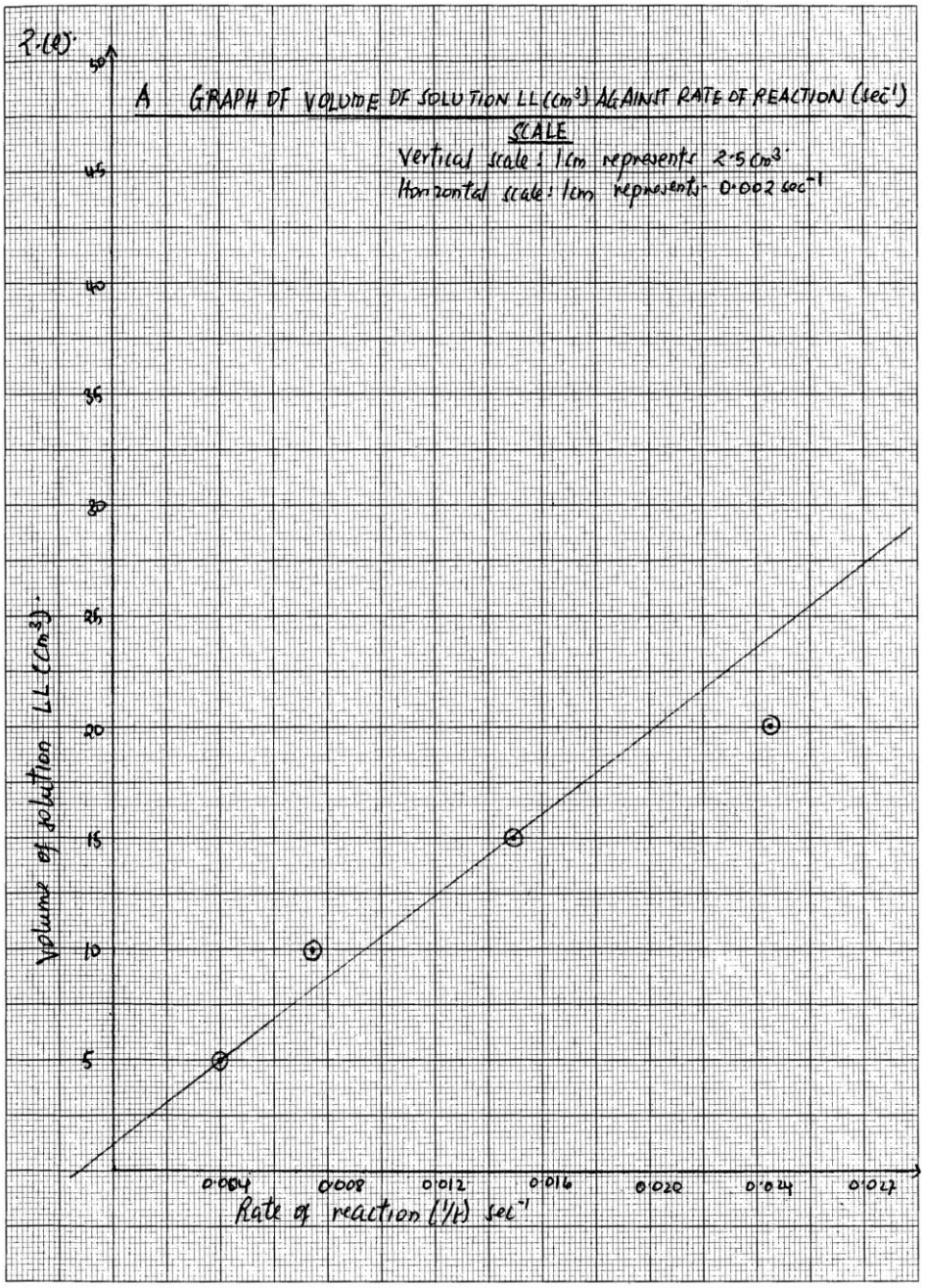
(c) A balanced chemical equation between LL and NN

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

(d) The concentration varied in this experiment through the addition of water in solution LL which reduce the concentration of it hence it became varied.

(e) Consider in the graph.

(f) As the concentration of solution LL decreases even the rate of reaction descreases hence the concentration of solution LL was directly proportional to the rate of reaction



Extract 18.1: A sample of correct responses to question 2, paper 2A

In Extract 18.1, the candidate filled the table of results correctly, interpreted the reciprocal of time and wrote a balanced chemical equation for the reaction which took place. He/she pointed the means of varying concentration, plotted the graph and interpreted the effect of concentration on the rate of the reaction.

On other hand, the candidates who scored low marks failed to complete the table of results correctly in part (a) Some of them recorded time which deviated much from the expected range, implying that they lacked skills of timing the stop watch. Others recorded similar values of both time and 1/t, indicating failure in recognizing the relationship between the two dimensions. In part (b), the candidates did not indicate the reciprocal of time as the rate of the reaction. For instance, one of the candidates wrote that "1/t show the progress of the reaction." In part (c), the candidates wrote chemical equations with incorrect products while others failed to balance the equations. For example, there were candidates who did not indicate sulphur as one among the products. Similarly, some candidates obtained a mole ratio of 1:1 due to failure to balance the chemical equation. In part (d), the candidates failed to state how the concentration was varied in the experiment. For example, one candidate wrote that the concentration was not changed. In part (e), some of the candidates plotted the graph without labeling the axes, while others did not indicate the title of the graph. Similarly, in sketching the graph, some candidates used inappropriate vertical and horizontal scales. Moreover, there were candidates who sketched curves instead of linear graphs. In part (f), the candidates gave inappropriate comments regarding the relationship between concentration and rate of the reaction. This shows that the candidates lacked adequate knowledge about chemical kinetics. Extract 18.2 shows a sample of incorrect responses in this question (Alternative 2A).

2. a)

Experiment No	volume of NN (cm^3)	Volume of LL cm^3	volume of distilled water cm^3	Time Sec	$\frac{1}{t}$ (Sec^{-1})
1	10	20	0	15.00sec	0.15sec
2	10	15	5	18.00sec	0.18sec
3	10	10	10	20.00sec	0.20 sec
4	10	5	15	25.00 sec	0.25 sec

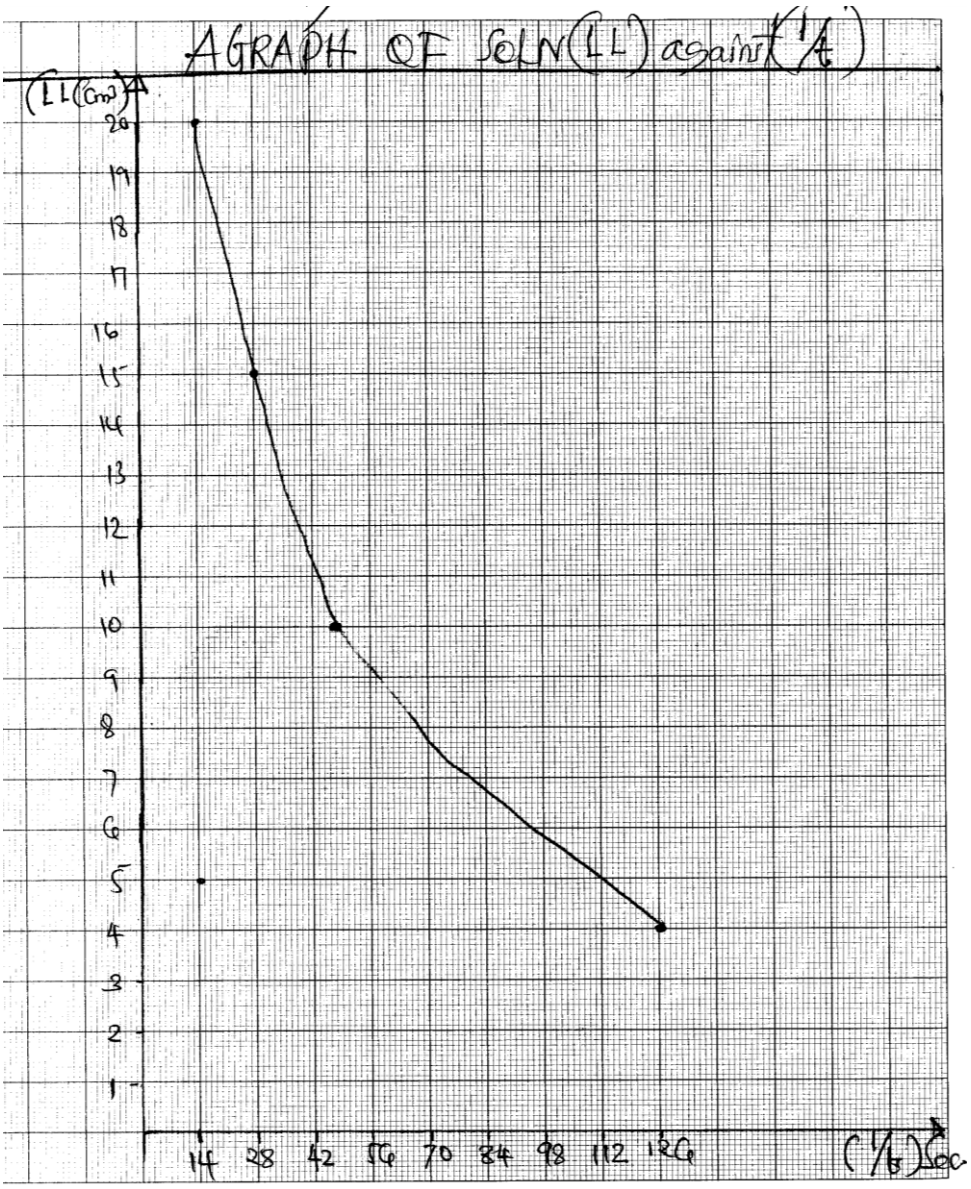
b) $\frac{1}{t}$ = represent Minutes

c) LL = 0.8M $Na_2S_2O_3$ (Sodium thiosulphate)
NN = 2 N HCL

Sodium thiosulphate + HCL →

d) The factor of concetration variety this of milk

f) The variation of concetration affect the ratio of rate of the Chemical reaction for various different time like time, distilled water and ratio of NN and LL for general



Extract 18.2: A sample of incorrect responses to question 2, paper 2A

In Extract 18.2, the candidate recorded incorrect data (time), and calculated 1/t incorrectly, in part (a). He/she regarded that 1/t represented minutes, instead of rate of the reaction. In part (c), the candidate contradicted name and chemical formula without indicating the products of the reaction. In part (e), the candidate plotted incorrect graph, while in part (f), he/she did not specify the trend of variation of the rate of the reaction by factor of concentration of sodium thiosulphate.

2.2.2.2 Alternative 2B

The aim of the experiment was to determine the effect of temperature on the rate of chemical reaction. The candidates were required to study the reaction between sodium thiosulphate and hydrochloric acid. The chemicals provided were labeled as **FF**, containing 0.2 M sodium thiosulphate solution and **EE**, containing 0.1 M hydrochloric acid solution. Also, they were provided with thermometer, stopwatch/ stop clock and a sheet of white paper marked **X**.

Candidates were required to proceed as follows:

*(i) Place 50 cm^3 beaker on top of cross **X** on the plain sheet of paper provided such that the cross **X** is visible through the mouth of the beaker when viewed from above.*

(ii) Prepare a water bath using 250 cm^3 or a 300 cm^3 beaker.

*(iii) Measure exacctly 10 cm^3 of solution **FF** and 10 cm^3 of **EE** and pour into separate boiling test tubes.*

(iv) Put the two boiling test tubes into the water bath in step (ii) and warm the contents to 40 ^oC.

*(v) Pour the hot solutions **FF** and **EE** into the 50 cm^3 beaker in step (i) and immediately start the stopwatch/clock. Record the time taken in seconds for the cross to disappear completely.*

(vi) Repeat the procedures stated in (iii) to (v) at different temperatures of 50 ^oC, 60 ^oC and 70 ^oC and record your readings as shown in the following table.

Table: Experimental Data

Temperature (^0C)	***Time (sec)***	$\frac{1}{time}$ ***(sec^{-1})***
40		
50		
60		
70		

The candidates were then asked the following questions:

(a) Complete filling the table.

*(b) What does $\frac{1}{time}$ in the table represent**?***

*(c) Write a balanced chemical equation for the reaction between **EE** and **FF**.*

(d) *What is the name of the product causing the solution to turn cloudy making the letter **X** to disappear?*

(e) *Plot graph of temperature against* $\frac{1}{time}$

(f) *From the graph what do you conclude about the effect of increasing temperature on the rate of reaction?*

The candidates who scored high marks in this question recorded correct data of time, which were decreasing with increasing temperature, in part (a). In part (b), they were able to notice that $\frac{1}{t}$ represented the rate of the reaction. This was attributed to sufficient knowledge on the concept of rate of chemical reaction; that is rate of reaction $= \frac{Change\ in\ concentration}{Change\ in\ time}$. In parts (c) and (d), the candidates wrote well balanced chemical equation between **EE** and **FF**, and identified Sulphur which caused the cross **X** to disappear. The candidates accurately plotted the graph (to obtain a straight line) as required in part (e), and correctly commented on its nature in part (f), that the increase in temperature led to the increase in the rate of reaction. Extract 19.1 shows a sample of correct responses in question 2 (Alternative 2B).

Room temperature = 30.1 °C

02. (a) soln

Temperature (°C)	Time (sec)	1/time (sec⁻¹)
40	12	0.0769
50	10	0.1000
60	8	0.1250
70	6	0.1667

(b) - 1/time (sec^{-1}) represents the rate of the chemical reaction taking place.
Then, sec^{-1} represents Rate / Speed of the chemical reaction.

ⓒ Soln

Given, EE – HCl (Hydrochloric acid)

FF – $Na_2S_2O_3$ (Sodium thiosulphate)

Required; Balanced equation for the reaction between EE (HCl) and FF ($Na_2S_2O_3$)

Then

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

02. ⓓ

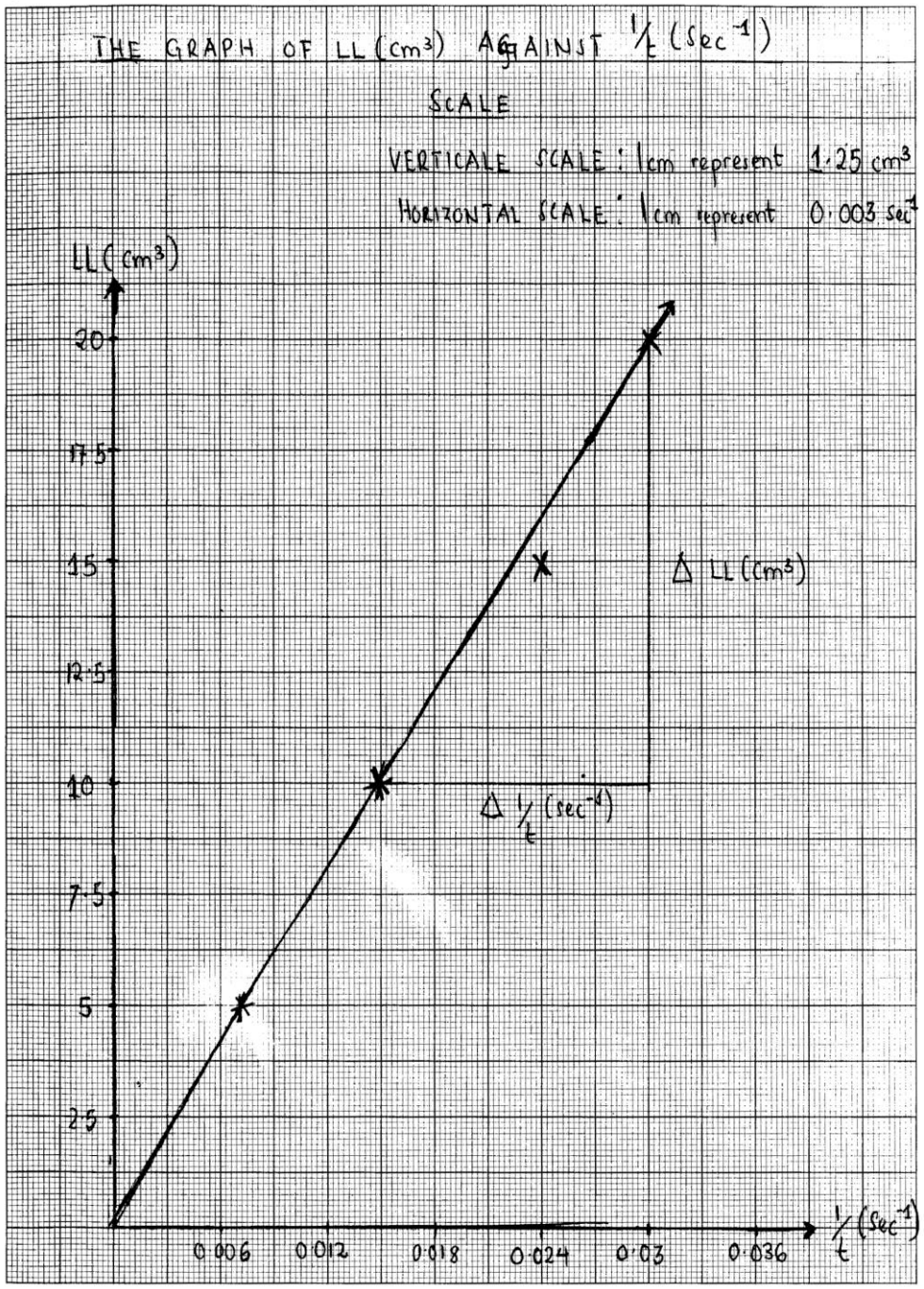
- The name of product causing solution to turn cloudy causing letter X to disappear is <u>Sulphur precipitate</u>

ⓕ From the graph,

Since the graph is <u>straight</u>, it means that;

- When the temperature in the reaction increases, it cause also the rate of chemical reaction to increases and vice versa.

Hence; <u>Temperature is direct proportional to the rate of chemical reaction. ($T \propto R$)</u>



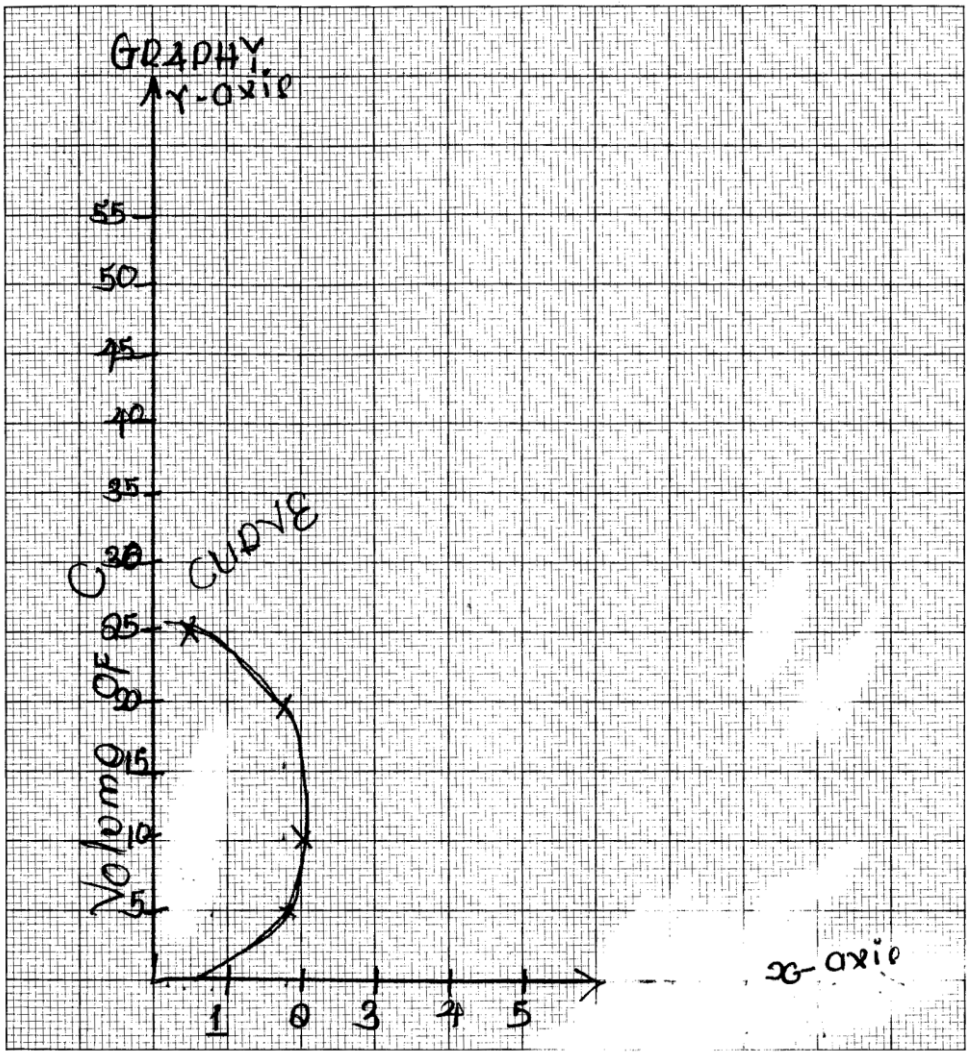
Extract 19.1: A sample of correct responses to question 2, paper 2B

Nonetheless, the candidates who scored low marks failed to attempt most parts of the question. In part (a), they filled the table by supplying incorrect data, implying inadequate skills of data collection. Others recorded time in

minutes instead of seconds. In part (b), the candidates failed to indicate that the reciprocal of time represented rate of the reaction. For instance, one of the candidates wrote "1/time represent concentration", instead of rate of the reaction. Similarly, the candidates wrote incorrect chemical equation for the neutralization, in part (c). Some indicated incorrect reactants and products. For instance, one candidate wrote the formula for sodium sulphate, instead of sodium thiosulphate in the chemical equation. In part (d), some candidates mentioned sulphate instead of sulphur as the product which obscured mark **X**. Also, the candidates tried to sketch the graph, in part (e), but failed to label the axes of the graph. Others did not indicate the title of the graph. Similarly, some of the candidates used inappropriate vertical and horizontal scales, thus, failed to draw the best line appropriately. In part (f), the candidates gave inappropriate comments based on the relationship between temperature and rate of chemical reaction. This shows that the candidates had insufficient knowledge of the effects of temperature on the rate of chemical reaction. Extract 19.2 shows a sample of incorrect responses in this question (Alternative 2B).

Q2	TABLE FORMULAR			
	VOLUME OF C (cm^3)	Distilled Water Com	Volume of H Com^3	Time taken for cross to disappear
	25	0	5	1-90·2·00
	20	5	5	0·55
	15	10	5	1·20
	10	15	5	0:50
	5	20	5	0·59

2'	c) Balance equation for the reaction between solution EE and ff'
	~~$Na_2S_2O_3 + MHCl \rightarrow NaM +$~~
	$Na_2S_2O_3 + MHCl \rightarrow 2NaCl + S_2M_8 + H_2O$
	b) ~~Y/t represent~~
	~~time and second'~~
	.
	b) Y/t represent Time and second.
	d) : The product in solution is
	i) Sodium Thiosulphate



Extract 19.2: A sample of incorrect responses to question 2, paper 2B

In Extract 19.2, the candidate recorded incorrect data and chemical equation. Also, the candidate used the incorrect data to plot a curve which led him/her to interpret the nature of the graph incorrectly. The candidate also wrote incorrect chemical equation for the reaction between HCl (acid) and $Na_2S_2O_3$ solution, hence, could not identify the substance which caused the letter **X** to disappear.

2.2.2.3 Alternative 2C

The aim of the experiment was to determine the effect of concentration on the rate of chemical reaction. The chemicals provided were **C** which contained 10.0 g of sodium thiosulphate in 500 cm^3 litre of solution and **H** which contained 2 M nitric acid solution. The candidates were also provided with a stopwatch and a piece of white paper marked **X** and distilled water.

Candidates were provided with the following procedures:

*(i) Place a 100 cm^3 beaker on top of cross **X** on the plain paper such that the cross **X** is visible through the mouth of the beaker when viewed form above.*

*(ii) Measure 25 cm^3 of **C** and pour it into a beaker in step (i).*

*(iii) Measure 5 cm^3 of **H** and pour it into a beaker containing **C** in step (ii) and instantly start the stop watch.*

(iv) Stear the mixture with a glass rod while keep on observing the cross from above: record the time taken for the cross to dissapear completely.

*(v) Repeat the procedures (ii) – (iv) for different concentration of **C** as indicated in the following table.*

Table: Experimental Data

Volume of C (cm^3)	***Distilled water (cm^3)***	***Volume of H (cm^3)***	***Time taken for the cross to disappear (sec).***
25	*0*	*5*	
20	*5*	*5*	
15	*10*	*5*	
10	*15*	*5*	
5	*20*	*5*	

The candidates were then asked the following questions:

(a) Complete filling the Table.

(b) (i) Using the data in the table, plot a graph of volume (cm^3) against time (s).

(ii) What does the shape of the graph indicate?

*(c) Write the ionic equation for the reaction between **C** and **H**.*

(d) Why did the cross X disappear?

(e) From the graph, what do you conclude about the effect of increasing concentration on the rate of reaction?

The candidates who scored high marks in this question filled the table correctly in which time was increasing with decrease in concentration of **C** in part (a). The candidates accurately plotted the graph (obtaining a curve) as required, in part (b) (i), and commented on its nature in part (b) (ii), that the decrease in volume of sodium thiosulphate was inversely proportional to time for the cross to disappear. In parts (c) and (d), the candidates wrote a balanced ionic equation for the reaction between **C** and **H**. Also, they stated that sulphur formation obscured mark **X** to disappear. Likewise, in part (e), the candidates commented on the relationship between concentration and the rate of the chemical reaction. For instance, one of the candidates wrote "as concentration decreases also the rate of the reaction decreases." Generally, the candidates had adequate knowledge about the concept of laboratory apparatuses, ionic equation and the effect of concentration on rate of reaction. Extract 20.1 shows a sample of the correct responses in question 2 (Alternative 2C).

2a.

Volume of C (cm³).	Distilled water (cm³)	Volume of H (cm³).	Time taken for the cross to disappear (Sec)
25	0	5	18
20	5	5	25
15	10	5	32
10	15	5	50
5	20	5	110

2b ii) The shape of the graph is curve that indicates that as the concentration decrease, time increase and as the concentration increase, time decrease, thus indicating the rate of chemical reaction.

c. C → Sodium thiosulphate ($Na_2S_2O_3$)
H → Nitric acid (HNO_3).

Word equation;
Sodium thiosulphate + Nitric acid → Sodium nitrate + Sulphur + water + Sulphur dioxide.

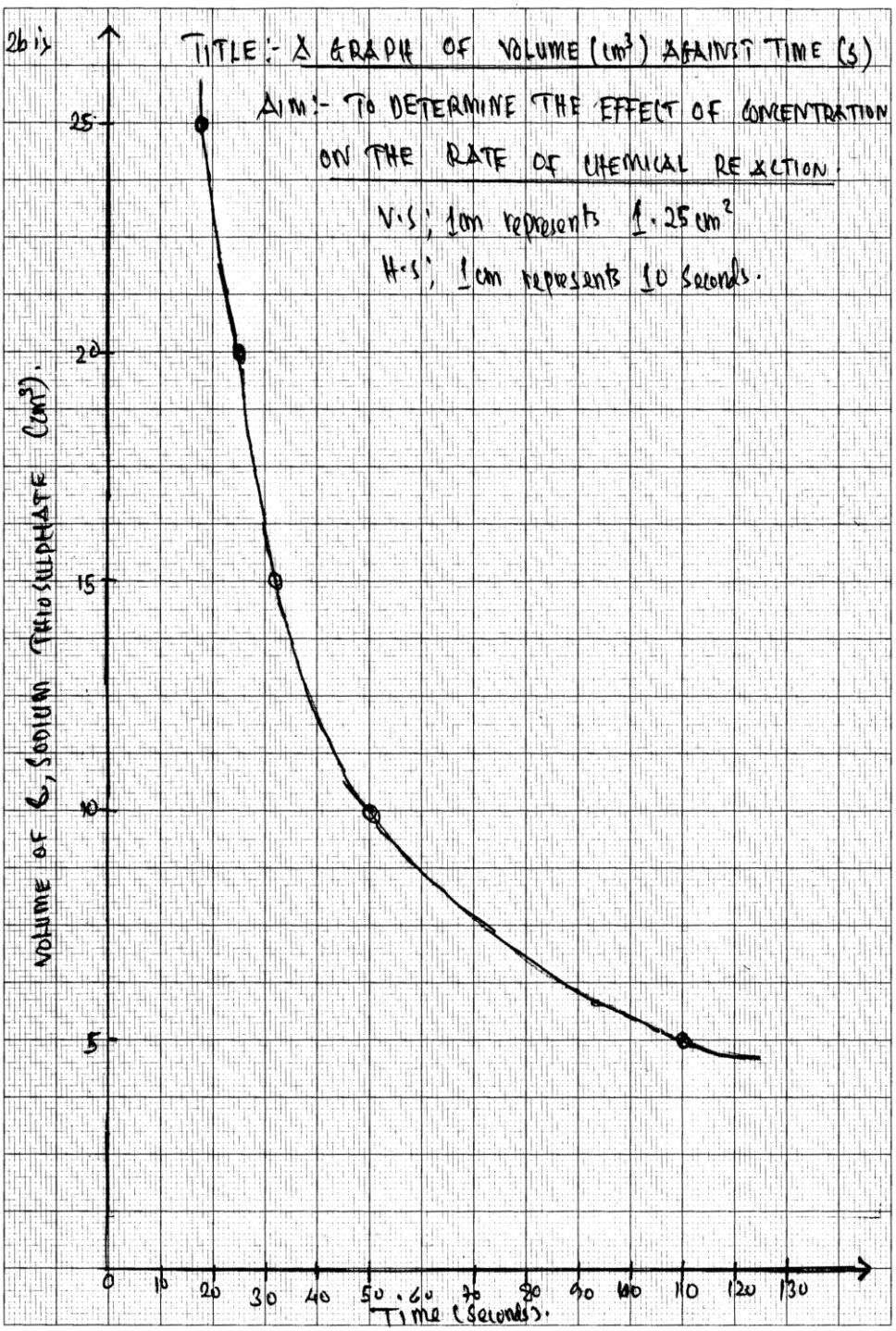
Chemical equation;
$Na_2S_2O_3 + 2HNO_3 \longrightarrow 2NaNO_3 + S + H_2O + SO_2$
(aq) (aq) (aq) (s) (l) (g)

ii. Ionic equation.
$Na_2S_2O_3 + 2HNO_3 \longrightarrow 2NaNO_3 + S + H_2O + SO_2$
(aq) (aq) (aq) (s) (l) (g)

$\therefore S_2O_3^{2-}_{(aq)} + 2H^+_{(aq)} \longrightarrow S_{(s)} + H_2O_{(l)} + SO_{2(g)}$

d. The cross X disappear due to the formation of milky of Sulphur during the chemical reaction.

e. When the concentration is increased the rate of chemical reaction increase since the reaction become faster as it takes less time ~~for~~ till completion.



Extract 20.1: A sample of correct responses to question 2, paper 2C

In Extract 20.1, the candidate collected accurate data for the reaction. He/she used the data to plot the graph, and gave correct interpretation

based on the nature of the graph. Finally, the candidate wrote the correct ionic equation for the reaction between HCl (acid) and $Na_2S_2O_3$.

On the other hand, the candidates who scored low marks failed to attempt most parts of the question correctly. For example, in part (a), some of them filled the table with incorrect data ranging between 100 and 150 seconds, which is too high. Also, some candidates recorded time which was below the expected range. In part (b), the candidates failed to label the axes of the graph, while others did not indicate the title of the graph. Some of the candidates used inappropriate vertical and horizontal scales, while others plotted the graph using incorrect data or failed to plot the curve. In parts (c) and (d), the candidates failed to write well balanced ionic equation between sodium thiosulphate and dilute HCl. Likewise, they failed to write ionic chemical equation with correct state symbols. Similarly, the candidates were not able to identify the cause of the disappearance of cross **X**, which was sulphur. In part (e), most of the candidates who scored low marks gave inappropriate comments. This is attributed to lack of adequate knowledge of the effects of concentration on the rate of reaction. Extract 20.2 shows a sample of incorrect responses in this question (Alternative 2C).

2°

Table: Experimental Data.

a) Volume of C (cm^3)	Distilled water (cm^3)	volume of H (cm^3)	Time taken the cross. (secs)
25 cm	0	5	28 sec.
20	5	5	21 sec
15	10	5	23 sec
10	15	5	24 sec.
5	20	5	42 sec

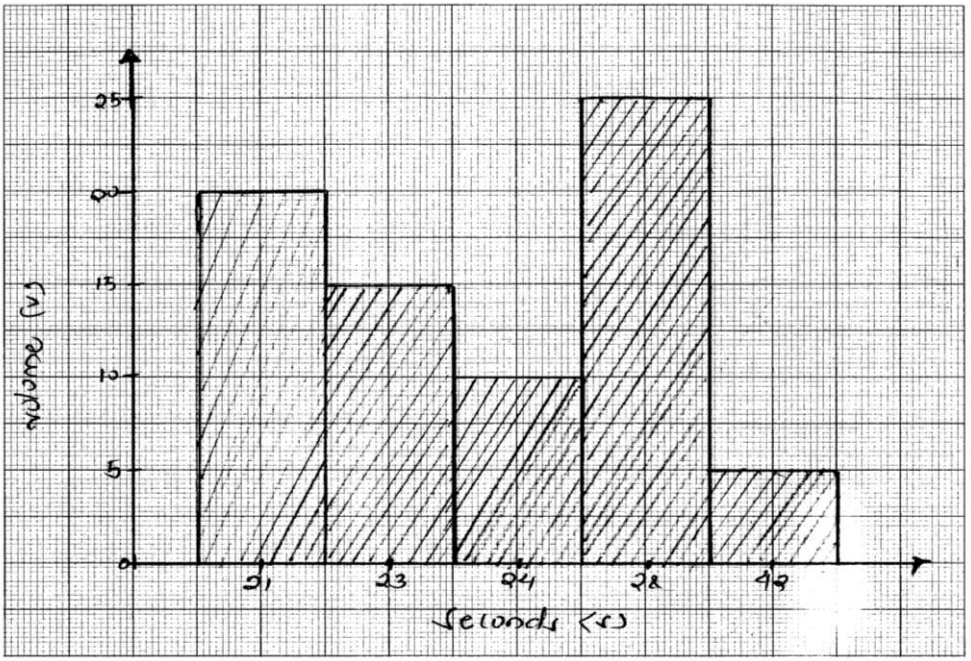
ii) The shape is triangle.

c) Conc + rate → reaction.

$HCl + H_2O \rightarrow H_3O^+ + OH^-$.

d) It used to show significance of the observation to the crow e x.

e) The rate change in white colour but when concentration increase the reaction become more colourless.



Extract 20.2: A sample of incorrect responses to question 2, paper 2C

In Extract 20.2, the candidate recorded time (data) for the reaction inaccurately. The candidate used the incorrect data to plot a bar graph (instead of a line graph) which led to incorrect interpretation of the graph. He/she also wrote incorrect ionic equation for the reaction between HCl acid and $Na_2S_2O_3$.

3.0 ANALYSIS OF THE CANDIDATES' PERFORMANCE IN EACH TOPIC

Chemistry papers 1 and 2 had a total of 16 questions, covering 18 topics. The analysis shows that six topics attained good performance. Those topics were Soil Chemistry (96.76%), Pollution (91.86%), Volumetric Analysis (90.16%), Compounds of Metals (88.18%), Matter (66.01%) and Formulae, Bonding and Nomenclature (64.88%). Question 1 covered eight topics which collectively attained a good performance of 94.82 per cent. The question comprised the following topics: Water; Atomic Structure; Fuels and Energy; Matter; Organic Chemistry; Laboratory Techniques and Safety; Non-Metals and Their Compounds; Air, combustion, Rusting and Fire Fighting.

Furthermore, the analysis reveals that four topics attained average performance. Those topics were Chemical Kinetics, Equilibrium and Energetics (63.77%), Hardness of Water (51.10%), Acids, Bases and Salts (46.09%) and Extraction of Metals (38.21%).

However, the analysis indicates that the candidates performed weakly in two (2) topics namely, Ionic Theory and Electrolysis (27.81%), and Organic Chemistry (27.27%). The weak performance in these topics was caused by failure of the candidates to interpret scientific facts, lack of adequate knowledge about the properties of matter and mathematical skills. The performance of the candidates in different topics is summarized in the attached appendix.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

Generally, the performance of the candidates in Chemistry CSEE 2022 was good because 93.68 per cent of the candidates passed the examination. The candidates performed well in question number 1 and 2 (from both theory and practical papers). Moreover, question number 3, 4, 5, 7, 8, 9, 10, 11, 13 and 14 from the theory paper were well attempted. The performance of the candidates was weak in question number 6 and 12.

The good performance of the candidates in Chemistry subject was contributed by adequate knowledge of concepts, understanding of the

demands of the questions and. On the other hand, some candidates had weak performance due to the following reasons:

(a) Inability to apply appropriate chemical formulae to represent compounds and chemical equations during chemical reactions, for example in questions 4, 5, 6 and 7.

(b) Lack of adequate knowledge on various concepts. For example, in question 8, some of the candidates failed to explain the effect of boiling on hardness of water.

(c) Failure of the candidates to identify the requirements of the questions. For example, some of the candidates gave causes of water pollution, instead of the effects in question 14.

(d) Lack of adequate mathematical skills: This was evidenced in question 6 as some candidates failed to respond correctly to such question which required calculations.

(e) Poor English language proficiency: This hindered some of the candidates from understanding the demands of the questions and from writing correct and meaningful sentences for example question 14.

4.2 Recommendations

The following are recomended to improve the candidates' perfomance in future examinations:

(a) Teachers are advised to present subject matter through more practical activities. This will help candidates to have better understanding of properties and daily applications of chemicals. For example, in attempting questions 7, some of the candidates failed to classify the compounds based on their solubility in water.

(b) Candidates are advised to thoroughly read the instructions of each question before attempting it. Additionally, candidates are advised to revise on their responses before submitting the scripts. This will help them to discover some errors, hence making necessary corrections. For example, in attempting question 6, some of the candidates calculated amount of electric current without indicating the units of the physical quantities involved.

(c) When teaching the topic of Organic Chemistry and Extraction of Metals, teachers are encouraged to use valence cards and wall charts to show the functional groups of organic compounds. They can also use diagrams to show extraction of metals such the Down's cell and blast furnance. This will help to sharpen candidates understanding of the homologous series and extraction of metals. For example, in question 12.

(d) Candidates should be encouraged to speak English language regularly. This will help them improve their ability to communicate in English. For example, in attempting question 13, some of the candidates wrote sentences with major grammatical errors.

Appendix: Analysis of Performance of Candidates in Each Topic

S/N	Topic	Question Number	% of Candidates who Scored 30% or Above	Average	Remarks
1	Soil Chemistry	14	96.76	96.76	Good
2	Water; Atomic Structure; Fuels and Energy; Matter; Organic Chemistry; Laboratory Techniques and Safety; Non-Metals and their Compounds; and Air Combustion, Rusting and Fire fighting	1	94.82	94.82	Good
3	Pollution	13	91.86	91.86	Good
4	Volumetric Analysis	1 Practical	90.16	90.16	Good
5	Compounds of Metals	11	88.18	88.18	Good
6	Matter	3	76.24	66.01	Good
		9	55.77		
7	Formulae, Bonding and Nomenclature	5	64.88	64.88	Good
8	Chemical Kinetics, Equlibrium and Energetics	2	67.77	63.77	Average
		4	34.48		Average
		2 Practical	89.06		Average
9	Hardness of Water	8	51.10	51.10	Average
10	Acids, Bases and Salts	7	46.09	46.09	Average
11	Extraction of Metals	10	38.21	38.21	Average
12	Ionic Theory and Electrolysis	6	27.81	27.81	Weak
13	Organic Chemistry	12	27.27	27.27	Weak