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) 2023

CHEMISTRY

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032 CHEMISTRY

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FOREWORD

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 2023 Certificate of Secondary Education Examination (CSEE) Candidates' Item Response Analysis (CIRA) Report in Chemistry has been prepared to offer insights into the candidates' performance and the challenges they experienced in attempting the examination. Its purpose is to provide feedback to educators, candidates, parents, policy makers, and the public in general.

The analysis reveals that the candidates who achieved high scores had adequate knowledge of the tested concepts in Chemistry, and managed to apply mathematical skills in responding to some questions. On the contrary, candidates with lower scores exhibited insufficient understanding of the subject matter, and struggled to discern the requirements of some questions. In addition, the candidates who scored low marks had insufficient numerical skills and poor English language proficiency.

The insights offered 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 acknowledges the valuable contribution of all individuals who aided in 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) 2023 in Chemistry subject. The Chemistry examination was set according to the 2022 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; questions 1 and 2. Each item in question 1 and 2 carried one mark, making a total of 10 marks for question 1, and 6 marks for question 2. Section B consisted of six-short response questions which carried 9 marks each. Section C comprised three essay questions which carried 15 marks each. The candidates were required to respond to all the questions in sections A and B, and only two questions 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 162,652 candidates sat for the Chemistry examination in CSEE 2023. The overall candidates' performance was good, with 96.14 per cent successfully passing the examination. Such a performance marks an increase of 2.46 per cent relative to candidates' performance in 2022.

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 (both correct and incorrect). The third section covers the analysis of candidates' performance topic-wise, while the fourth section offers conclusion and recommendations.

2.0 ANALYSIS OF THE CANDIDATES' PERFORMANCE IN EACH QUESTION

The analysis of Candidates' performance in each question 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 and good respectively. Moreover, red, yellow and green colours have been used to in figures, tables and appendix to represent poor, average and good performance respectively.

2.1 032/1 CHEMISTRY 1

2.1.1 Section A: Objective Questions

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

2.1.1.1 Question 1: Multiple Choice Items

The question consisted of 10 multiple choice items constructed from ten (10) topics which were: *Atomic Structure; Formula, Bonding and Nomenclature; Chemical Equations; Oxygen; Periodic Classification; Organic Chemistry; Mole Concept and Related Calculations; Compounds of Metals; Hardness of Water* and *Acids, Bases and Salts*. In each item, the candidates were required to choose the correct response from the given alternatives, A to E and write its letter beside the item number in the response booklet provided.

This question was attempted by 162,652 candidates (100%). The analysis of the candidates' performance indicates that 35.40 per cent scored from 0 to 2 marks, 58.36 per cent scored from 3 to 6 marks, while 6.24 per cent scored from 7 to 10 marks. Generally, the performance in this question was good because 64.60 per cent of the candidates scored 3 marks or above. The candidates' performance in this question is summarized in Figure 1.

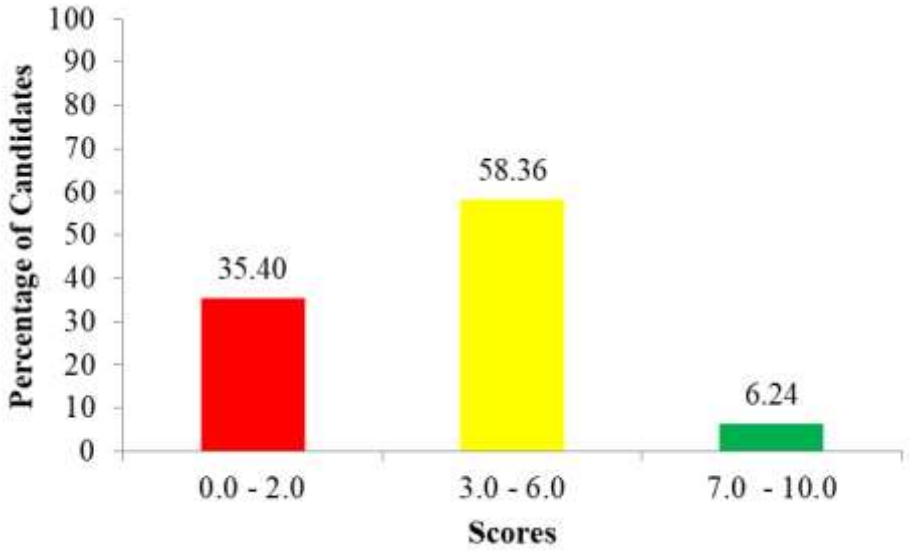


Figure 1: *Candidates' Performance in Question 1*

In item (i), the candidates were asked to identify the correct description of nucleons. The correct response was A, *Nucleons are neutrons and protons in the* nucleus *of an atom*. The candidates who chose the correct response had adequate knowledge on the sub-atomic particles and their location within the atom. The candidates who chose distracter B, *Nucleons are neutrons in the nucleus of an atom* had the knowledge on the location of the nucleons, but were not aware that nucleons is a combination of neutrons and protons. Those who opted for distractor C, *Nucleons are protons and electrons in the nucleus of an atom*, distractor D, *Nucleons are neutrons and electrons in the nucleus of an atom* and distractor E, *Nucleons are neutrons, protons and electrons in the nucleus of an atom*, lacked adequate understanding of the composition of nucleons, thus included electrons as part of nucleons. They also suggested that electrons are located within the nucleus which was incorrect.

In item (ii), the candidates were required to identify the action which characterizes ions formation. The correct response was E, *Metal atoms losing electrons from their outermost shells.* Candidates who chose the correct response had the knowledge that metal atoms are electropositive elements which form ions by losing electrons from their outermost shell. They were also aware that only the outermost electrons can be lost and not electrons from innermost shell. Those who opted for distractor A,

Metal atoms gaining electrons in their outermost shells, had inadequate knowledge on the electropositive character of metals, hence suggested that metals are electronegative thus gaining electrons to form ions. The candidates who opted for distractor B, *Non-metal atoms losing electrons from their outermost shell* misunderstood the nature of non metals being electronegative, thus they do not lose electrons, but gain electrons to form ions. The candidates who opted for distractor C, *Metal atoms losing electrons from their innermost shells* failed to identify which electrons are lost by suggesting that the electrons are lost from the innermost shell instead of the outermost shell. Similarly, the candidates who chose distractor D, *Non-metal atoms gaining electrons in their innermost shells* were not aware that the electrons are gained in the outermost shell instead of the innermost shell.

In item (iii), the candidates were given the steps of writing ionic equation and were required to identify the wrong step. The correct response was D, *Writing all insoluble ionic products.* The candidates who chose the correct response had adequate knowledge on the general concepts of writing ionic equations since all ionic species are soluble. The candidates who chose distractor A, *Writing the correct formula for the reaction,* B, *Writing all soluble ionic substances,* C, *Writing the reaction in words* and E, *Writing balanced formula equation for the reaction* lacked good understanding of the procedures followed in writing ionic equations; Writing the equation in words, then writing the correct formula equation for the reaction, balancing the formula equation for the reaction and finally writing all the possible ionic products.

In item (iv), the candidates were given the information that "*A Form Two student was given the following staffs for preparation of oxygen gas, (i) Source of heat (ii) Manganese dioxide (iii) Hydrogen peroxide and (iv) Potassium Chlorate.* They were asked *which combination will fast produce oxygen?* The correct response was E, *(i), (ii) and (iv), decomposition of potassium chlorate in the presence of manganese dioxide catalyst.* The candidates who opted for this response, had adequate knowledge on different methods of preparation of oxygen. The process is faster when potassium chlorate is heated in the presence of catalyst. The candidates, who chose distractor A, *(ii) and (iv) manganese dioxide and potassium chlorate did not know that potassium chlorate cannot produce oxygen without being heated*. The candidates who chose

distractor B, *(i) and (iii), source of heat and hydrogen peroxide,* were not aware that hydrogen peroxide requires only catalyst and not heating to produce oxygen. The candidates who opted for distractor C,*(iii) and (iv), hydrogen peroxide and potassium chlorate,* had the knowledge that hydrogen peroxide or potassium chlorate can be used to prepare oxygen, but lacked enough knowledge on the conditions required by the two to produce oxygen. Similarly, the candidates who opted for distractor D, *(i), (iii) and (iv), source of heat, hydrogen peroxide and potassium chlorate,* had inadequate knowledge on the correct combination of the staffs necessary for the preparation of oxygen. Principally, catalyst should be used instead of applying heat whenever hydrogen peroxide is used in such preparation.

In item (v), the candidates were asked to *consider the given trends in physical properties of elements in the periodic table (i) Electron affinity increases from left to right, (ii) Densities increases down the group (iii) Melting points of metals increases down the group (iv) metallic character increases from left to right. Which combination demonstrates correct results?* The correct response was D, *(i) and (ii), Electron affinity increases from left to right and Densities increases down the group.* The candidates who chose the correct response had good understanding of the general trends of physical properties of elements in the periodic table. Electron affinity and electronegativity increase due to decrease in mettalic character. Across the period from left to right, electronegativity increases, hence electron affinity also increases. Again density is direct proportional to mass. Down the group atomic mass increases hence density also increases. The candidates who chose distractor *A, (iii) and (iv), Melting points of metals increases down the group and metallic character increases from left to right* lacked knowledge that the melting point of metals depends on the bond strength within the metallic structure which decreases down the group, hence metals melt easily down the group. These candidates were also not aware that metallic character decreases from left to right due to the increase in ionization energy across the period, making it difficult for the metals to lose electrons. Those who chose distractor B,*(i) and (iii), Electron affinity increase from left to right and melting point of metals increases down the group,* were aware of the trend of electron affinity across the period but lacked the knowledge on the effect of decreasing

metallic bond strength down the group, leading to decrease in the melting point of metals. The candidates who opted for distractor C, *Densities increases down the group, melting point increase down the group* did not know that down the group, melting point does not increase, but decrease, although densities increases. The candidates who opted for distractor E, *(i) and (iv),electron affinity increases from left to right and metallic character increases from left to right,* were not aware that metallic character decreases from left to right due to increase in ionization energy from left to right, making it difficult for the metals to lose electrons. They had the knowledge on the trend of electron affinity from left to right.

Item (vi) stated that organic compounds marked A and B reacted together to form compound C as shown in the equation:

$$\underset{\text{A}}{CH_3CH_2-OH(l)} + \underset{\text{B}}{CH_3COOH(l)} \xrightarrow{\text{Conc. } H_2SO_4} \underset{\text{C}}{CH_3COOCH_2CH_3(l)}$$

The candidates were asked to give the names of compounds A, B and C. The correct response was *D, Ethanol, ethanoic acid and ethylethanoate.* These candidates were knowledgeable on the names of the organic compounds A, B and C involved in the given equation. The candidates who opted for distractor A, *Ester, ethanoic acid and alcohol and* E, *Carboxylic acid, ethanol and ethylethanoate* did not realize that the distractors had a mixture of names of organic compounds and family of organic compounds. Those who opted for distractors B, *alcohol, carboxylic acid and ester* and C, *alcohol, ester and carboxylic acid* failed to realize that all the items given were names of family rather than names of organic compounds.

In item (vii), the candidates were asked to identify a substance which does not constitute one mole. The correct response was D*, 48 g of carbon monoxide molecule*. The candidates who chose distractor A, *32 g of oxygen molecule,* B, *2 g of hydrogen molecule,* C, *19 g of hydroxonium ion and* E, *98 g of sulphuric acid* had inadequate knowledge on the mole concept and its related calculations, hence failed to calculate the correct number of moles of the given species.

In item (viii) the candidates were given the following statement *When a student mixed a solution of a certain copper (II) salt and sodium hydroxide, blue precipitate is formed*. The candidates were asked to

identify the substance which was produced. The correct response was B, *Copper hydroxide*. The candidates who chose the correct response had good understanding of the general concept of preparation of compounds of metals. Those who opted for distractor A, *Copper (II) oxide*, had inadequate knowledge on double decomposition reactions as copper (II) ion combines with hydroxyl (OH^-) ion from sodium hydroxide to form copper hydroxide. The candidates who chose distracters C, *copper salt*, D, *copper (I) oxide and* E, *copper metal* had insufficient knowledge on of chemical reactions.

In item (ix), the candidates were given the statement that; *Permanent hardness of water can be removed by using washing soda. Which reaction is the correct ionic equation for the softening process?* The correct response was *B,* $Ca^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s)$. Candidates who answered correctly had good understanding of the causes of permanent hardness of water and the ionic equations for the removal of the ions which cause hardness of water. The candidates who chose distractor A, $Ca^{2+}(aq) + SO_4^{2-}(aq) \longrightarrow CaSO_4(aq)$ and C, $Mg^{2+}(aq) + SO_4^{2-}(aq) \longrightarrow MgSO_4(aq)$ had inadequate knowledge on the ionic equations involved during softening of the permanent hardness in water, since the two chemical equations indicates reactions of ions forming permanent hardness of water. Other candidates who chose distractor D, $Ca^{2+}(aq)+2HCO_3^-(aq) \longrightarrow Ca(HCO_3)_2(aq)$ and E, $Mg^{2+}(aq)+2HCO_3^-(aq) \longrightarrow Mg(HCO_3)_2(aq)$ opted for ionic equations involved in the formation of temporally hardness of water instead of softening process.

In item (x), the candidates were asked *Why sodium hydroxide pellets should be stored in a closed container?* The correct response was C, *sodium hydroxide is deliquescent.* The candidates who chose the correct response had sufficient knowledge on the concept of salt' ability to absorb moisture. The candidates who opted for distractor A, *sodium hydroxide is efflorescence* failed to understand that efflorescence substances tend to release water into the atmosphere and sodium hydroxide does not contain water. Those who chose distractor B, *sodium hydroxide is hygroscopic* had inadequate knowledge about substances that absorbs water from the atmosphere without formation of solution. Similarly, the candidates who wrote distractor D, *sodium hydroxide is*

volatile failed to realize that sodium hydroxide molecules are held strongly by ionic bonds which do not break easily to allow it to volatilize. Those who chose distractor E, *sodium hydroxide is flammable* had inadequate knowledge on flammable materials which catch fire easily due to low ignition point, which sodium hydroxide is not.

2.1.1.2 Question 2: Matching Items

The question was constructed from the topic of *Chemical Equations*, and consisted of six chemical equations in List A to be matched with types of chemical reactions in List B as follows:

List A	List B
(i) $NH_3(g) + HCl(g) \rightleftharpoons NH_4Cl(s)$	A Endothermic reaction
(ii) $C(s) + O_2(g) \rightarrow CO_2(g) + Heat$	B Ionic reaction
(iii) $2C(s) + 2H_2(g) + Heat \rightarrow C_2H_4(g)$	C Exothermic reaction
(iv) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$	D Neutralization reaction
(v) $H_2SO_4(aq) + 2KOH(aq) \rightarrow K_2SO_4(s) + 2H_2O(l)$	E Reversible reaction
(vi) $CaCO_3(s) \xrightarrow{\Delta} CaO(s) + CO_2(g)$	F Homogeneous reaction
	G Displacement reaction
	H Decomposition reaction

The question was attempted by 162,652 candidates (100%). Candidates who scored from 0 to 1 mark were 16.28 per cent while 34.83 per cent scored from 2 to 3 marks. The candidates who scored from 4 to 6 marks were 48.89 per cent, including 7.44 per cent who scored full marks. Generally, the candidates' performance in this question was good as 83.72 per cent of the candidates scored 2 marks or above. The summary of the candidates' performance in this question is shown in Figure 2.

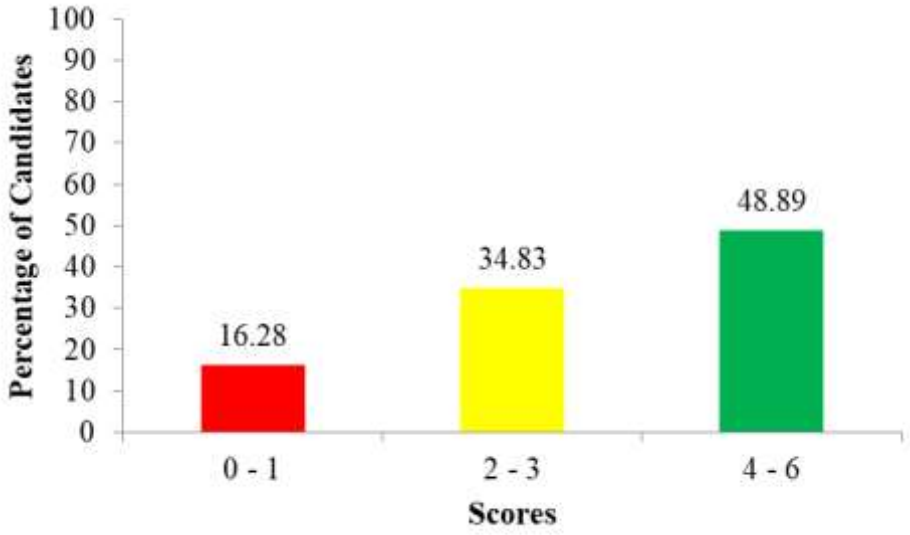


Figure 2: *Candidates' Performance in Question 2*

The candidates who scored high marks (48.89%) matched the items given correctly. This indicates that they had adequate knowledge on the types of chemical reactions. Extract 2.1 is a sample of correct responses from one of the candidates to this question.

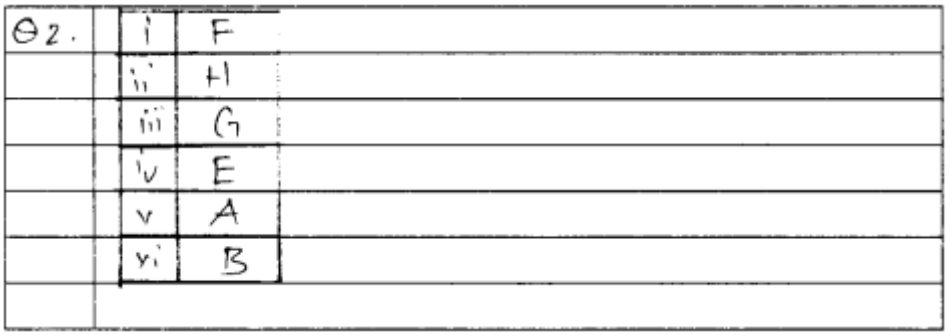
2.	i	ii	iii	iv	v	vi
	E	C	A	F	D	H

Extract 2.1: A sample of correct responses to question 2

In Extract 2.1, the candidate matched correctly the chemical equations in **List A** with the corresponding types of chemical reactions in **List B** demonstrating good mastery of the general concept of chemical reactions.

However, some of the candidates who scored low marks (16.28%) failed to relate the types of chemical reactions given with the corresponding examples. For instance, there were candidates who incorrectly associated item *(i)* $NH_3(g) + HCl(g) \rightleftharpoons NH_4Cl(s)$ with response F, *Homogeneous reaction* instead of response *E, Reversible reaction*. Other candidates incorrectly related *(ii)* $C(s) + O_2(g) \rightarrow CO_2(g) + Heat$ with *A, Endothermic reaction* instead of C, *Exothermic reaction*. Also, in item *(iii)*, $2C(s) + 2H_2(g) + Heat \rightarrow C_2H_4(g)$ incorrectly matched with C, *Exothermic reaction*, instead of A, *Endothermic reaction*. Some candidates also incorrectly matched item *(iv)*,

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ with E, *reversible reaction* instead of F, *Homogeneous reaction.* At the same time some candidates matched item (*v*), $H_2SO_4(aq)+2KOH(aq) \rightarrow K_2SO_4(s) + 2H_2O(l)$ with *G, Displacement reaction* instead of D, *neutralization reaction.* Similarly, some candidates incorrectly matched item *(vi),*
$CaCO_3(s) \xrightarrow{\Delta} CaO(s) + CO_2(g)$ with D, *neutralization reaction* instead of H, *decomposition reaction.* All these responses indicate poor mastery of the concept of chemical reactions in general which has resulted to the low performance. A sample of incorrect responses is shown in Extract 2.2.



Extract 2.2: A sample of correct responses to question 2

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

2.1.2 Section B: Short Response Questions

This section consisted of 6 short answer questions.

2.1.2.1 Question 3: Water

The question required the candidates to use a schematic diagram to illustrate the correct sequence of urban water treatment.

A total of 162,652 candidates (100%) attempted this question in which 79.59 per cent scored from 0 to 2 marks. Candidates who scored from 3 to 5 marks were 9.95 per cent, while those who scored from 6 to 9 marks were 10.45 per cent. The general performance of candidates was weak as only 20.41 per cent of the candidates scored 3 marks or above. Figure 3 gives a summary of the candidates' performance in question 3.

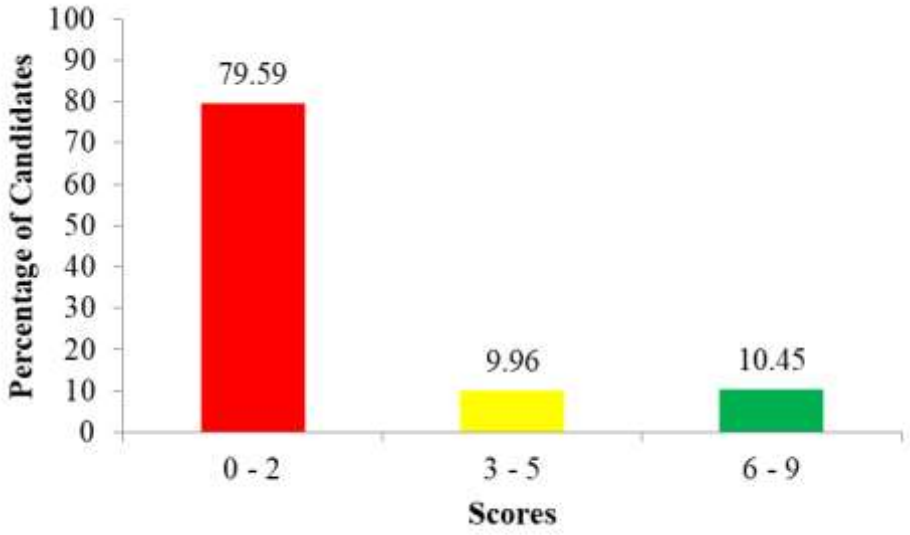
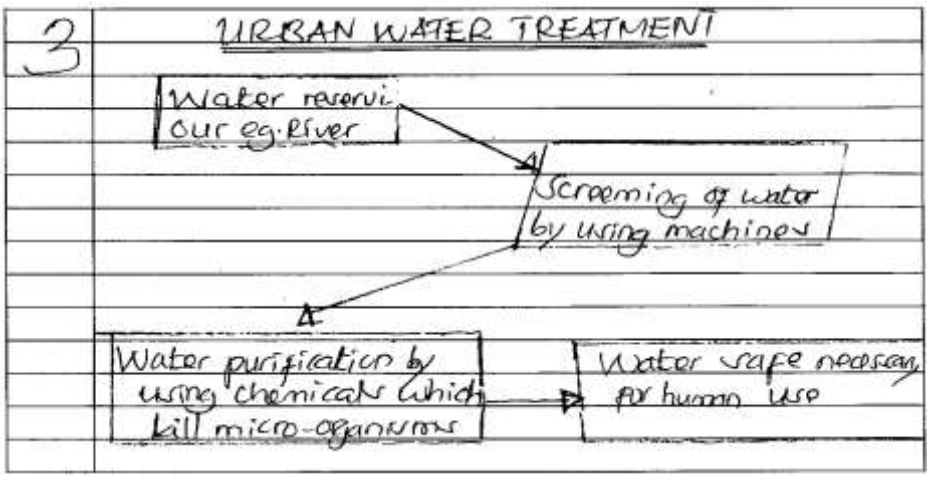


Figure 3: *Candidates' Performance in Question 3*

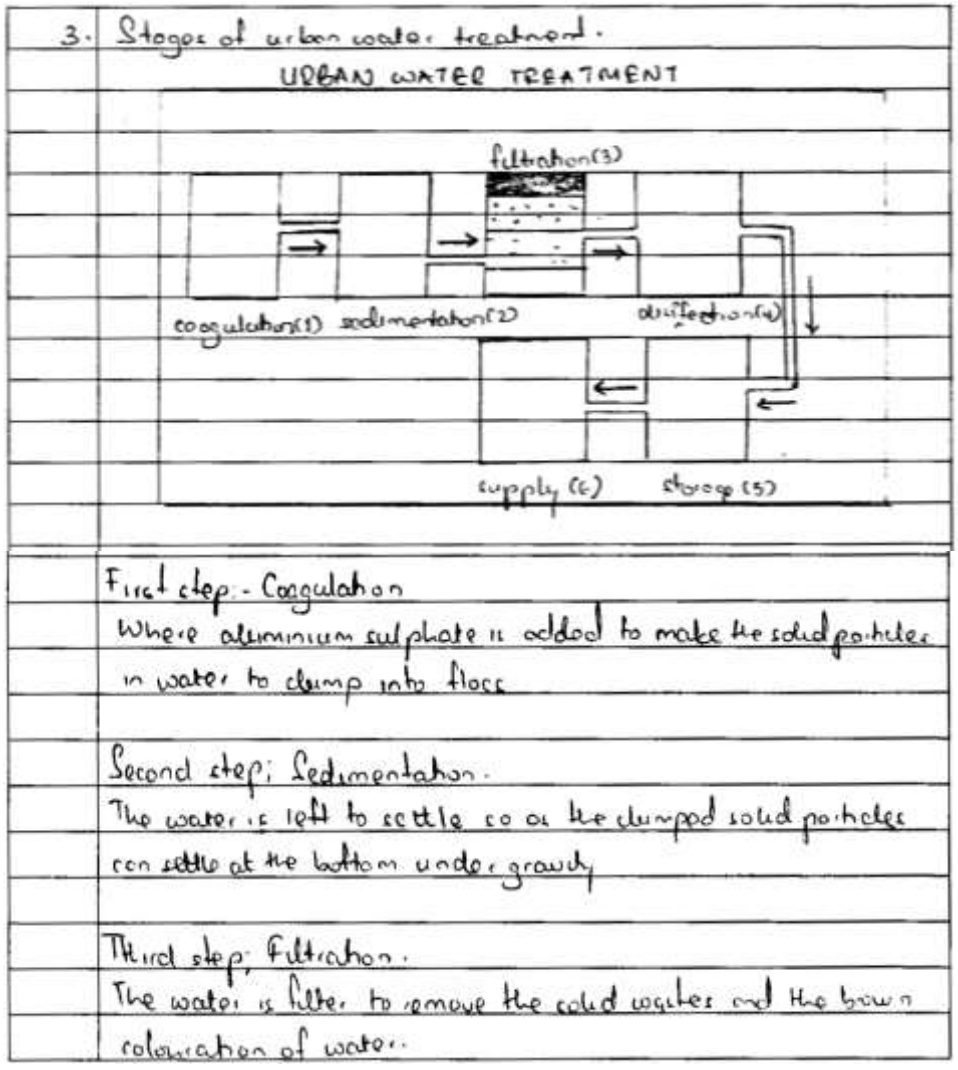
Candidates who scored low marks (79.59%) failed to draw a schematic diagram illustrating the correct sequence of the processes of urban water treatment. Similarly, some candidates interchanged the sequence. For instance, one candidate started the sequence with filtration instead of flocculation. Some candidates incorrectly explained the role of disinfection as to remove small particles instead of killing microorganisms. Generally, most of the candidates did not fully understand the question which required three responses, schematic diagram, brief explanation and sequence. Extract 3.1 shows a sample of incorrect responses from one of the candidates.

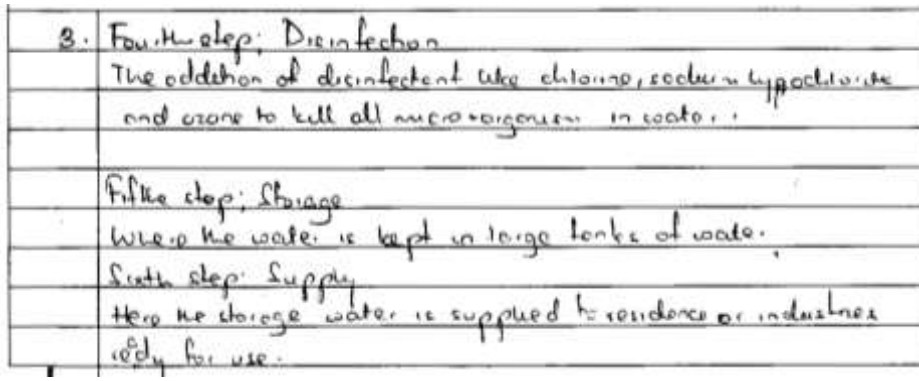


Extract 3.1: A sample of incorrect responses to question 3

In Extract 3.1, the candidate drew an incorrect diagram and gave no explanation for the process, an indication that he/she had inadequate understanding about water treatment.

On the other hand, candidates who scored high marks (10.45%) drew correct schematic diagram with correct explanations in each step. This shows that, they had adequate knowledge of the sequence and the processes of urban water treatment. Extract 3.2 shows a sample of correct responses from one of the candidates.





Extract 3.2: A sample of correct responses to question 3

2.1.2.2 Question 4: Laboratory Techniques and Safety

The question comprised parts (a) and (b). In part (a), the candidates were required to explain briefly the importance of a laboratory coat, safety goggles, gloves and protective masks as safety equipment in the Chemistry laboratory.

Part (b) of the question required the candidates to *identify the uses of the given apparatuses (i) Reagent bottle, (ii) Filter funel (iii) Pipette, (iv) Mortar and pestle and (v) Bunsen burner.*

The question was attempted by 162,652 candidates (100%). The candidates who scored from 0 to 2 marks were 11.28 per cent, whereas 29.42 per cent scored from 3 to 5 marks. The analysis of the performance of the question indicates that 59.30 per cent scored from 6 to 9 marks. Generally, the performance of the candidates in this question was good, as 88.72 per cent scored 3 marks or above. A summary of the candidate's performance in this question is shown in Figure 4.

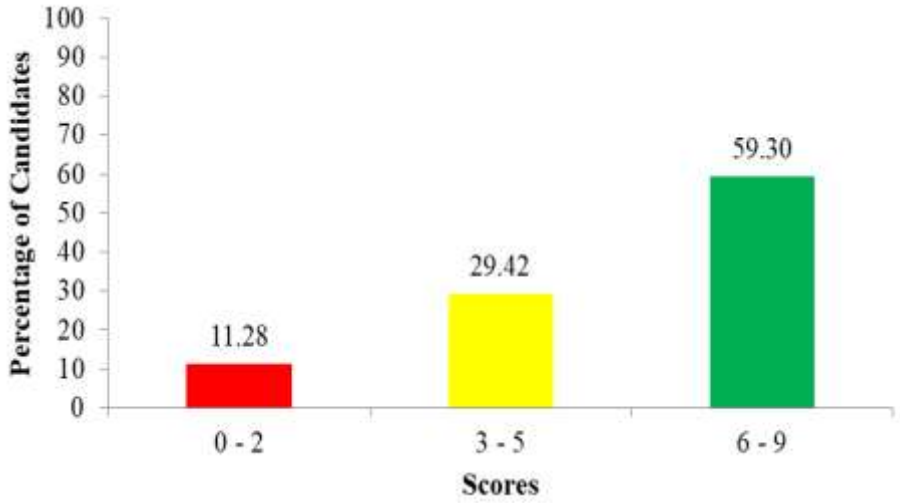
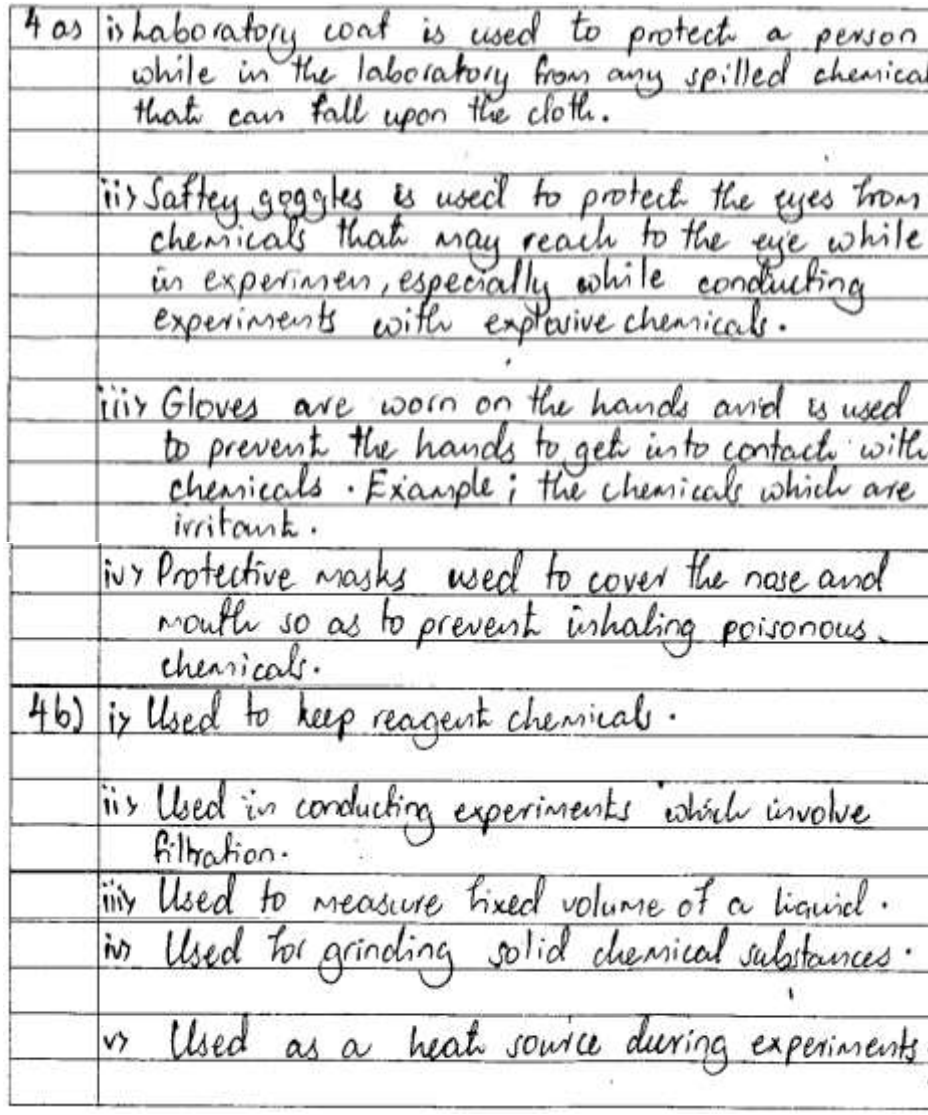


Figure 4: *Candidates' Performance in Question 4*

The candidates who scored high marks (59.30%) gave correct explanations of the importance of laboratory coat, safety goggles, gloves and protective masks as safety equipments in the chemistry laboratory as required in part (a) of the question. This shows good mastery of the safety measures needed to avoid accidents in a Chemistry laboratory. Likewise, the good performance in part (b) of the question indicates that the candidates had adequate knowledge on the uses of each Chemistry apparatus. Extract 4.1 shows a sample of correct responses from one of the candidates.


4 a) i) laboratory coat is used to protect a person while in the laboratory from any spilled chemicals that can fall upon the cloth.

ii) Saftey goggles is used to protect the eyes from chemicals that may reach to the eye while in experimen, especially while conducting experiments with explosive chemicals.

iii) Gloves are worn on the hands and is used to prevent the hands to get into contact with chemicals. Example; the chemicals which are irritant.

iv) Protective masks used to cover the nose and mouth so as to prevent inhaling poisonous chemicals.

b) i) Used to keep reagent chemicals.

ii) Used in conducting experiments which involve filtration.

iii) Used to measure fixed volume of a liquid.

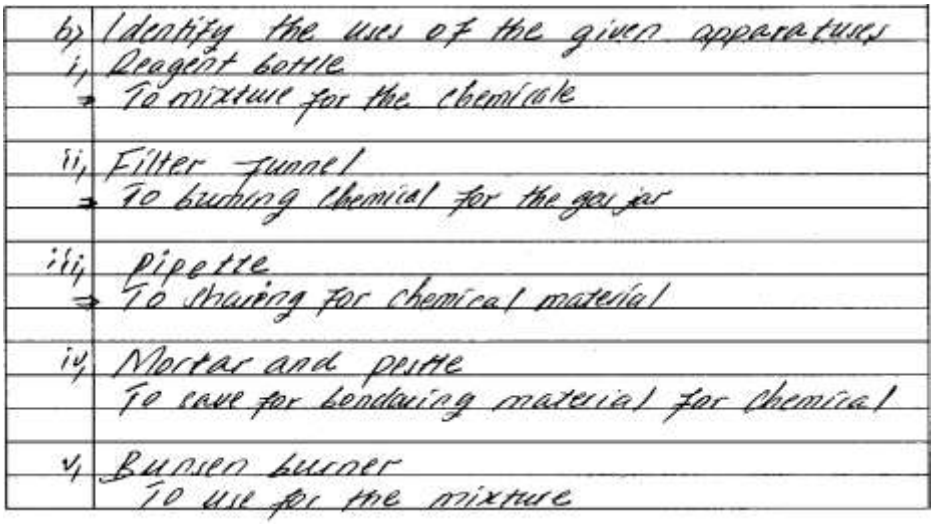
iv) Used for grinding solid chemical substances.

v) Used as a heat source during experiments.

Extract 4.1: A sample of correct responses to question 4

In Extract 4.1, the candidate correctly explained the importance of all the given safety equipments in the chemistry laboratory as per the requirement in part (a). In part (b), the candidate gave the correct uses of all the given apparatuses, demonstrating good understanding of the chemistry apparatuses and their uses.

On the contrary, the candidates who scored low marks (11.28%) failed to explain the importance of the given laboratory safety equipments in part (a). For instance one candidate explained the causes of laboratory accidents in part (a) instead of the importance of the given items. Other candidates seemed not to have idea of the items in question, thus wrote irrelevant responses. For instance one candidate wrote the importance of safety gloves as to hold hot objects instead of protecting hands from corrosive chemicals. In part (b), some candidates did not know the given apparatuses or their uses. For instance, one candidate incorrectly identified the use of reagent bottle as heating chemicals, instead of storage of liquid chemicals. Another candidate identified the use of filter funnel as filtering water instead of filtering solutions/adding chemical solutions. Likewise, another candidate wrote that Pipette is used for measuring volume of solutions instead of measuring fixed/exact volume of solutions. While another one wrote the use of bunsen burner as burning chemicals instead of production of different flames for heating. In general, these candidates had insufficient knowledge on the uses of chemistry laboratory apparatuses and safety measures. Extract 4.2 shows a sample of incorrect responses from one of the candidates for part (b) of the question.



Extract 4.2: A sample of incorrect responses to question 4

In Extract 4.2, the candidate gave incorrect points on the importance of laboratory equipment.

2.1.2.3 Question 5: The Scientific Procedure

The question required the candidates to *explain six scientific procedures used by scientists to investigate scientific problems.*

The question was attempted by 162,652 candidates (100%). The candidates who scored from 0 to 2 marks were 13.77 per cent while 24.08 per cent scored from 3 to 5 marks. The analysis shows that 62.15 per cent scored from 6 to 9 marks. The general performance in this question was good as 86.23 per cent of the candidates scored 3 marks or above. A summary of the candidate's performance in this question is shown in Figure 5.

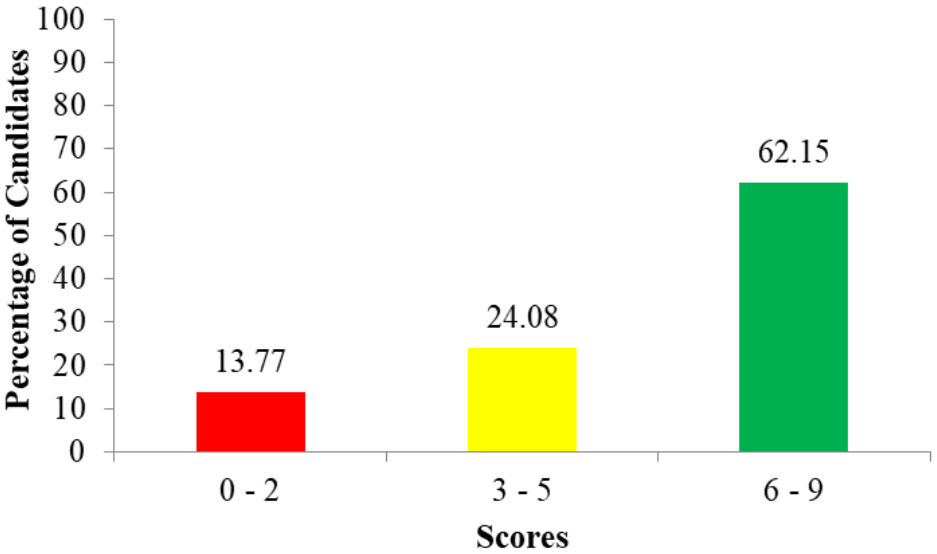
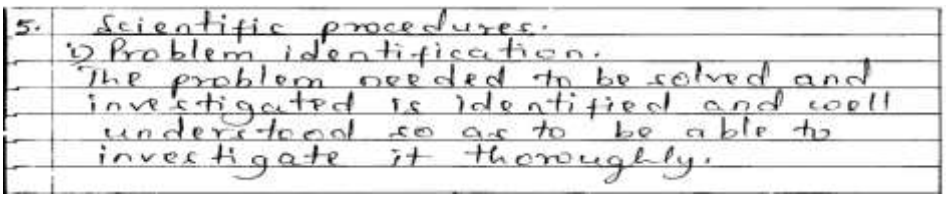


Figure 5: *Candidates' Performance in Question 5*

The candidates who scored high marks (62.15%) gave correct explanations of the sequence of scientific procedures. Most of them were coversant as they arranged them in sequence from the first to the last procedure. This shows that the candidates had adequate competency on the concept of scientific procedure. Extract 5.1 shows a sample of correct responses from one of the candidates.


5. Scientific procedures.
i) Problem identification.
The problem needed to be solved and investigated is identified and well understood so as to be able to investigate it thoroughly.

ii) formulation of hypothesis.
Hypothesis is a tentative guess of an answer to the investigated problem. A hypothesis has to be testable so as to yield good results.

5. iii) Experimentation.
This is a step that involves a series of experiments done so as to investigate a scientific problem. There is a control and a test experiment in experimentation procedure.

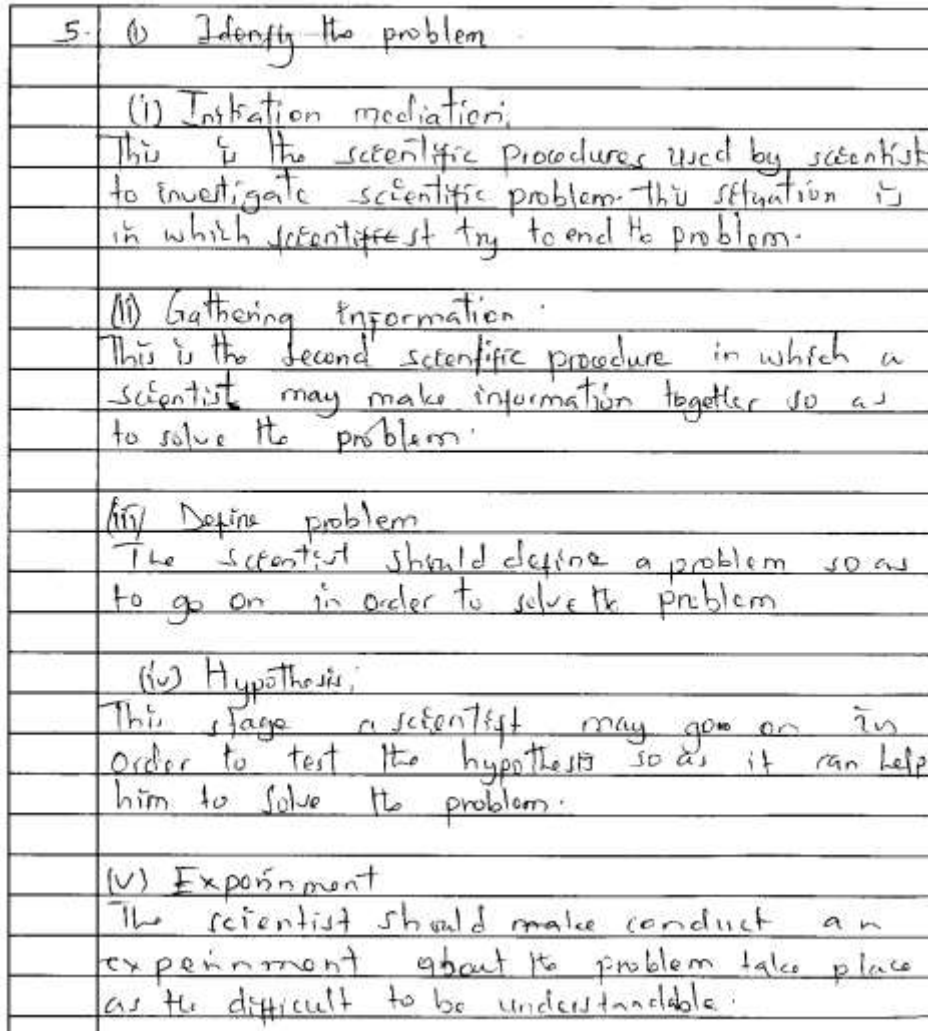
iv) Data collection and recording.
This procedure in an investigating of a scientific problem involves collecting all the data obtained during the experimentation. The data is collected and recorded.

v) Data analysis and interpretation.
The collected and recorded data from the field after experimentation is then analyzed and interpreted so as to give the required yields of the scientis problem.

vi) Drawing a conclusion and report writing.
A conclusion is a summary of the whole scientific investigation. The conclusion must obey the hypothesis for the investigation to be correct. If it is though then a report is written. If not, the investigation repeated

Extract 5.1: A sample of correct responses to question 5

However, the candidates who scored low marks (13.77%) did not observe the correct sequence of the procedures while some wrote incorrect explanation for the respective steps. For instance, one of the candidates combined experimentation and data collection. This shows that the candidate had poor mastery of the general concept of scientific procedures. Extract 5.2 shows a sample of incorrect responses in question 5.


5. (i) Identify the problem

(i) Initiation mediation:
This is the scientific Procedures used by scientists to investigate scientific problem. This situation is in which scientiffest try to end the problem.

(ii) Gathering information:
This is the second scientific procedure in which a scientist may make information together so as to solve the problem.

(iii) Define problem
The scientist should define a problem so as to go on in order to solve the problem

(iv) Hypothesis:
This stage a scientist may go on in order to test the hypothesis so as it can help him to solve the problem.

(v) Experiment
The scientist should make conduct an experiment about the problem take place as the difficult to be understandable.

Extract 5.2: A sample of incorrect responses to question 5

In Extract 5.2, the candidate wrote some incorrect stages including *initiation mediation* and gathering information. The other stages given were not in proper serial arrangement

2.1.2.4 Question 6: Matter

The question had two parts, (a) and (b). In part (a), the candidates were required to justify each of the folowing statements;

(i) It is advisable to use an evaporating dish instead of conical flask to evaporate a solution.

(ii) In filtration process, the filtrate passes through the filter paper while the residue does not.

(iii) Melting of ice is regarded as a physical change.

(iv) Rusting of iron is regarded as a chemical change.

(v) Carbon is a non-metal.

In part (b), the candidates were required to give four points to justify the fact that a solution of sugar is a mixture.

A total of 162,652 (100%) candidates attempted this question. The candidates' performance indicates that 35.64 per cent scored from 0 to 2 marks, 36.66 per cent scored from 3 to 5 marks, whereas 27.70 per cent scored from 6 to 9 marks. Generally, the performance in this question was average since 64.36 per cent of the candidates scored 3 marks or above. The summary of the candidates' performance in this question is as shown in Figure 6.

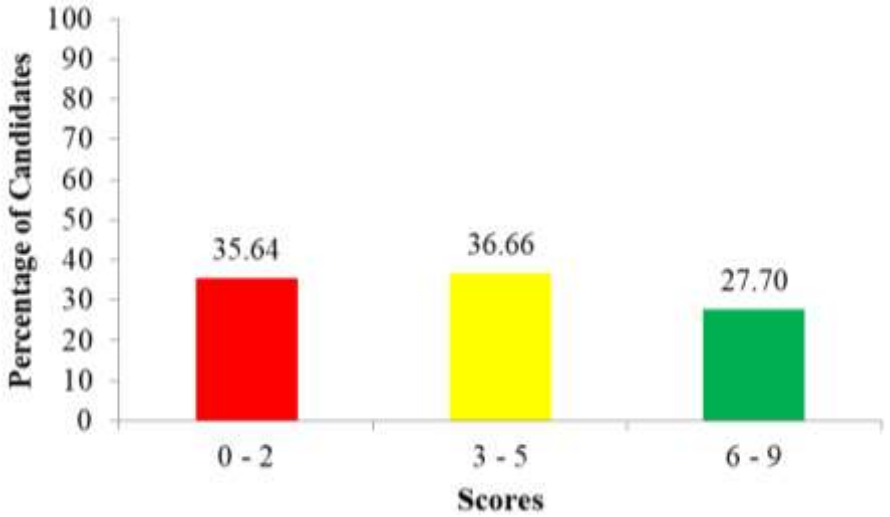
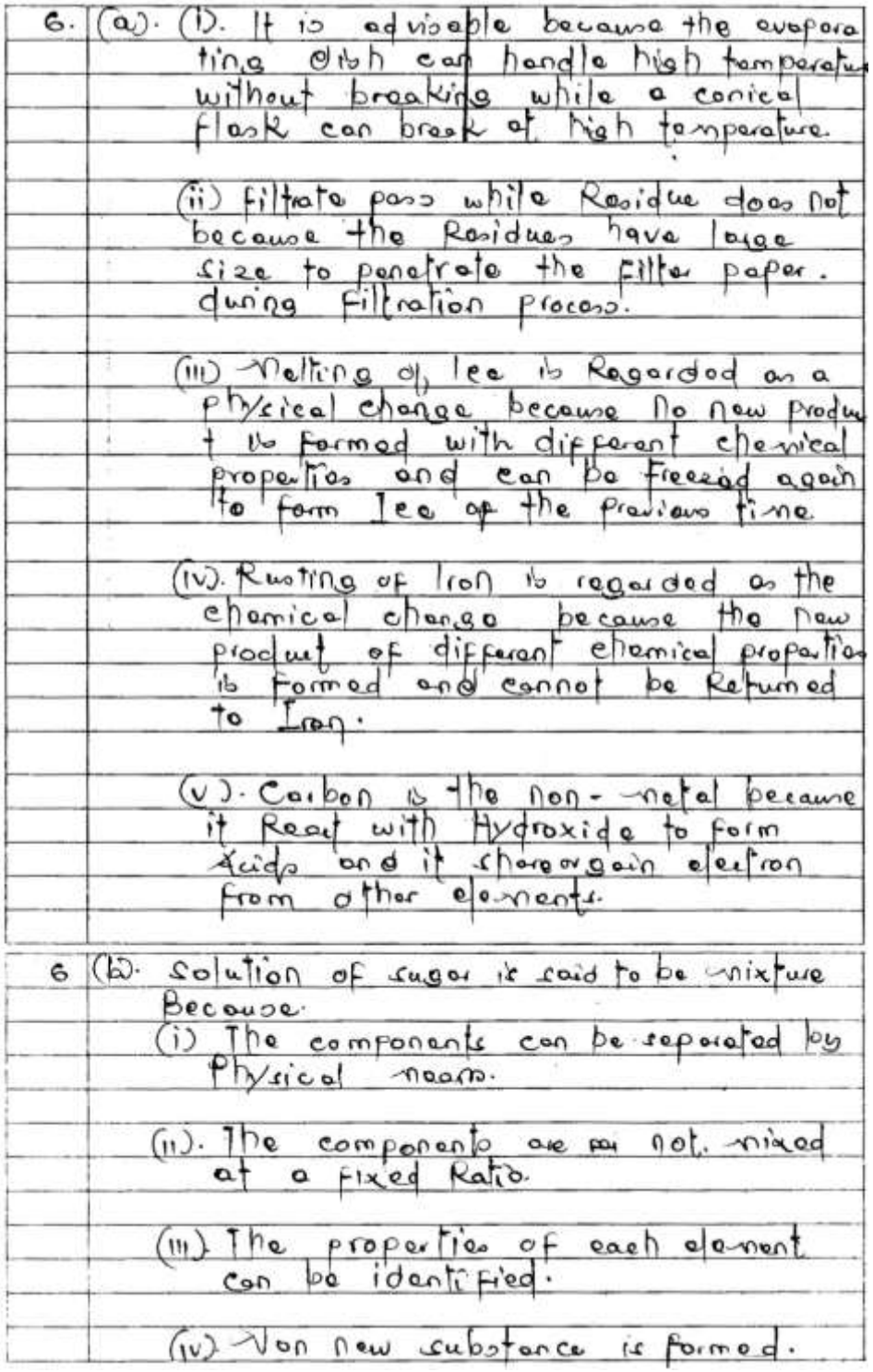


Figure 6: *Candidates' Performance in Question 6*

The candidates who scored high marks (27.70%) justified all the given statements correctly. This indicates that they had good understanding on the properties of characteristics of mixtures and compounds. Also, they

had good mastery of the concepts of physical and chemical changes. Extract 6.1 shows a sample of correct responses in question 6.


6. (a). (i). It is advisable because the evaporating dish can handle high temperature without breaking while a conical flask can break at high temperature.

(ii) Filtrate pass while Residue does not because the Residues have large size to penetrate the filter paper. during filtration process.

(iii) Melting of Ice is Regarded as a physical change because No new product is formed with different chemical properties and can be freezed again to form Ice at the previous time.

(iv). Rusting of Iron is regarded as the chemical change because the new product of different chemical properties is formed and cannot be Returned to Iron.

(v). Carbon is the non-metal because it React with Hydroxide to form Acids and it share or gain electron from other elements.

6 (b). Solution of sugar is said to be mixture Because.
(i) The components can be separated by Physical means.

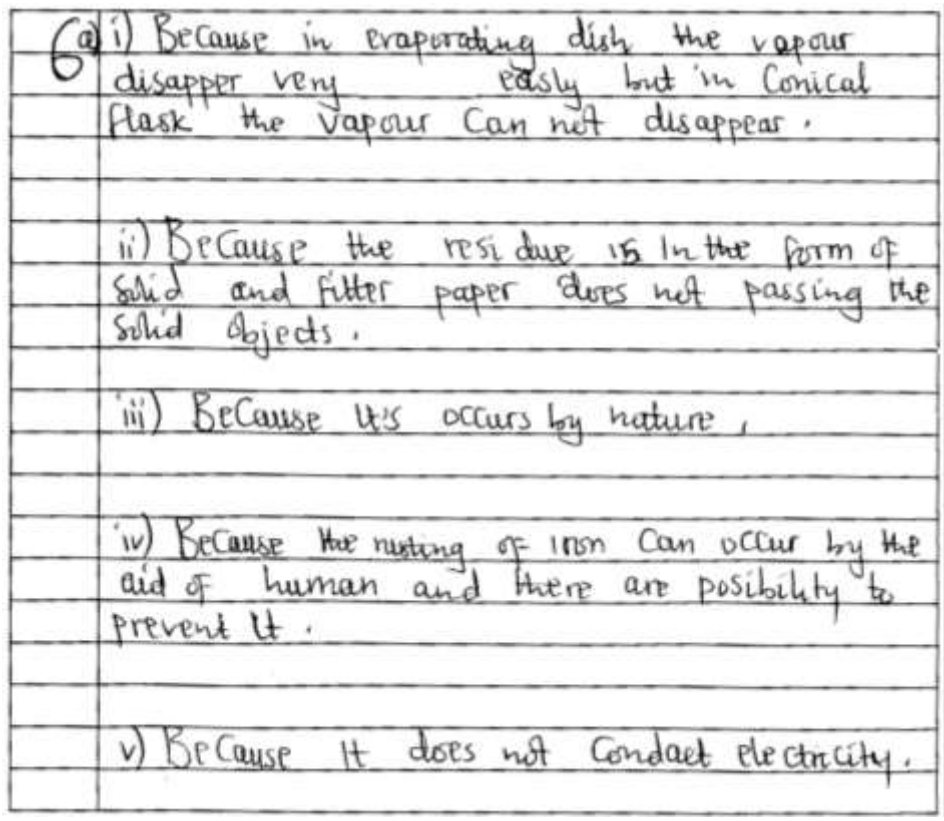
(ii). The components are not mixed at a fixed Ratio.

(iii) The properties of each element can be identified.

(iv) Von new substance is formed.

Extract 6.1: A sample of correct responses to question 6

The candidates who scored low marks (35.64%) failed to justify the statements given in part (a). For instance, in item (i), some candidates wrote that evaporating dish is made of metal instead of porcelain. In item (ii*)*, some candidates described filtration process instead of giving reasons as to why filtrate passes leaving behind the solid residue. Similarly in item (iii), the candidates incorrect justification for melting of ice being a physical change. For instance, one candidate wrote that when ice melts, a new substance is formed; which is a property of chemical change rather than physical change. In the same way, the candidates gave incorrect responses to the rest of the items in part (a). In part (b), some candidates gave the characteristics of compounds instead of mixtures. For example one candidate wrote that a solution of sugar is said to be a mixture because sugar chemicaly combines with water. Some candidates in this category skipped this part of the question. This indicates that, the candidates had poor mastery on the concept of properties of matter. Extract 6.2 shows a sample of incorrect responses in question 6.


6 a) i) Because in evaporating dish the vapour disapper very easly but in Conical flask the vapour Can not disappear.

ii) Because the resi due is in the form of solid and filter paper does not passing the solid objects.

iii) Because it's occurs by nature.

iv) Because the rusting of iron Can occur by the aid of human and there are posibilty to prevent it.

v) Because it does not Condact electricity.

Extract 6.2: A sample of incorrect responses to question 6

In Extract 6.2, the candidate gave incorrect reasons for each of the phenomena given in part (a).

2.1.2.5 Question 7: Ionic Theory and Electrolysis

The question had two parts (a) and (b) as follows: *(a) Justify each of the following statements: (i) Why is not advisable to examine a car battery using burning candle light? (ii) Why is the blue colour disappears during electrolysis of copper (II) sulphate solutions using carbon electrode and (iii) Why is a concentrated sulphuric acid not an electrolyte? (b) With the aid of ionic equations at the anode and cathode, explain the difference between the electrolysis of dilute NaCl using carbon electrode and molten NaCl.*

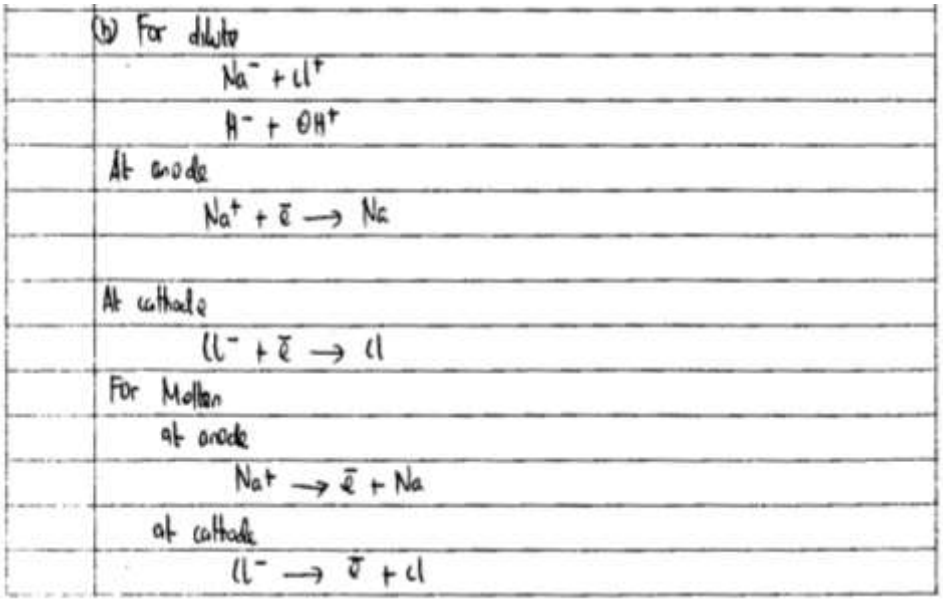
A total of 162,652 candidates (100%) attempted this question. The analysis shows that 86.36 per cent scored from 0 to 2 marks, 11.16 per cent scored from 3 to 5 marks while 2.49 per cent scored from 6 to 9 marks. The general performance of the candidates in this question was weak as only 13.62 per cent of the candidates scored 3 marks or above. The candidates' performance in this question is as shown in Table 1.

Table 1: Candidates' Performance in Question 7

Scores' Range	Percentage of Candidates
0 - 2	86.36
3 - 5	11.15
6 - 9	2.49

On the contrary, candidates who scored low marks (86.36%) failed to identify the products of electrolysis of dilute sulphuric acid in car battery in part (a) (i). For example, some of the candidates gave incorrect reason that the candle light produces carbon which is harmful. In item (a) (ii) some candidates specified that copper is a transition metal, a reason which does not account for the disappearance of blue colour of copper(II) sulphate. Similarly, in item (a) (iii) the candidates gave inappropriate reasons as to why concentrated sulphuric acid is a non-electrolyte. For example, some candidates incorrectly cited that sulphuric acid is a non-electrolyte because it is corrosive. In part (b), the candidates failed to identify the ions in molten NaCl and dilute NaCl. For instance, some of the candidates incorrectly wrote that the ions in molten NaCl included H^+. Also, some candidates indicated incorrect products formed at the anode such as HCl gas. Generally, the candidates

had inadequate knowledge on mechanism of discharge of ions and the ionic theory. Extract 7.1 shows a sample of incorrect responses in question 7.

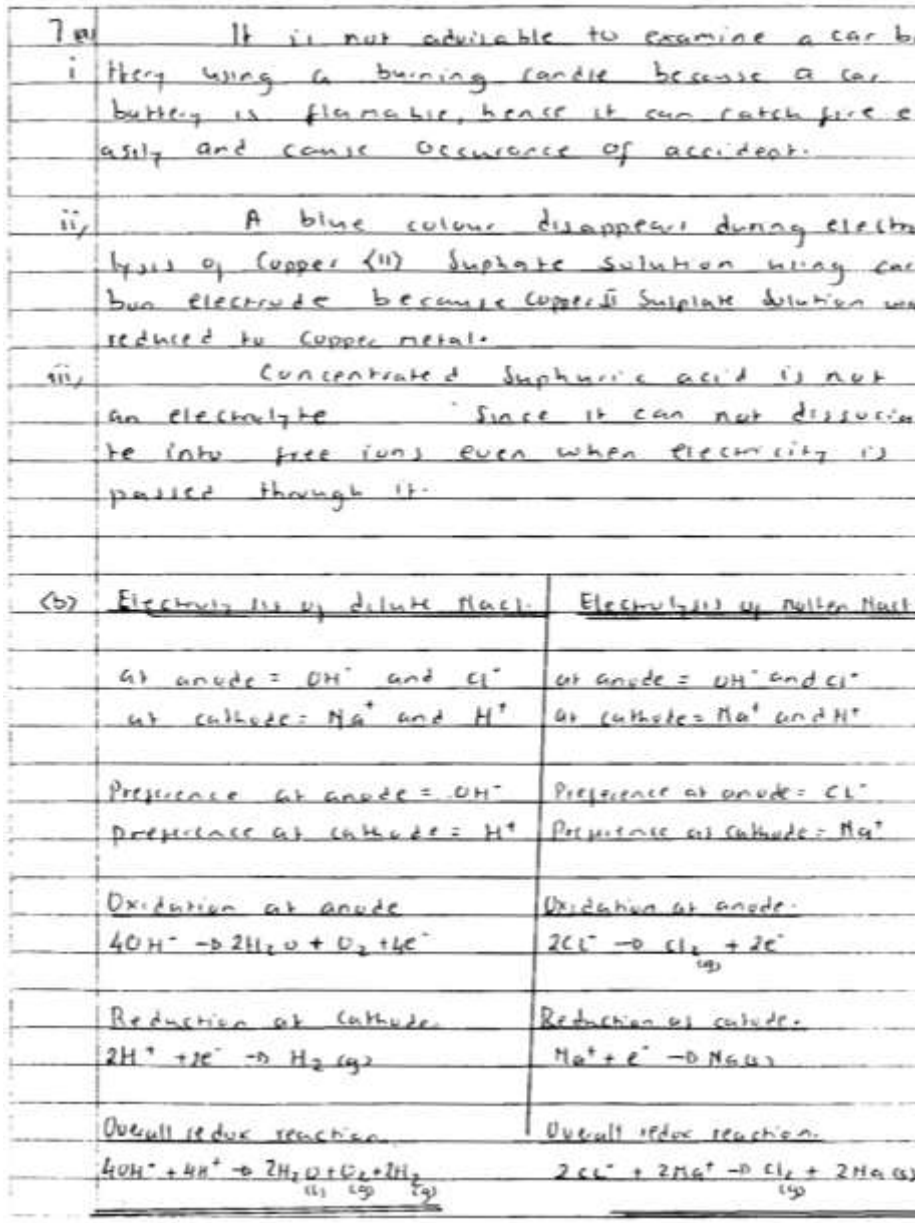


Extract 7.1: A sample of incorrect responses to question 7

Extract 7.1 shows that the candidate responded in part (b) by writing the ions present in dilute NaCl as Na^- and Cl^+ instead of Na^+, Cl^-, H^+ and OH^-, consequently gave incorrect chemical equations at the electrodes by writing $Na^+ \rightarrow e^- + Na$ and $Cl^- \rightarrow e^- + Cl$ instead of $Na^+ + e^- \rightarrow Na$ and $2Cl^- \rightarrow Cl_2 + e^-$ respectively.

On the other hand, the candidates who scored high marks (2.49%) correctly indicated in part (a) (i) that in the car battery, there is electrolysis of dilute sulphuric acid which produces hydrogen gas which in presence of burning candle light may explode. In part (a)(ii), the candidates wrote that the blue colour of copper(II) sulphate was due to copper ions, which during electrolysis, are discharged at the cathode; hence get removed from the solution causing disappearance of the blue colour. Similarly, in part (a)(iii) the candidates explained that concentrated sulphuric acid is a non-electrolyte because it does not possess free ions. In part (b) the candidates identified correctly the ions present in molten and aqueous NaCl, thereafter giving the resulting products at the electrodes upon electrolysis. The correct responses given

by the candidates indicate adequate competence in identification of electrolytes and the preferential discharge of ions based on position of ions in the electrochemical series, nature of electrodes and concentration of ions in solution. Extract 7.2 shows a sample of correct responses to question 7.



7 (a)

i It is not advisable to examine a car battery using a burning candle because a car battery is flamable, hence it can catch fire easily and cause occurrence of accident.

ii A blue colour disappears during electrolysis of Copper (II) Suphate solution using car bun electrode because Copper(II) Suphate solution was reduced to Copper metal.

iii Concentrated Suphuric acid is not an electrolyte since it can not dissociate into free ions even when electricity is passed through it.

(b)

Electrolysis of dilute NaCl	Electrolysis of molten NaCl
at anode = OH^- and Cl^-	at anode = OH^- and Cl^-
at cathode = Na^+ and H^+	at cathode = Na^+ and H^+
Preference at anode = OH^-	Preference at anode = Cl^-
preference at cathode = H^+	Preference at cathode = Na^+
Oxidation at anode	Oxidation at anode.
$4OH^- \rightarrow 2H_2O + O_2 + 4e^-$	$2Cl^- \rightarrow Cl_2(g) + 2e^-$
Reduction at cathode.	Reduction at cathode.
$2H^+ + 2e^- \rightarrow H_2(g)$	$Na^+ + e^- \rightarrow Na(s)$
Overall redox reaction.	Overall redox reaction.
$4OH^- + 4H^+ \rightarrow 2H_2O(l) + O_2(g) + 2H_2(g)$	$2Cl^- + 2Na^+ \rightarrow Cl_2(g) + 2Na(s)$

7(b)	The electrolysis of dilute NaCl leads to production of oxygen and water at the end of the electrolysis process because OH^- and H^+ were discharged rather than Na^+ and Cl^-. But in molten NaCl due to high concentration of NaCl as than water, only Na^+ and Cl^- were discharged hence producing $Na_{(s)}$ (sodium) and Cl_2 (chlorine gas).

Extract 7.2: A sample of correct responses to question 7

2.1.2.6 Question 8: Air, Combustion, Rusting and Fire Fighting

The question had three parts (a), (b) and (c). In part (a) the candidates were required to explain with examples, the given terms as used in chemistry

(i) Fire extinguisher

(ii) Combustible material

In part (b), the candidates were required to identify the four stages of extinguishing fire using a carbondioxide extinguisher. While in part (c), the candidates were required to suggest the three components needed to start fire.

The question was attempted by 162,652 candidates (100%). The candidates who scored from 0 to 2 marks were 10.34 per cent, 64.68 per cent scored from 3 to 5 while 24.99 per cent scored from 6 to 9 marks. The analysis shows that 89.66 per cent of the candidates scored 3 marks or above, indicating good performance overall. The candidates' performance in this question is summarized in Figure 7.

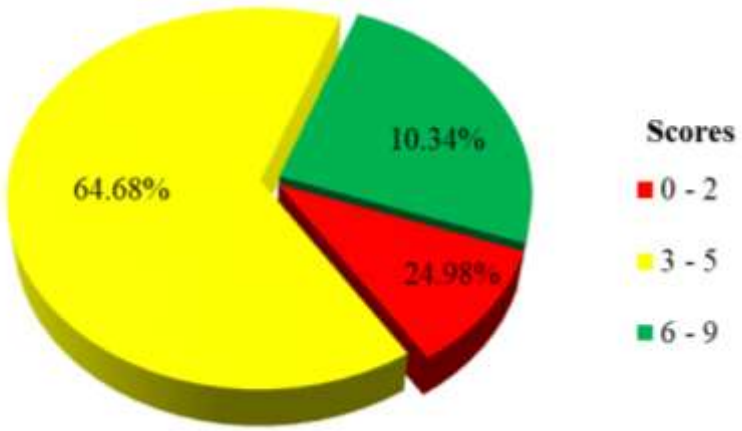
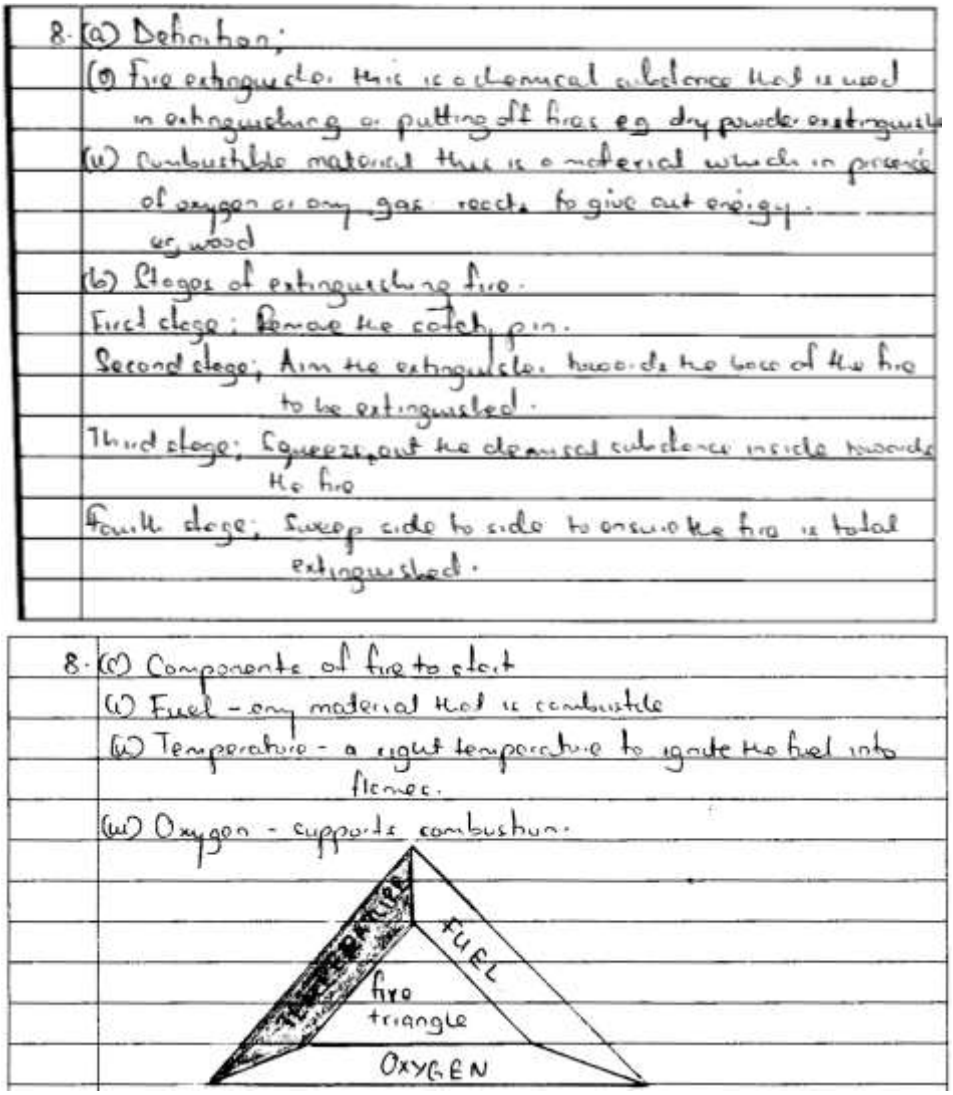


Figure 7: *Candidates' Performance to Question 8*

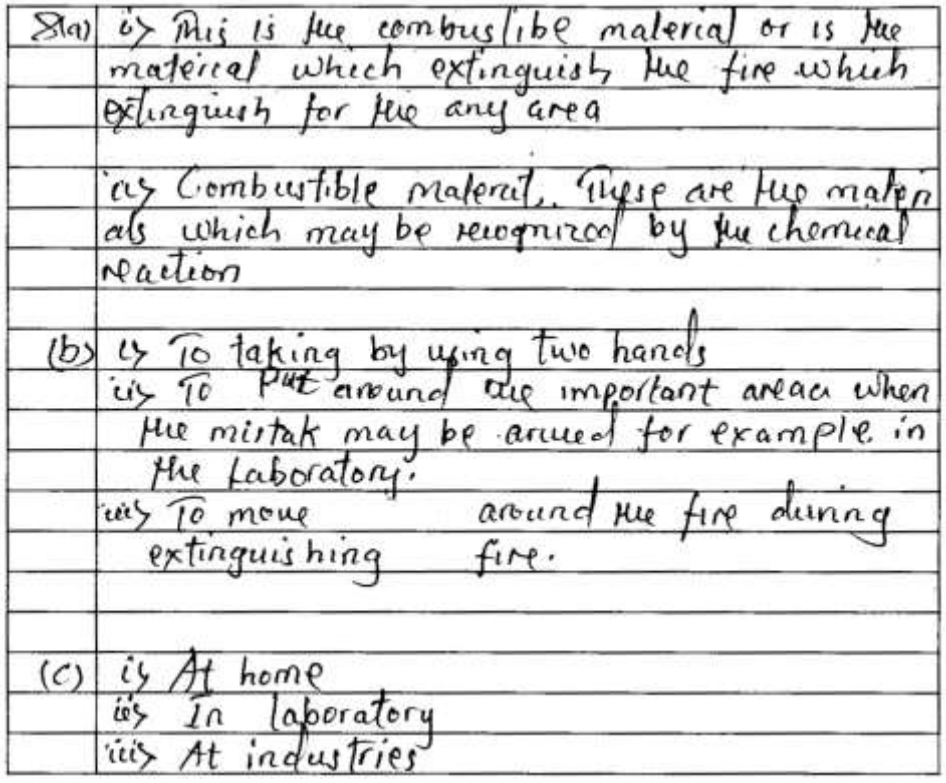
The candidates who scored high marks (24.98%) correctly illustrated the fire triangle showing components necessary for fire to start and gave satisfactory explanation of fire extinguisher and a detailed description of the stages for putting off fire using carbon dioxide extinguisher. This shows that they were knowledgeable on the general concepts of fire-fighting and its components. Extract 8.1 shows a sample of correct responses in question 8.



Extract 8.1: A sample of correct responses to question 8

On the other hand, the candidates who scored low marks (10.34%) wrote incorrect meanings of the concepts in part (a). For example, one of the candidates described the nature and red colour of the container of fire

extinguisher instead of defining it. Other candidates in this category stated the classes of fires, which is contrary to the demand of the question. Similarly, some candidates mentioned examples of combustible materials instead of giving precise meaning combustible material. In part (b), some of the candidates hardly cited the stages of extinguishing fire using the stated fire extinguisher however, the stages were jumbled up. For example, one candidate wrote that a fire fighter needs to start by directing the nozzle to the base of the fire instead of removing the safety pin. Other candidates skipped some stages especially squeezing the top lever to release the extinguishing agent. In part (c) the candidates failed to mention the components needed to start fire. In most cases they ended up by giving only one component. There were candidates who cited gas instead of oxygen gas. Also some candidates mentioned temperature instead of source of heat. Generally, the candidates in this category had insufficient knowledge on the concept of fire and fire-fighting. Extract 8.2 shows a sample of incorrect responses to question 8.


8(a) i) This is the combustible material or is the material which extinguish the fire which extinguish for the any area

ii) Combustible material. These are the materials which may be recognized by the chemical reaction

(b) i) To taking by using two hands
ii) To put around the important areas when the mistak may be arised for example in the laboratory.
iii) To move around the fire during extinguishing fire.

(c) i) At home
ii) In laboratory
iii) At industries

Extract 8.2: A sample of incorrect responses to question 8

In Extract 8.2 part (a), the candidate wrote incorrect meanings of fire extinguisher and combustible material. In part (b), the candidate wrote incorrect stages of using carbon dioxide extinguisher while in part (c), he/she wrote areas or places instead of components needed to start fire which were heat, oxygen and fuel.

2.1.3 Section C: Essay Questions

This section comprised three questions. The candidates were required to respond to only two questions.

2.1.3.1 Question 9: Fuels and Energy

The question was as follows: *You paid a visit to a certain village which has a scarcity of cooking fuel but plenty of raw materials for generating biogas. How would you advise the villagers with regard to the given aspects?*

(a) Nature of the gas.
(b) Raw material for generating the gas.
(c) The process involved in generating the gas.
(d) Three advantages of using biogas over charcoal.

This question was optional in which it was attempted by a total of 22,429 candidates (13.79 %). Candidates who scored from 0 to 4 marks were 42.37 per cent, 40.14 per cent scored from 5 to 9 marks while 17.48 per cent scored from 10 to 15 marks. The general performance was average as 57.63 per cent of the candidates scored 5 marks or above. The summary of the candidates' performance is presented in Figure 8.

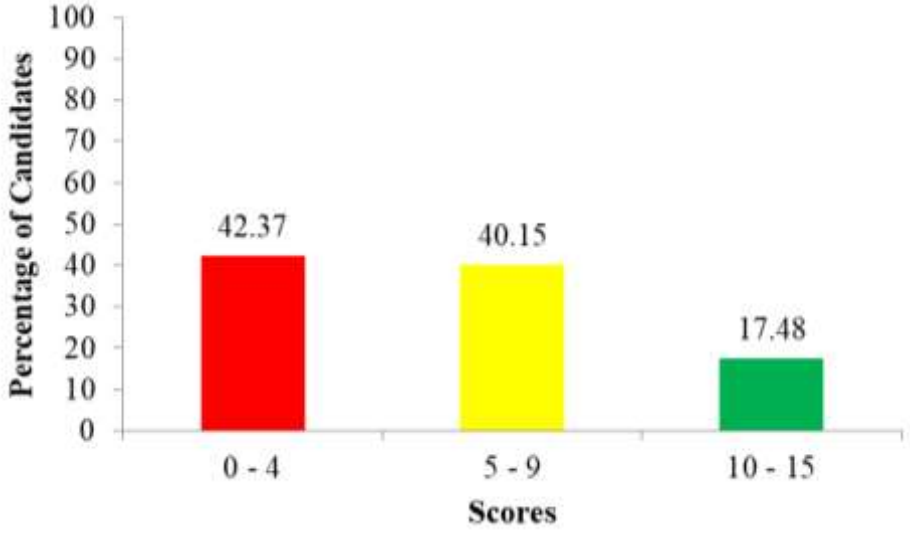


Figure 8: *Candidates' Performance in Question 9*

The analysis of the candidates' response shows that, those who scored high marks (17.48%) gave the correct nature, raw materials and the processes involved in generating biogas in parts (a), (b) and (c). Likewise, in part (d) the candidates gave adequate advantages of using biogas over charcoal. In general, they had adequate knowledge on the nature and working mechanism of a biogas plant and raw materials required for its generation. Extract 9.1 shows a sample of correct responses in question 9 from one of the candidates.

9. a) Biogas is the fuel gas which is produced by fermentation of organic materials such as remains of plants and animals by the action of bacteria.
- The gas produced contains different gases such as Methane (CH_4) which proximately found at 35%.

b) Raw materials which can be used to generate the gas includes:-
i) Remains of farm products (plants remains). They are corrected and are kept in biogas tanks so as to decompose.

ii) Animal wastes (Thij includes animal dungs): Domestic animal wastes can be used example cow dung is very useful and remains of the food they chew.

iii) Homo products associated wastes such as vegetables peels, remains of food, fruits (rotten fruits) can be ~~f~~ used in biogas plant for generating biogas.

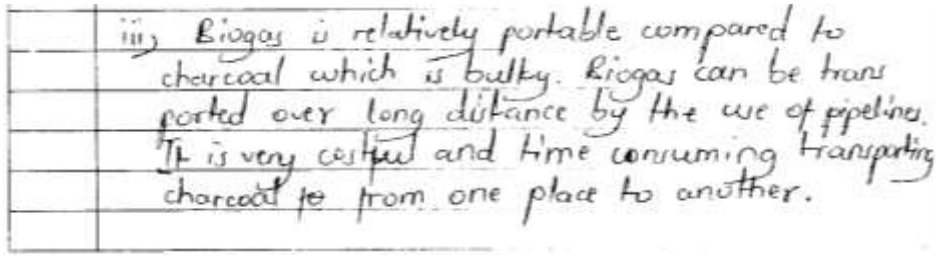
c) The process involved in generation of the gas is fermentation process.
- After all materials (raw materials) have been emptied in a biogas plant. The biogas's outlets are closed such that no air is allowed to enter in the biogas plant.
- Organic materials start to decay by the action of bacteria and fungi to breats organic materials

9. c) into energy and gases without the use of oxygen gas (~~Aerob~~ Anaerobic respiration).

- Then after few weeks inlets are opened thus allowing gases to flow to gas storage devices and finally used in cooking and other dome stic heatings also in large scale can be used for electricity generation.

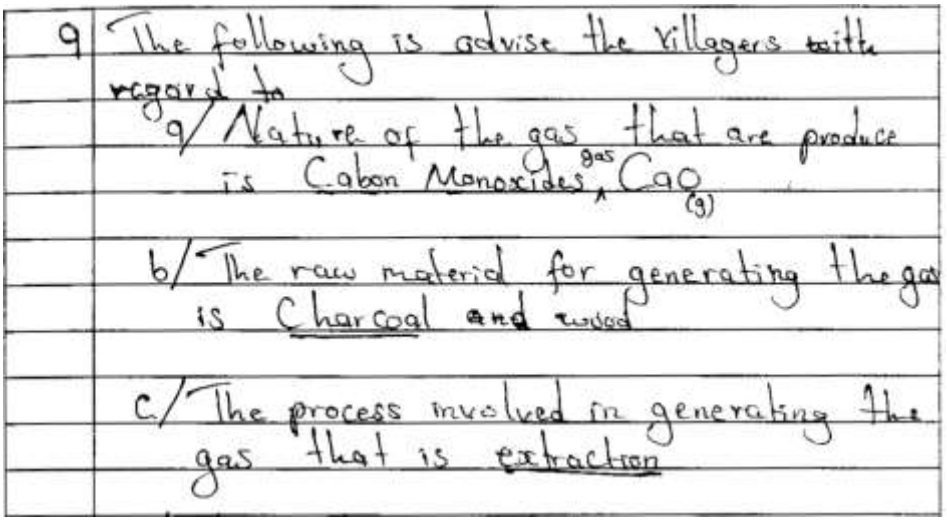
d) Advantages of using biogas over charcoal.
i) Biogas release high quantity of heat when used as fuel compared to charcoal which gives out small quantity of heat. This makes cooking process and other domestic activities depending on heat take place faster.

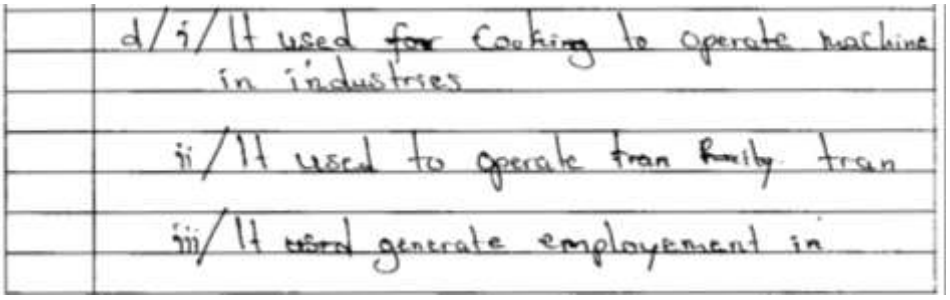
ii) Biogas release very little wastes and dangerous by products as opposed to the use of charcoal which tend to give out many dangerous by products such as smoke, carbondioxige gase and ashes.



Extract 9.1: A sample of correct responses to question 9

On the other hand, the candidates who scored low marks (42.37%) gave incorrect nature, raw material and the processes involved in generating biogas in parts (a), (b) and (c). For instance, some candidates wrote that the gas is manufactured in the industry and that it is sold in cylinders. This indicates that they had inadequate knowledge on the raw materials for generating biogas. Also, the candidates lacked consistency in explaining the working mechanism of a biogas plant that generates the gas. For instance, some candidates wrote that the biogas plant needs to be supplied with water throughout, which is not true. Likewise, in part (d) they failed to give advantages of using biogas over charcoal. For example, some of them gave differences between biogas and charcoal such as colour and burners. Also some candidates incorrectly wrote that biogas is non-renewable. Similarly, another candidate wrote that biogas has very high ignition point. In general, the candidates were unaware that the gas is renewable and environmentally friendly as compared to charcoal. Extract 9.2 shows a sample of incorrect responses in question 9.





Extract 9.2: A sample of incorrect responses to question 9

In Extract 9.2, the candidate gave incorrect responses in all parts of the question. In part (a), the candidate wrote the nature of the gas as carbon monoxide gas rather than gaseous fuel. In part (b), he/she wrote the raw materials for generating the gas as charcoal and wood instead of domestic and industrial wastes like sewage, and animal wastes. In part (c), the candidate failed to describe the process involved in generating the gas by writing extraction which is incorrect. Similarly, in part (d), the candidate wrote incorrect advantages of biogas fuel over charcoal.

2.1.3.2 Question 10: Extraction of Metals

In this question, the candidates were required to illustrate five environmental destructions caused by the process of extraction of metals and suggest five intervention measures to control the problem.

A total of 141,728 candidates (87.14%) attempted this question. The analysis of performance indicate that 14.34 per cent of the candidates scored from 0 to 4 marks, 35.97 per cent scored from 5 to 9 marks, while 49.69 per cent scored from 10 to 15 marks. Thus, the general performance was good since 85.66 per cent of the candidates scored 5 marks or above. Figure 9 summarizes candidates' performance in question 10.

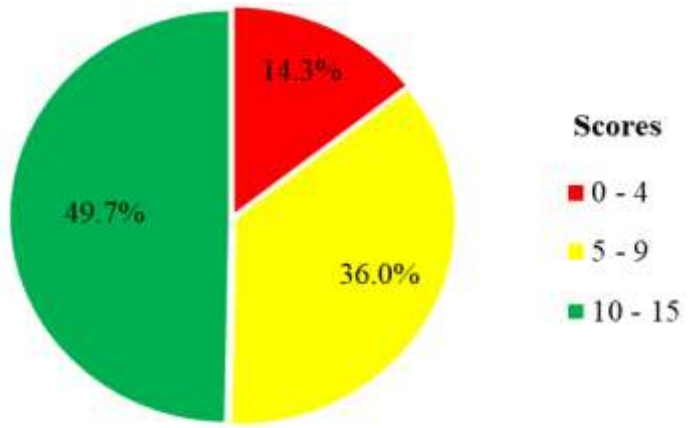


Figure 9: *Candidates' Performance in Question 10*

The candidates who scored high marks (49.69%) explained five environmental destructions caused by the process of extraction of metals and also suggested five intervention measures to control the problem. Extract 10.1 shows a sample of correct responses from one of the candidates in question 10.

10. Extraction of metals is the process of extracting or removing metals from their ores. The process may sometimes be harmful to the environment. There are various environmental destructions caused by the process of extraction of metals together with their preventive or control measures to control the problem.
Beginning with the environmental destructions caused by extraction of metals, they are as follows;
Soil erosion, since extraction of metals lead to bare land or sometimes the extractors cut down the trees and do not replant them and so leads to soil erosion and hence it is an environmental destruction caused by the process of extracting metals.
Loss of biodiversity, since extraction of metals may sometimes involve the cutting down of trees so as to extract some metals from a certain area. Therefore, the cutting down trees leads to loss of biodiversity because biodiversity involves both plants and animals.
Noise pollution, this is very true because sometimes metals are found near human residences or settlement and so it means when doing extraction in such kind of a place, it will lead to noise because of those machines being used.

Loss of soil fertility, this is because in extracting some metals, the cutting down of trees may be involved leaving the soil bare or the land bare and so that piece of land or soil will/ lose its fertility because nothing will take place there and hence environmental destruction caused by the process of extraction of metals.

10 Water pollution, this is also an environmental destruction because when extracting some metals various chemicals may be used. Those chemicals may reach the water sources through leaching or even surface off running water and hence it is an environmental destruction.

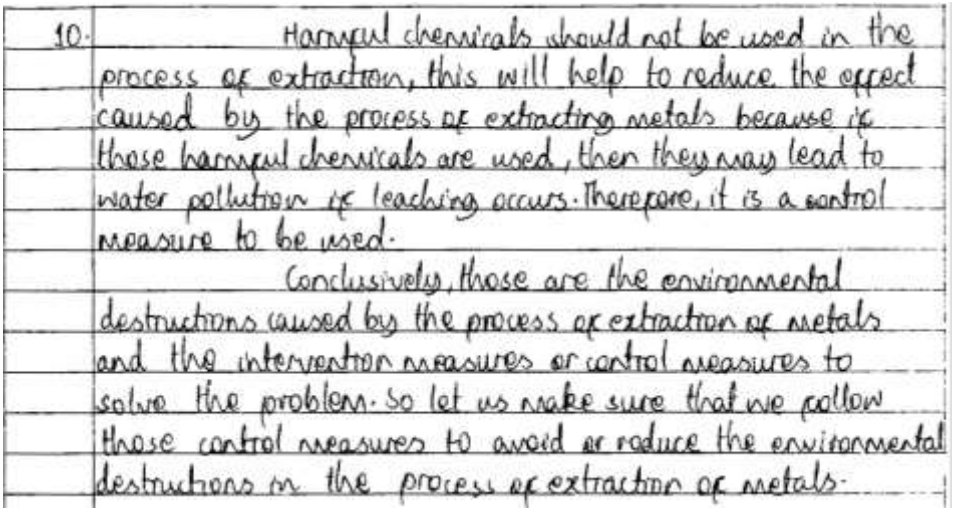
Turning to the measures involved in controlling the problems caused by the process of extraction of metals. They are as follows;

The government should establish strict rules and regulations against those extractors who will cause environmental destruction in the process of extraction of metals. This is a very important measure because it will at least reduce the rate of environmental destructions.

Afforestation and reforestation, the ones extracting metals from the ground should make sure that they plant trees after extracting them and in case if they cut before extraction they should do reforestation in order to reduce the environmental destructions caused by the process of extracting metals.

Metals should be extracted far away from human settlement, in order to avoid such environmental destructions such as noise pollution, then extraction should be done in areas where people don't live in order to reduce these environmental problems.

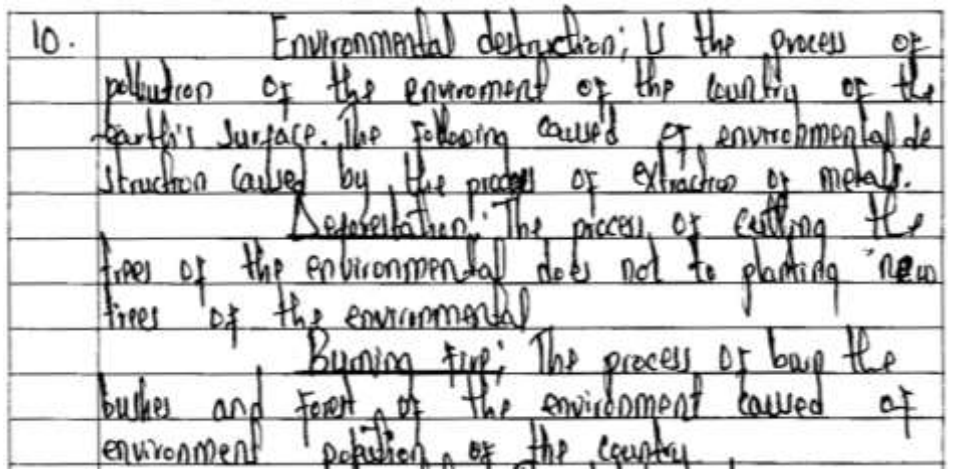
Establishment or formation of some agencies which can ensure that the environment is conserved and that will aid in reducing the rate of environmental problems or destructions during or caused by the process of extraction of metals and hence it is a control measure to be used.


10. Harmful chemicals should not be used in the process of extraction, this will help to reduce the effect caused by the process of extracting metals because if those harmful chemicals are used, then they may lead to water pollution if leaching occurs. Therefore, it is a control measure to be used.

Conclusively, those are the environmental destructions caused by the process of extraction of metals and the intervention measures or control measures to solve the problem. So let us make sure that we follow those control measures to avoid or reduce the environmental destructions in the process of extraction of metals.

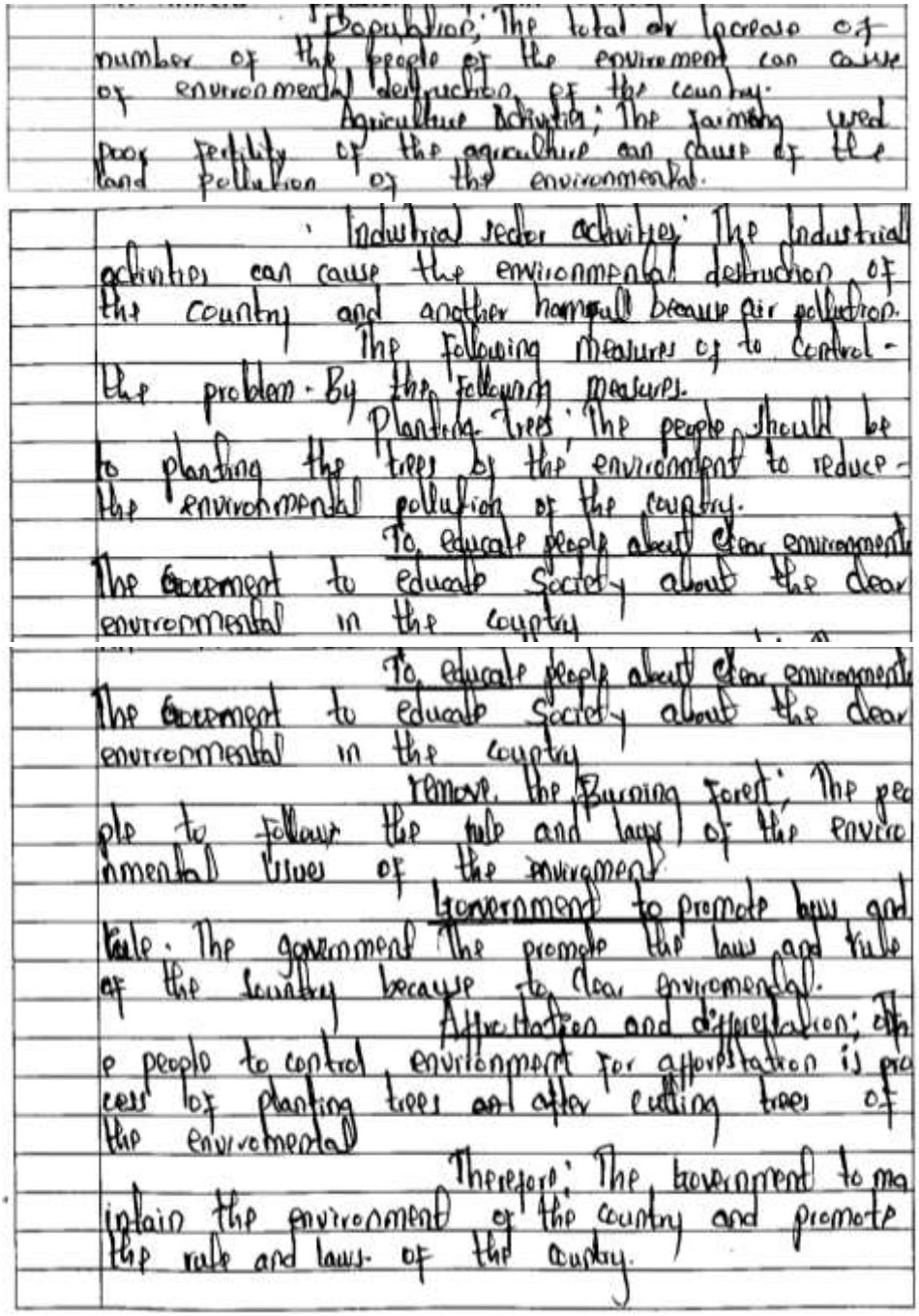
Extract 10.1: A sample of correct responses to question 10

On the other hand, the candidates who scored low marks (14.34%), failed to illustrate the environmental destructions caused by the process of extraction of metals. Some of the candidates wrote that extraction of metals causes water pollution, without any substantiation. Others incorrectly explained extraction of some metals such as iron and copper and aluminium. Similarly, some candidates stated generally that extraction of metals causes pollution, however they could not give details. Additionally, the candidates suggested incorrect intervention measures to control the problem. For instance, one candidate wrote that metals extracted should not be recycled after use. This shows lack of adequate knowledge on the impact of extraction of metals to the environment. Extract 10.2 shows a sample of incorrect responses from one of the candidates in question 10.


10. Environmental destruction; U the process of pollution of the environment of the country of the earth's surface. The following caused of environmental de struction caused by the process of extraction of metals.

Deforestation; The process of cutting the trees of the environmental does not to planting new trees of the environmental

Burning fire; The process of burn the bushes and forest of the environment caused of environment pollution of the country.


Population; The total or increase of number of the people of the environment can cause of environmental destruction of the country.

Agriculture Activities; The farming used poor fertility of the agriculture can cause of the land pollution of the environmental.

Industrial feeder activities; The industrial activities can cause the environmental destruction of the country and another harmfull because air pollution.

The following measures of to control the problem. By the following measures.

Planting Trees; The people should be to planting the trees by the environment to reduce the environmental pollution of the country.

To educate people about clear environment The Goverment to educate Society about the clear environmental in the country

To educate people about clear environment The Goverment to educate Society about the clear environmental in the country

remove the Burning forest; The people to follow the rule and laws of the environmental issues of the environment

Government to promote laws and rule. The government The promote the laws and rule of the country because to clear environmental.

Afforestation and deforestation; the people to control environment for afforestation is process of planting trees and after cutting trees of the environmental

Therefore; The Government to maintain the environment of the country and promote the rule and laws of the country.

Extract 10.2: A sample of incorrect responses to question 10

In Extract 10.2, part (a), the candidate described general environmental pollution like deforestation, increased population, burning fire (such as forest) and poor agriculture due to reduced fertility rather than focusing on those associated with extraction of metals like solid waste production, noise pollution, toxic gaseous products, unreacted chemical wastes and

introduction of heavy metals to the environment. In part (b), he/she focused the general intervention measures instead of specific interventions addressing environmental destruction caused by extraction of metals.

2.1.3.3 Question 11: Pollution

In this question, the candidates were required to use five points, to explain the harmful effects of terrestrial pollution.

A total of 158,618 candidates (97.52%) attempted this question. The analysis of the candidates' performance indicates that 12.01 per cent scored from 0 to 4 marks, 30.88 per cent scored from 5 to 9 marks, while 57.11 percent scored from 10 to 15 marks. The general performance of candidates was good because 87.99 per cent of the candidates scored 5 marks or above. Figure 10 summarizes candidates' performance in question 11.

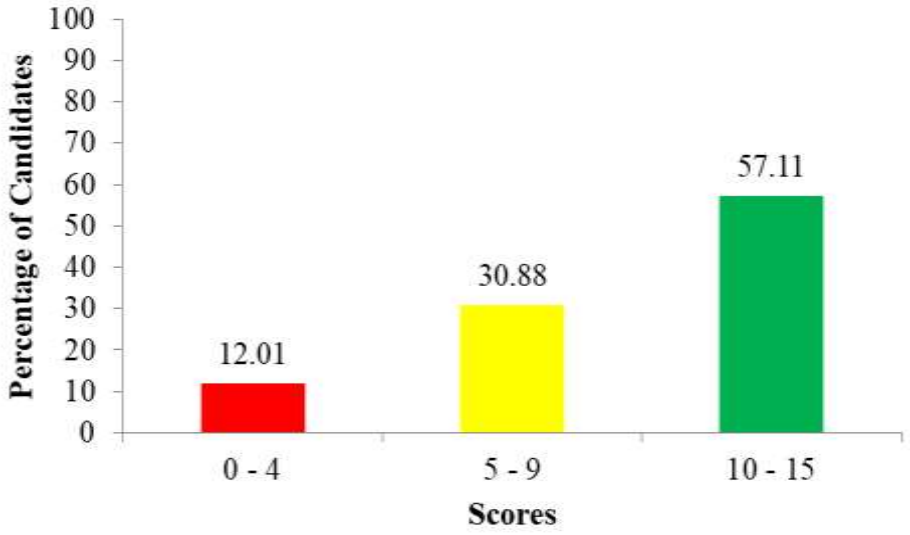


Figure 10: *Candidates' Performance in Question 11*

The candidates who scored high marks (57.11%) explained five effects of terrestrial pollution, especialy the effects on the soil, organisms, land, diseases and bad smell. This shows that the candidates had good understanding of the concept of terrestrial pollution. Extract 11.1 shows a sample of correct responses from one of the candidates in question 11.

11. Terrestrial pollution is also known as land pollution. This is the introduction of unwanted materials to the land. The causes for land pollution are like mining activities, agricultural activities, wastes from industries and others. Terrestrial pollution has many harmful effects some of which are;

It leads to loss of soil fertility. Some of the wastes introduced in the land such as the harmful chemicals from industries and hospitals may lead to destruction of the soil structure making the soil not to be able to resist erosion thus washing away of the nutrients in the soil hence leading to soil losing its fertility.

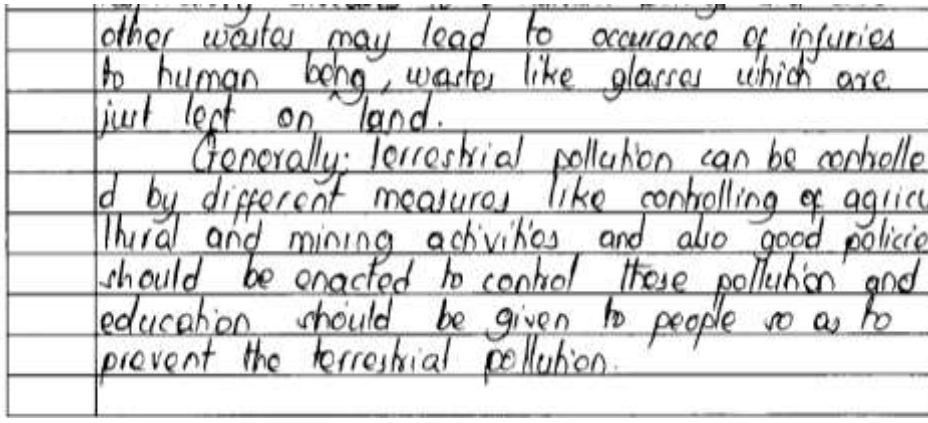
It leads to death of organisms that live in the soil. This is whereby when the land is polluted to harmful chemicals which can not be adhered by the burrowing organisms it creates a bad environment for these organisms to survive hence leading to death of burrowing organisms Hence it is a

11. harmful effect since these organisms help in soil formation.

It leads to decrease in valuable land which could be used for other activities like agriculture. This is whereby when large pieces of land are used as garbage deposits, it makes those lands to be useless again hence it reduces the amount of valuable land which could be used for different other activities.

It also leads to destruction of the natural beauty of the environment. Terrestrial pollutions makes the land unattractive since it is polluted by different unwanted materials like plastics, Iron and destroyed clothes. Thus this will make the environment to lose its natural beauty.

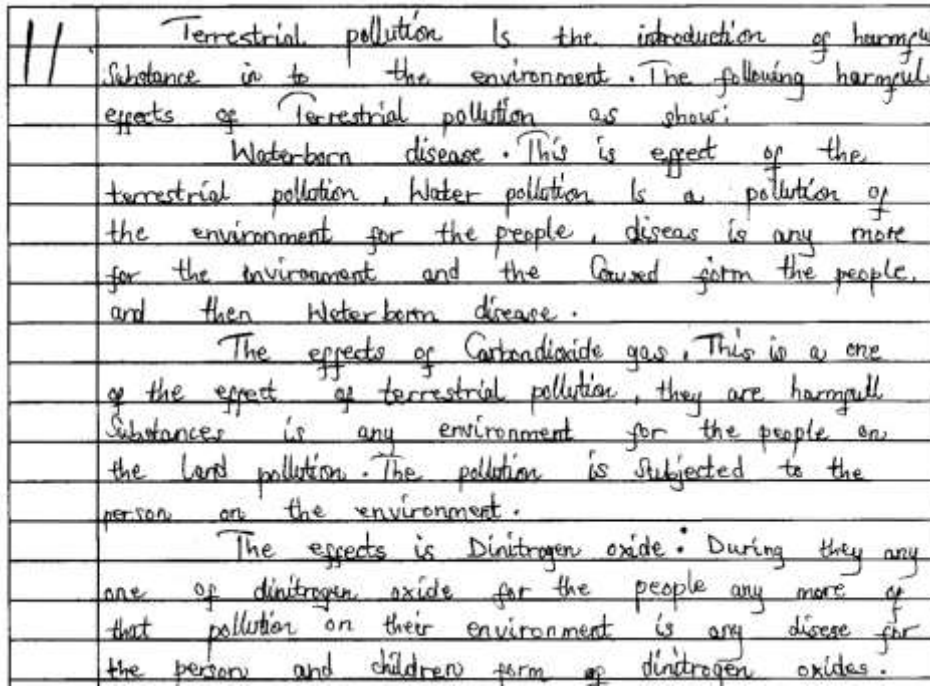
It leads to outbreak of diseases in the environment. This is because the wastes scattered on land may give out bad smells which may lead to respiratory diseases to human beings and also other wastes may lead to occurance of injuries


other wastes may lead to occurance of injuries to human being, wastes like glasses which are just left on land.

Generally: terrestrial pollution can be controlle d by different measures like controlling of agricu lthural and mining activities and also good policies should be enacted to control these pollution and education should be given to people so as to prevent the terrestrial pollution.

Extract 11.1. A sample of correct responses to question 11

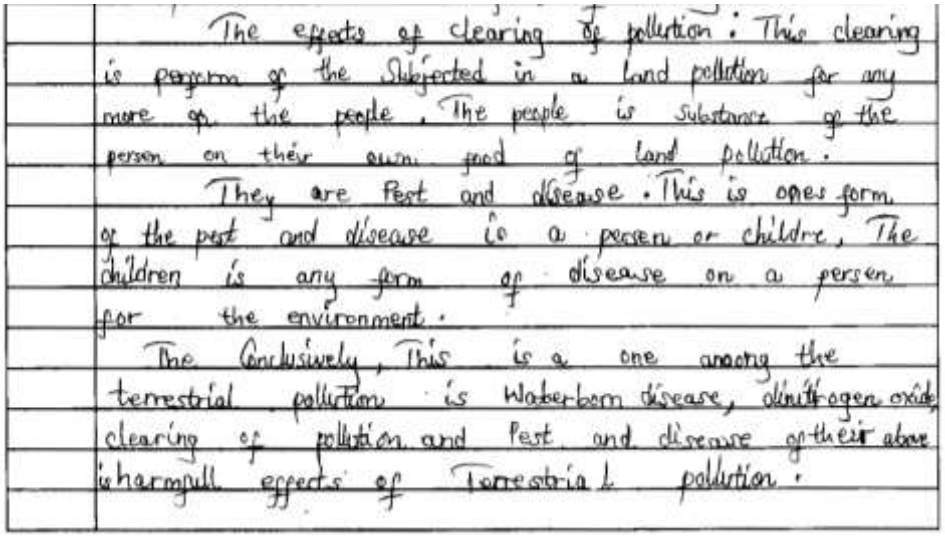
On the contrary, the candidates who scored low marks (12.01%) gave incorrect responses on the harmful effects of terrestrial pollution. Some candidates discussed the effects of aerial pollution, while others focused on aquatic pollution instead of terrestrial pollution. For example one candidate suggested that terrestrial pollution causes loss of aquatic life, which ought to have been an effect of aquatic pollution. Another candidate wrote that terrestrial pollution causes global warming, which is incorrect. Extract 11.2 shows a sample of incorrect responses from one of the candidates in question 11.


11. Terrestrial pollution is the introduction of harmful substance in to the environment. The following harmful effects of Terrestrial pollution as shown:

Water-born disease. This is effect of the terrestrial pollution, Water pollution is a pollution of the environment for the people, diseas is any more for the environment and the Caused form the people. and then Water born disease.

The effects of Carbondioxide gas, This is a one of the effect of terrestrial pollution, they are harmfull substances is any environment for the people on the land pollution. The pollution is Subjected to the person on the environment.

The effects is Dinitrogen oxide. During they any one of dinitrogen oxide for the people any more of that pollution on their environment is any disease for the person and children form of dinitrogen oxides.


The effects of clearing of pollution: This clearing is process of the Subjected in a land pollution for any more of the people. The people is substance of the person on their own good of land pollution.

They are Pest and disease. This is ones form of the pest and disease is a person or children. The children is any form of disease on a person for the environment.

The Conclusively, This is a one among the terrestrial pollution is Water-born disease, dinitrogen oxide clearing of pollution and Pest and disease of their above is harmfull effects of Terrestrial pollution.

Extract 11.2: A sample of incorrect responses to question 11

In Extract 11.2, the candidate has written irrelevant harmful effects of terrestrial pollution such as water born diseases, effect of carbon dioxide, effect of dinitrogen oxide and also pests and diseases instead of the relevant points like effects on soil fertility, microorganisms, appearance of the land and bad smell.

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 set from the topic of Volumetric Analysis, while question 2 was set from the topic of Chemical Kinetics, Equilibrium and Energetics.

2.2.1 Question 1: Volumetric Analysis

The question was attempted by 162,652 candidates (100%). The analysis indicates that 5.40 per cent of the candidates scored from 0 to 7 marks, 35.21 per cent scored from 8 to 16 marks and 59.39 per cent scored from 17 to 25 marks. Generally, the performance in this question was good because 94.60 per cent of the candidates scored 8 marks or above. The summary of the performance is shown in Figure 11.

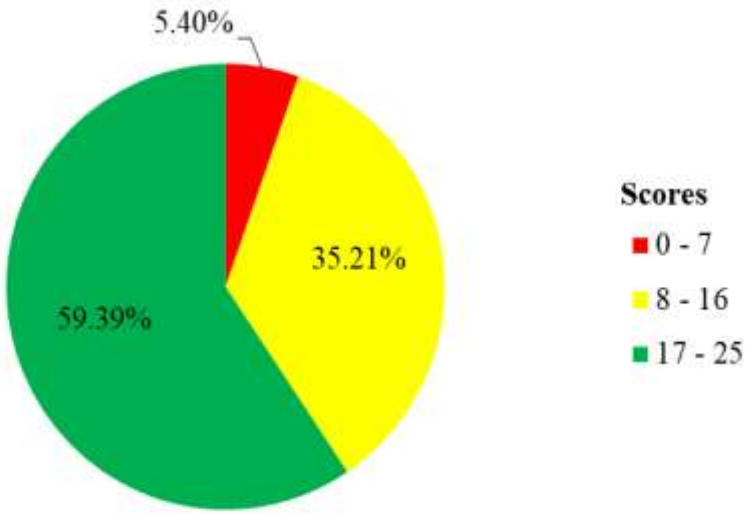


Figure 11: *Candidates' Performance in Question 1, Practical*

2.2.1.1 Alternative 2A

The question was as follows: *You are asked to determine the concentration of sodium hydroxide contaminating drinking water source in a certain village. In order to investigate the problem, a sample from the village water source (containing NaOH) has been brought in the chemistry laboratory for you to carry out a volumetric analysis. You are also given a standard solution of 1.825 g hydrochloric acid dissolved in 0.5 dm^3 of the solution. Use methyl orange (MO) and litmus papers as indicators.*

Procedure

*(i) Pour about 2 cm^3 of solution **V1** into a test tube, use litmus papers to test if it is an acidic or a basic solution.*

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

*(iii) Repeat the procedure (i) and (ii) using solution **V2**.*

*(iv) Titrate the acid (in the burette) against the sample solution (sodium hydroxide) using **MO** up to the end point. Repeat the procedure to obtain three more readings and record your results in a tabular form.*

Questions

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

(b) Calculate the average volume of the acid used.

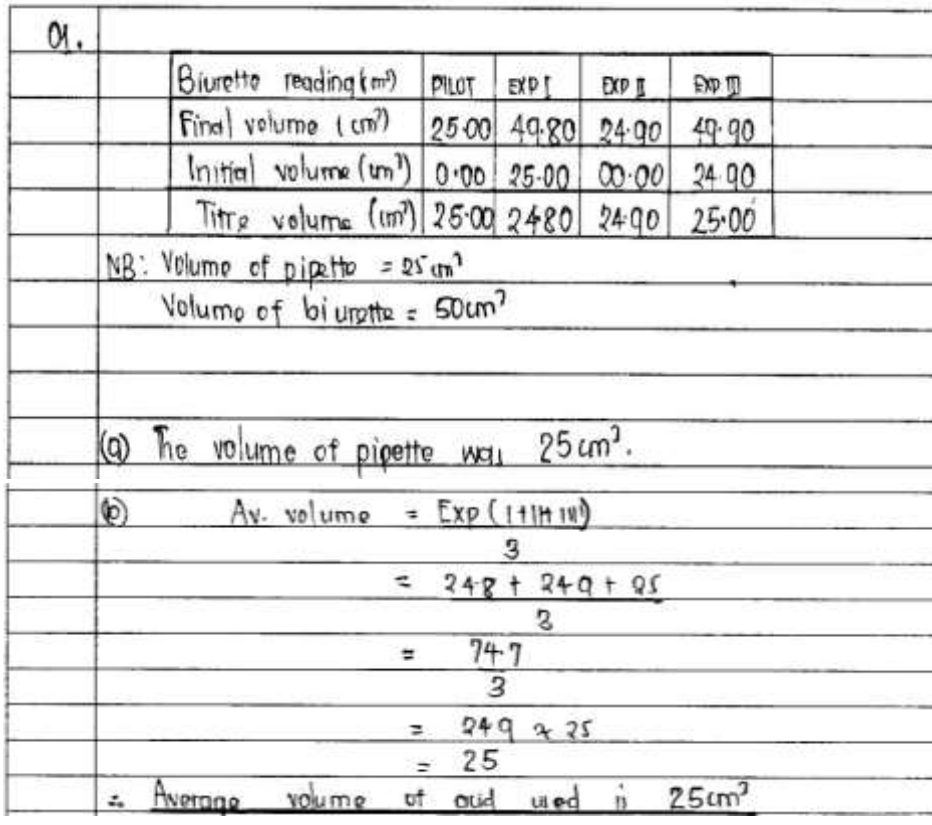
(c) What were the changes on the litmus papers?

*(d) Indicating all the state symbols, write a balanced chemical equation for the neutralization reaction between **V1** and **V2**.*

(e) Write an ionic equation for the reaction.

(f) Showing your procedures clearly, calculate the concentration in g/dm^3 of the claimed component (sodium hydroxide).

The candidates who scored high marks determined the nature of solution using litmus papers correctly. Also, they filled correctly the table of results by considering two decimal places, and accuracy of the data. This implies that, they followed correctly titrating procedures to obtain correct burrete readings. Similarly, the candidates identified the volume of pipette used in part (a) and recorded it correctly. In part (b) they correctly calculated the average volume of acid used. Moreover, the candidates wrote balanced formula and ionic chemical equation for the reaction between sodium hydroxide (NaOH) and hydrochloric acid (HCl) in parts (d) and (e). Likewise, in part (f) the candidates used mole concept to calculate mass concentration of hydrochloric acid and molarity. Finally, they applied the concept of stochiometry to calculate the molarity and mass concentration of pure sodium hydroxide with its appropriate SI unit. Extract 15.1 shows a sample of correct responses in question 1 (Alternative 2A).



01.

Biurette reading (cm^3)	PILOT	EXP I	EXP II	EXP III
Final volume (cm^3)	25.00	49.80	24.90	49.90
Initial volume (cm^3)	0.00	25.00	00.00	24.90
Titre volume (cm^3)	25.00	24.80	24.90	25.00

NB: Volume of pipette = 25 cm^3

Volume of biurette = 50cm^3

(a) The volume of pipette was 25 cm^3.

(b) Av. volume = $\frac{\text{Exp (I+II+III)}}{3}$

$= \frac{24.8 + 24.9 + 25}{3}$

$= \frac{74.7}{3}$

$= 24.9 \approx 25$

$= 25$

∴ Average volume of acid used is 25cm^3

(c) In solution V_1

- The red litmus paper remained unchanged as it retained its red colour
- The blue litmus paper turned red

∴ The solution is an acidic in nature

01. (c) In solution V_2.

- The red litmus paper turned to blue colour.
- The blue litmus paper retained its colour.

∴ The solution is basic in nature.

(d) $2NaOH_{(aq)} + 2HCl_{(aq)} \longrightarrow 2NaCl_{(aq)} + 2H_2O_{(l)}$

Where

V_1 = HCl (Hydrochloric acid)

V_2 = NaOH (Sodium hydroxide)

(e) Sodium hydroxide + Hydrochloric acid → Sodium chloride + water.

$2NaOH_{(aq)} + 2HCl_{(aq)} \longrightarrow 2NaCl_{(aq)} + 2H_2O_{(l)}$

$2Na^+_{(aq)} + 2OH^-_{(aq)} + 2H^+_{(aq)} + 2Cl^-_{(aq)} \rightarrow 2Na^+_{(aq)} + 2Cl^-_{(aq)} + 2H_2O_{(l)}$

$2Na^+_{(aq)} + 2OH^-_{(aq)} + 2H^+_{(aq)} + 2Cl^-_{(aq)} \rightarrow 2Na^+_{(aq)} + 2Cl^-_{(aq)} + 2H_2O_{(l)}$

$2OH^-_{(aq)} + 2H^+_{(aq)} \rightarrow 2H_2O_{(l)}$

ii. Ionic equation is $2OH^-_{(aq)} + 2H^+_{(aq)} \longrightarrow 2H_2O_{(l)}$

(f) Balanced chemical equation

$2NaOH_{(aq)} + 2HCl_{(aq)} \longrightarrow 2NaCl_{(aq)} + 2H_2O_{(l)}$

Mole ratio

2 : 2.

Given; mass of acid = 1.825g in $0.5dm^3$

volume of base = $25cm^3$

Volume of acid = $25cm^3$

Number of moles of acid = 2

Number of moles of base = 2.

01. (f) Calculate the concentration of acid

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

$$= \frac{1.825\,g}{0.5\,dm^3}$$

$$= 3.65\,g/dm^3$$

∴ The concentration of acid is $3.65\,g/dm^3$

Calculate the molarity of acid.

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

But the molarimass of acid HCl is

$$HCl = H + Cl$$

$$= 1 + 35.5$$

$$= 36.5\,g/mol.$$

∴ The molar mass of acid is $36.5\,g/mol$.

Then $$\text{Molarity} = \frac{\text{Conc}}{\text{mm}}$$

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

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

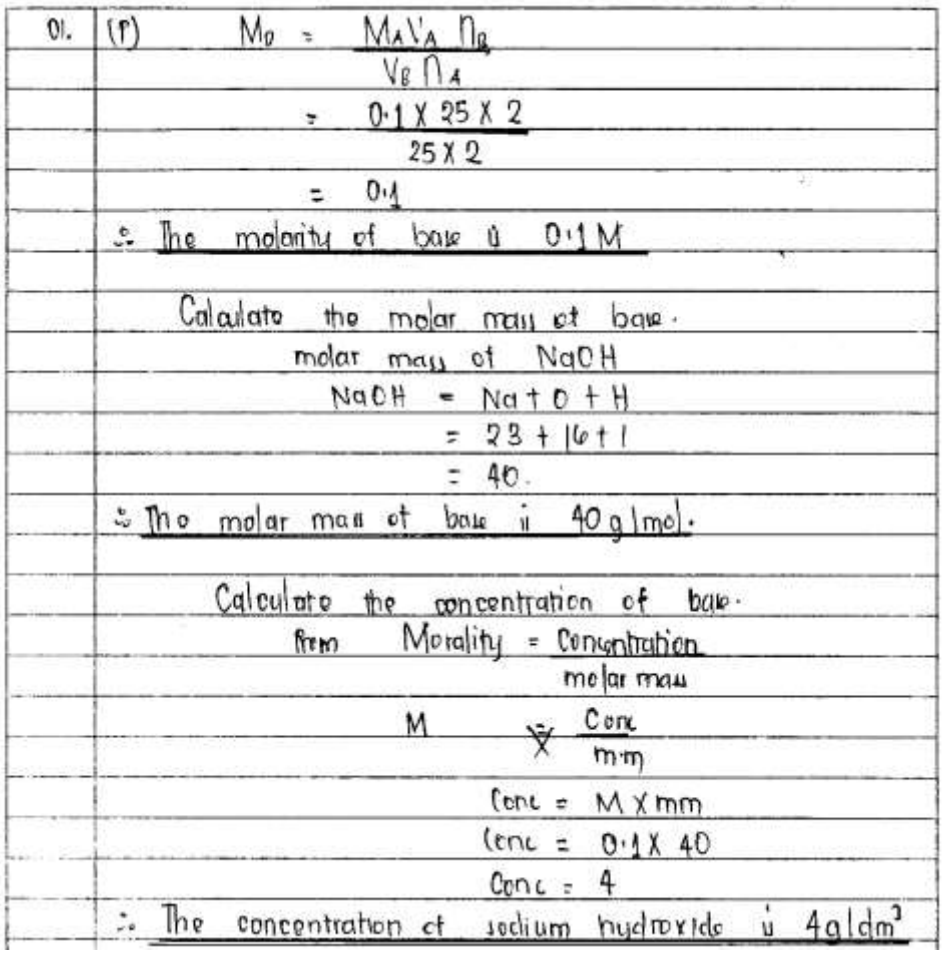
∴ The molarity of acid is 0.1 M

Calculate the molarity of base

from $$\frac{M_A V_A}{M_B V_B} = \frac{n_A}{n_B}$$

$$\frac{M_A V_A}{M_B V_B} \times \frac{n_B}{n_A} = \frac{n_A}{n_B} \times \frac{n_B}{n_A}$$

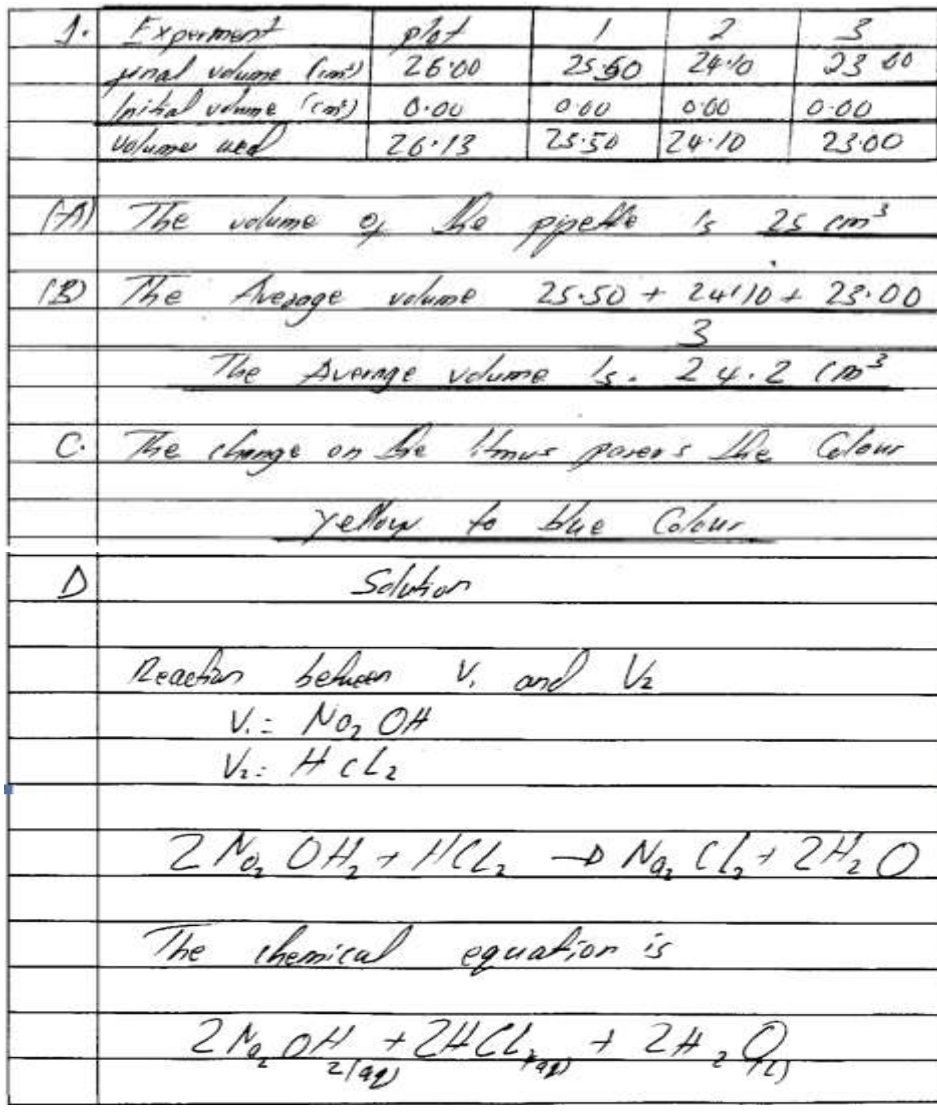
$$\frac{M_A V_A n_B}{V_B n_A} = \frac{M_B V_B n_A}{V_B n_A}$$

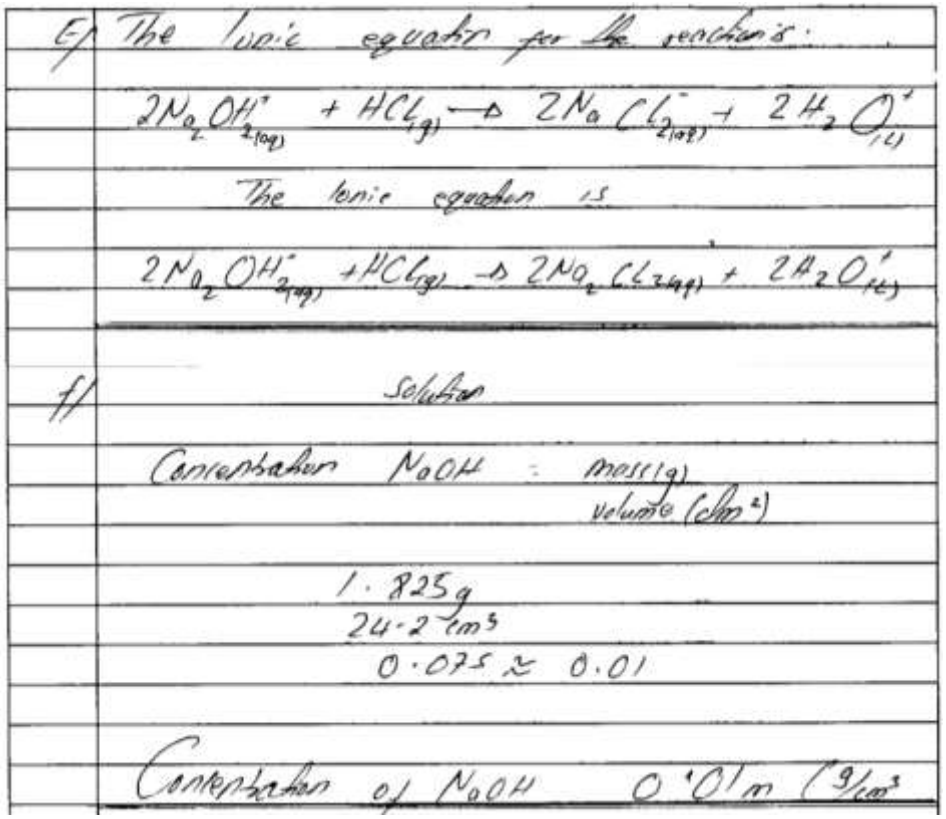


Extract 15.1: A sample of correct responses to question 1, paper 2A

However, the candidates who scored low marks failed to identify the nature of the given solutions using litmus paper. In addition, some candidates failed to fill the table of results correctly. The analysis shows that the titre volumes fell out of the expected range. Some candidates failed to take into consideration that the data should be recorded into 2 decimal places, while others left some gaps in the table of results. The analysis also shows that some of them did not indicate the volume of pipette used in part (a). Likewise, in part (d), some candidates failed to write well a balanced chemical equation between HCl and NaOH, including their state symbols. For example, some candidates wrote the equation as $HCl + 2NaOH \longrightarrow 2H_2O + H_2$ and others wrote $3HCl + 2NaOH \longrightarrow 5H_2O + NaCl_2$ resulting to incorrect mole ratio of acid to base which was important in the calculation of molarity of the reaction species. In part (e) some candidates wrote the ionic equation as

$Cl^- + Na^+ \longrightarrow NaCl(l)$ which was not correct. Furthermore, in part (f) they failed to apply appropriate formula in the successive calculations to determine mass concentration and molarity of both hydrochloric acid and sodium hydroxide. For instance, there were candidates who used incorrect formula such as Mana = Mbnb and MaVb = MbVa instead of $\frac{MaVa}{MbVb} = \frac{na}{nb}$. This implies that, the candidates had inadequate knowledge about the concepts of chemical equations and stochiometry, the indicators and laboratory apparatuses. Extract 15.2 shows a sample of averagely incorrect responses from one of the candidates.





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

In Extract 15.2, the candidate recorded 26.13 cm^3 in the column for pilot data which cannot found in the burrete scale. In part (c) the candidate wrote that the colour of litmus paper changed from yellow to blue instead of either blue to red when inserted in acid or red to blue when inserted in base. Furthermore, in part (d) he/she wrote incorrect chemical equation resulting to the wrong ionic equation in part (e). Moreover in part (f) the candidate used incorrect formula in calculating molarity of sodium hydroxide. Note that the candidate resorted into using capital letters (A, B, C, D and E) instead of small letters in the numbering.

2.2.1.2 Alternative 2B

The question appeared as follows: *Neutralization reaction can be employed to determine the concentration of unknown sample solution by using a standard solution. In this experiment you are provided with the following solutions:*

- *solution containing 7.3 g of hydrochloric acid dissolved in one litre of solution;*

- *solution containing 1.378 g of M_2CO_3 in a 0.5 dm^3 of solution;*
- *Methyl orange (**MO**) indicator.*
- *Phenolphthalein (**POP**) indicator.*

Procedure

*(i) Put 5 cm^3 of each solution into separate test tubes. Add 1-2 drops of **POP** indicator in each tube. Record the colour change.*

*(ii) Repeat procedure (i) using **MO** indicator. Record the colour change.*

*(iii) Label the acid as **B1** and the base as **B2**.*

*(iv) Measure 50 cm^3 of **B1** (acid) using a 100 cm^3 measuring cylinder. Transfer it into a 250 cm^3 or 300 cm^3 beaker and dilute it to make 100 cm^3 of solution.*

*(v) Put the diluted **B1** (acid) in the burette, then titrate it against **B2** (base) until the end point is attained. Repeat the procedure to obtain three more burette readings and record the results in a tabular form.*

Questions

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

(b) Calculate the average volume of the acid used.

*(c) Write a balanced chemical equation for the reaction between **B1** and **B2**.*

*(d) Determine the resulting molarity after diluting **B1** in procedure (iv) from 50 cm^3 of 0.2 M to 100 cm^3 of solution.*

*(e) Identify a metal **M** in the compound M_2CO_3.*

The candidates who scored high marks determined the nature of solution using litmus papers correctly, filled the table of results correctly considering two decimal places and within the accuracy of the data. In part (a), they managed to read the volume of pipette used and recorded it correctly. In part (b) candidates calculated correctly the average volumes of acid used. Likewise, in part (c) they wrote correct balanced chemical equation for the reaction of the two sample solutions (M_2CO_3 and HCl). In part (d) they used correct formula to calculate concentrated and dilute molarities of the acid. In addition, in part (e) the candidates calculated the mass concentration and molarity of M_2CO_3, and hence its molar mass. Finally, the candidates correctly identified the unknown element. In general, the candidates had adequate knowledge on the concepts of chemical equations, dilution law and stoichiometry. Extract 16.1 shows a sample of correct responses in question 1 (Alternative 2B) from one of the candidates.

Q1. B_1 - HCl.

B_2 - M_2CO_3.

POP indicator.

The colour change was colourless in B_1 and pink in B_2.

MO indicator.

The colour change was pink in B_1 and yellow in B_2.

Volume of pipette = 25cm³.

Burette reading: (cm³)	Pilot	I	II	III
Final volume used (cm³)	13.10	26.20	39.20	13.00
Initial volume (cm³)	0.00	13.10	26.20	0.00
Volume used (cm³)	13.10	13.10	13.00	13.00

a) The volume of the pipette used is 25cm³.

b) Average volume = $\frac{Vol\,1 + vol\,2 + Vol\,3}{3}$ cm³

Ave volume = $\frac{13.10\ cm^3 + 13.00 cm^3 + 13.00 cm^3}{3}$ = 13.03 ≈ 13.0.

Average volume = 13.00 cm³.

∴ The Average volume of acid used is 13.00 cm³

c) $M_2CO_3 + 2HCl_{(aq)} \longrightarrow 2MCl + H_2O_{(l)} + CO_{2(g)}$.

Q1. a) Molarity of dilute × volume of dilute = Molarity of concentrated × volume of concentrated

$M_d V_d = M_c V_c$.

Data given

$M_c = 0.2M$.

$V_c = 50cm^3$.

$V_d = 100cm^3$.

$M_d \times 100cm^3 = 0.2 \times 50cm^3$

$M_d = \frac{0.2 \times 50cm^3}{100cm^3}$

$M_d = 0.1M$

∴ The resulting molarity after dilution of B_2 is 0.1M.

e) Find Molar mass.

molar mass = $\frac{\text{concentration}}{\text{molarity}}$

where:

Concentration = $\frac{\text{mass}}{\text{volume}}$

mass = 1.378g

volume = $0.5dm^3$

Conc = $\frac{1.378g}{0.5dm^3}$

Concentration = $2.756g/dm^3$

Then

Find molarity

Data given

01. e) Molarity of acid, M_a = 0.1M

molarity of base, M_b = ?

number of moles of acid n_a = 2

number of moles of base n_b = 1

volume of base used V_b = $25cm^3$

volume of acid used V_a = $13cm^3$

Then

From

$M_a V_a n_b = M_b V_b n_a$

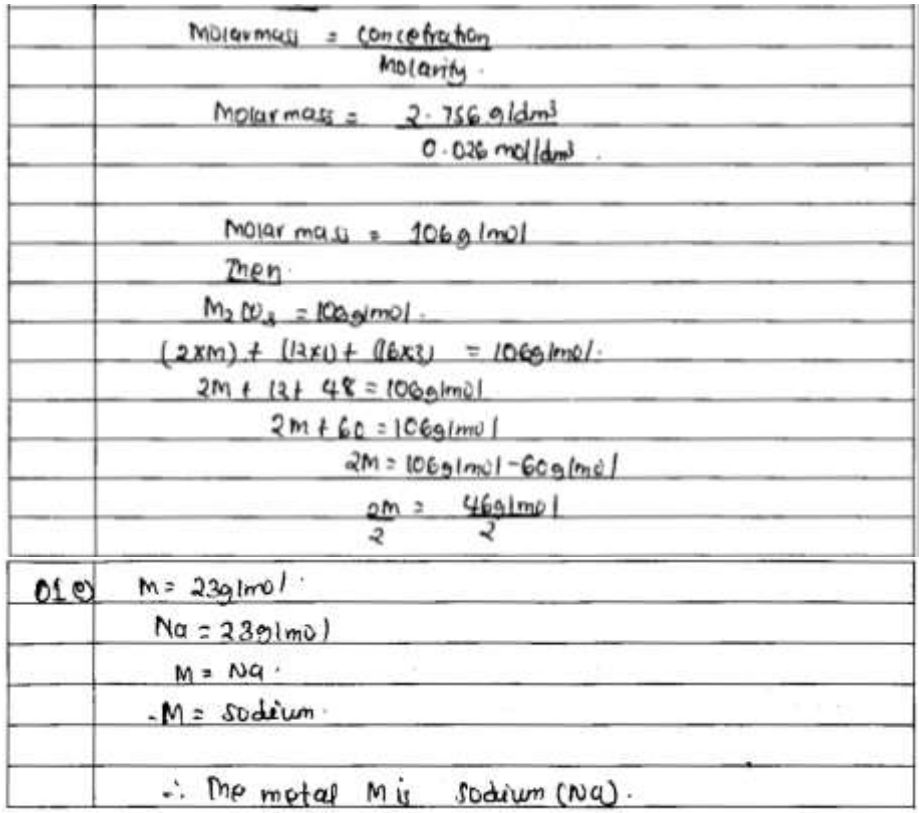
$M_b = \frac{M_a V_a n_b}{V_b n_a}$

$M_b = \frac{0.1 \times 13 \times 1}{25 \times 2}$

$M_b = 0.026M$

∴ The molarity of M_2CO_3 is 0.026M.

Then



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

However, the candidates who scored low marks failed to fill the table of results correctly by not adhering to 2 decimal places and accuracy. Also, in part (a) some candidates did not indicate the volume of the pipette used to measure the volume of the base. In part (b) candidates calculated incorrectly the average volume of acid used while others did not find the average. Likewise, in part (c) some candidates failed to write balanced chemical equation between M_2CO_3 and HCl which was important in the subsequent calculations. There were candidates who wrote $M_2CO_3 + HCl \longrightarrow MCl + CO_2 + H_2O$ while other candidates wrote $M_2CO_3 + HCl \longrightarrow 2MCl + H_2O$. Hence, they obtained acid base mole ratio of 1:1 instead of 1:2. Also, in part (d), some candidates used incorrect formulae in determination of dilute molarity of hydrochloric acid. For example, one candidate wrote,

$Md = McVc + Vd,\ Md = 0.1 \times 50 + 100,\ Md = 105$ instead of using formula $Md\,Vd = McVc$. Thus, they obtained incorrect values of molarity of dilute hydrochloric acid. Likewise, some candidates used

incorrect formula in determining the molarity of M_2CO_3. For instance, one candidate wrote $\text{Md Vd} = \text{McVc}$ instead of $\frac{MaVa}{MbVb} = \frac{na}{nb}$. However there were candidates who applied correct formula but some used incorrect data while others could not correctly manipulate the data. Generally, the candidates falling under this category had inadequate knowledge about the chemical equation, dilution law, mole concept, and volumetric analysis. Extract 16.2 shows a sample of incorrect responses in question 1 (Alternative 2B).

i. The colour change into pink
Colourless into pink

a) The volume of the pipette used is 25cm³

c) After using MO indicator the colour change into orange

	The volume of solution 25cm³		
Pilot	1	2	3
Initial volume	24·5	22·42	19·50
final volume	25·50	25·00	20·50
final volume	25·00	00·00	25·24

Average = $V_1 + V_2 + V_3$
$25{\cdot}00 + 00{\cdot}00 + 25{\cdot}24$
$= 50{\cdot}24\ cm^3$

b) $2HCl_2 + 3M_2CO_3 \longrightarrow M_2CO + 3HCl_2$

d) Initial volume = 50.24cm²
Final volume = 25cm²
volume of acid = 7.3g
volume of base = 13.78g
Moltanty of base =
Moltanty of Acid =
solution = 0.5dm³ solution

$$M_{ao} = \frac{M_a V_b}{V_b M_a}$$

$$\frac{7.3g \times 0.05}{1.378g \times 50.24}$$

$$= \frac{7.3g \times 0.5}{1.378g \times 50.24}$$

$$= \frac{3.65}{69.23}$$

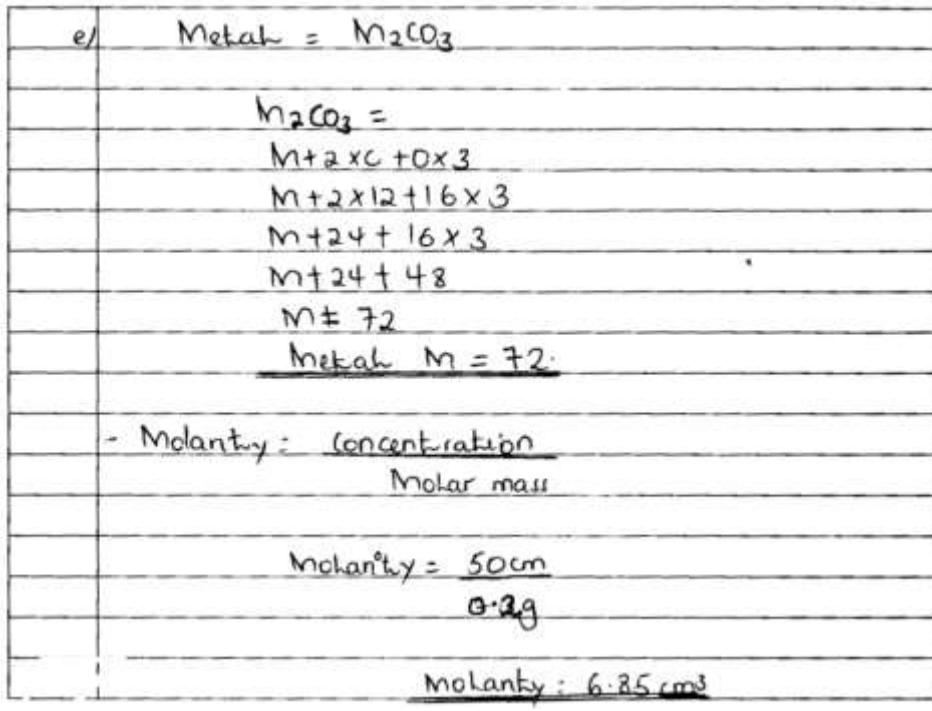
$$= 0.05 g/mol$$

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

$$= \frac{1004.8}{7.3g}$$

$$= 137.7.$$

∴ The concentration of solution is 137.7 g/mol.



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

In Extract 16.2, the candidate included data which cannot be obtained from the burette such as 22.42 and in part (b) he/she indicated incorrect average volume. Also, in (c) he/she wrote incorrect chemical equation resulting to incorrect mole ratio between the acid and base. Moreover, in part (d) the candidate used incorrect formula in calculating dilute molarity of acid. Furthermore, in part (e) he/she used incorrect formula of obtaining molarity of the base and unkwon element **M**.

2.2.1.3 Alternative 2C

The question was as follows: *You are provided with the following chemicals:*

KK: *Solution containing 3.15 g of hydrated oxalic acid* $\left(H_2C_2O_4.nH_2O\right)$ *dissolved in 0.25 dm*^{3}

LL: *Solution containing 1.4 g potassium hydroxide (KOH) dissolved in 0.25dm*^{3}*;*

MO*: Methyl orange indicator;*

POP*: Phenolphthalein indicator.*

Use the information given to determine the number of molecules of water of crystallization in the hydrated oxalic acid.

Procedure

(i) Select one suitable indicator among the two for this experiment.

(ii) Titrate the acid (in a burette) against 20 or 25 cm^3 of the base (in a conical flask) using two drops of the appropriate indicator. Repeat the titration to obtain three more titre values.

Questions

(a) Record the results in a tabular form.

(b) What was the volume of the pipette used?

(c) Calculate the average volume of the acid used.

*(d) Write a balanced chemical equation for the reaction between **KK** and **LL**.*

(e) Which indicator is suitable for this experiment? Give a reason to your response.

(f) Calculate the value of water of crystallization in the hydrated oxalic acid $\left(H_2C_2O_4.nH_2O\right)$.

The candidates who achieved high scores filled the table of results correctly by considering two decimal places and within accuracy of the data as required in part (a). Likewise, in part (b) they managed to read the volume of pipette used and recorded it correctly. In part (c) candidates calculated correctly average volume of acid used. Similarly, in part (d), they wrote correct balanced chemical equation for the reaction between $H_2C_2O_4$ and KOH. Also, in part (e) The candidates used phenolphthalein indicator (POP) as suitable indicator for the titration between strong base, KOH and weak acid, $H_2C_2O_4$. Furthermore, they followed the correct procedures, and used appropriate formulas in calculating the molarity of KOH. Similarly, through stoichiometry the candidates calculated molarity, mass concentration, and molar mass of pure hydrated oxalic acid $\left(H_2C_2O_4.nH_2O\right)$. Finally, they determined the value of n in hydrated oxalic acid $\left(H_2C_2O_4.nH_2O\right)$. 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. a. Table of results

Burette reading cm^3	Pilot	1	2	3
Final reading cm^3	12.50	24.90	12.60	12.50
Initial reading cm^3	0.00	12.50	0.00	0.00
Volume used cm^3	12.50	12.40	12.60	12.50

b. Volume of pipette used was $25\ cm^3$

c. Average volume of acid used.

Average volume used $= \frac{12.40 + 12.60 + 12.50}{3}$

$= 12.50\ cm^3$

Average volume of acid used was $12.50\ cm^3$.

d. Chemical equation

$$H_2C_2O_4(aq) + 2KOH(aq) \longrightarrow K_2C_2O_4(aq) + 2H_2O(l)$$

e. Suitable indicator is phenolphthalein (POP) indicator.

- Because there is weak acid and strong base.

Where: $H_2C_2O_4$ - Weak acid

KOH - Strong base.

1. f. Water of crystallization of $H_2C_2O_4 \cdot nH_2O$

Hydrated conc of $H_2C_2O_4 \cdot nH_2O$

Data.

Mass of $H_2C_2O_4 \cdot nH_2O = 3.15g$

Volume of $H_2C_2O_4 \cdot nH_2O = 0.25 dm^3$

then

Conc = Mass (g) / Volume (dm^3)

$= 3.15 g / 0.25 dm^3$

Conc $= 12.6 g/dm^3$

Anhydrous concentration of $H_2C_2O_4$

From equation.

$$H_2C_2O_4(aq) + 2KOH(aq) \longrightarrow K_2C_2O_4(aq) + 2H_2O(l)$$

Ma = ?

Va = $12.5 cm^3$

Mb = 14g dissolved in $0.25 dm^3$

Vb = $25 cm^3$

na = 1

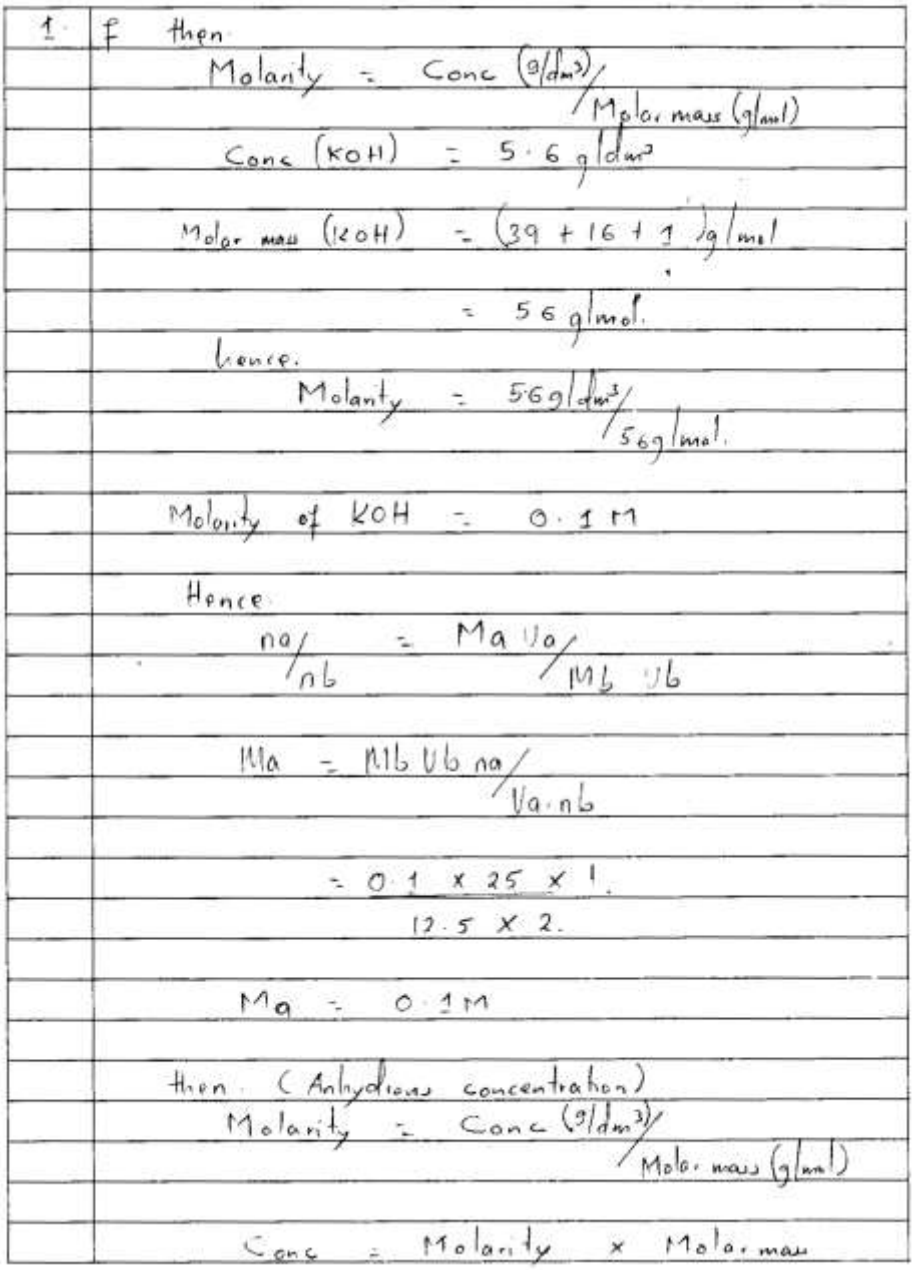
nb = 2

Molarity of base KOH

From Conc = Mass (g) / Volume (dm^3)

$= 14g / 0.25 dm^3$

$= 5.6 g/dm^3$

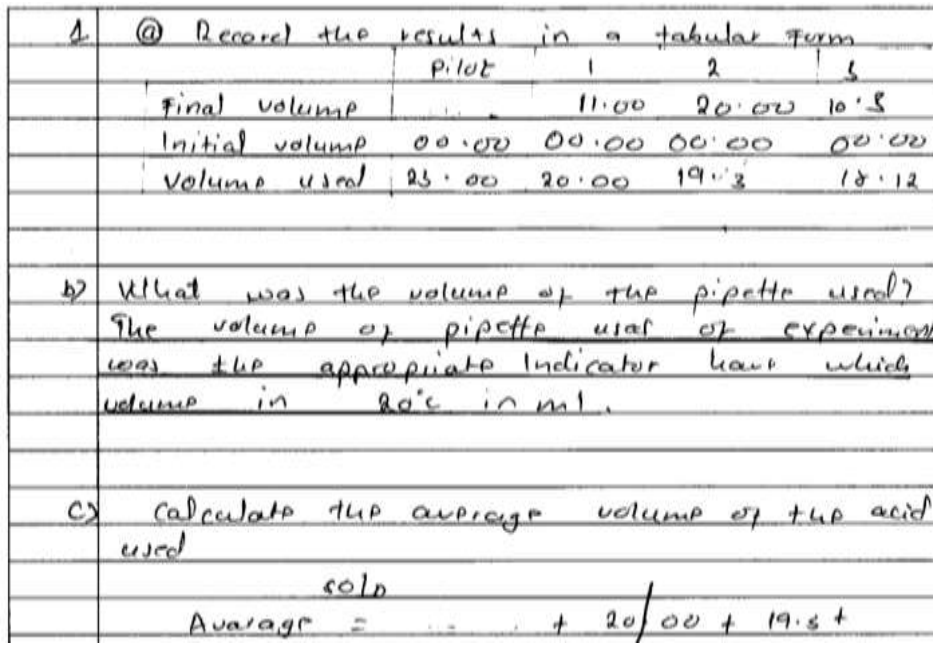


Extract 17.1: A sample of correct responses to question 1, paper 2C

However, the candidates who scored low marks failed to fill the table of results correctly. They did not consider two decimal places, and the volumes were out of range in part (a). For example, one candidate recorded data as follows:

Experiment	***Pilot***	***1***	***2***	***3***
Final burette reading (cm^3)	*16.6*	*15.5*	*18.7*	*17.6*
Initial burette reading (cm^3)	*0.0*	*0.0*	*0.0*	*0.0*
Titre volume (cm^3)	*16.6*	*15.5*	*18.7*	*17.6*

Also, in part (b) some candidates wrote incorrect volumes (capacity) of the pipettes such as 50 cm^3, which do not exist in secondary school laboratories. In part (c), some of the candidates either incorrectly calculated the average volume of the acid used or did not do the calculations. Moreover, in part (d) the candidates wrote incorrect/unbalanced chemical equations between $H_2C_2O_4$ and KOH, which led to wrong mole ratios. Likewise, in part (e) the candidates used incorrect indicator which was methyl orange. In part (f) the candidates failed to calculate the molarity of KOH as well as molarity of $H_2C_2O_4$ hence, failed to determine the value of water of crystallization. Generally, the candidates falling under this category had inadequate knowledge about the chemical equations and mole concept, thus applied inappropriate mathematical steps in determining the value of **n**. Extract 17.2 shows a sample of incorrect responses in this question (Alternative 2C).


1. @ Record the results in a tabular form

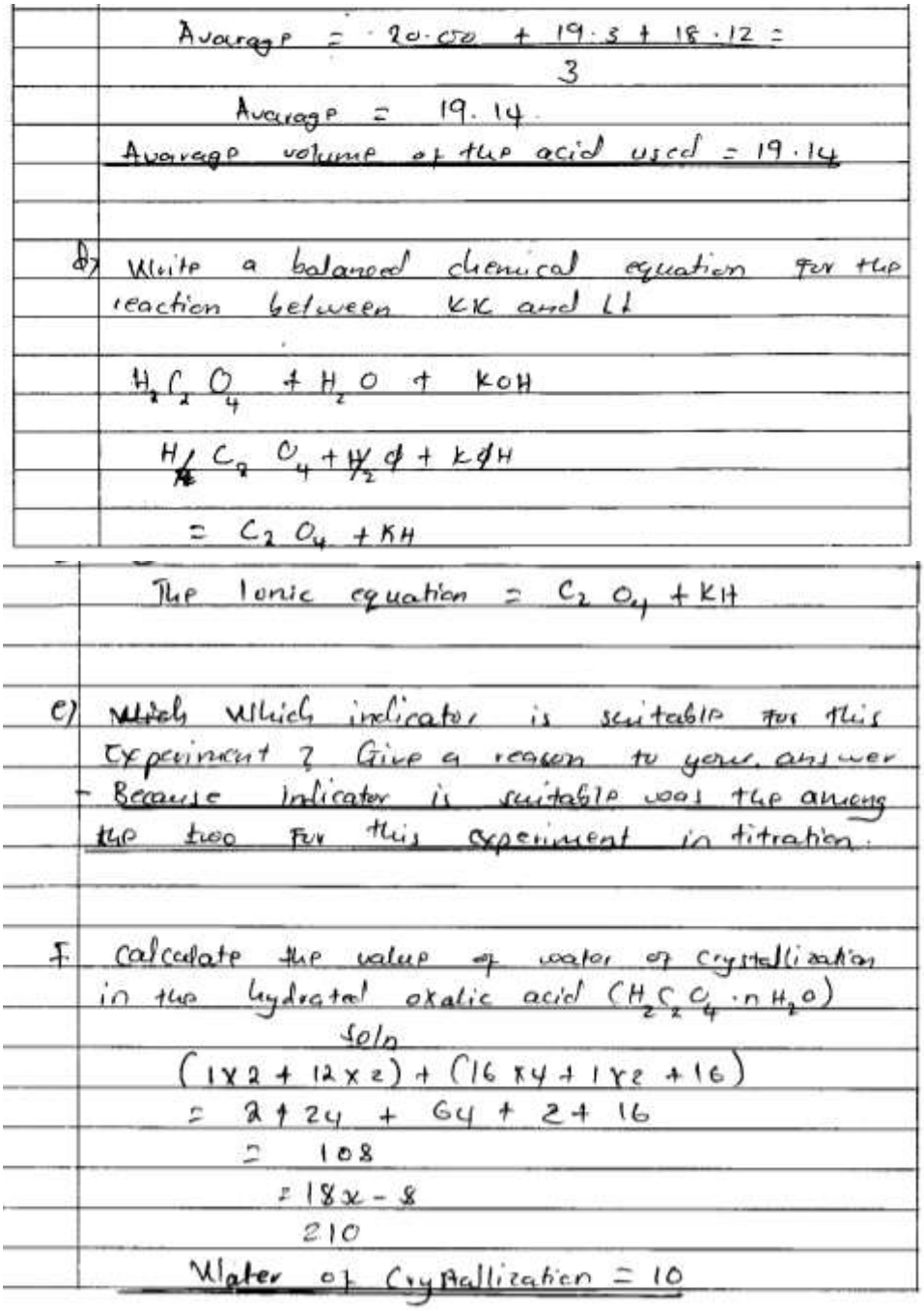
	Pilot	1	2	3
Final volume		11.00	20.00	10.8
Initial volume	00.00	00.00	00.00	00.00
Volume used	23.00	20.00	19.3	18.12

b) What was the volume of the pipette used?
The volume of pipette used of experiment was the appropriate Indicator have which volume in 20°c in ml.

c) Calculate the average volume of the acid used

sola

Average = + 20/00 + 19.8 +



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

In Extract 17.2, the candidate recorded the experimental results with one decimal place in second and third experiment in part (a). Similarly, in part (b) he/she recorded the temperature instead of the volume of the pipette used. Furthermore, in part (d) he/she wrote incorrect chemical equation between acid and base. Additionally, in part (e) the candidate

copied statement of the question instead of writing POP as suitable indicator. Finally, in part (f) the candidate used incorrect formula to calculate the water of crystallization.

2.2.2 Question 2: Chemical Kinetics, Equilibrium and Energetics

The question was attempted by 162,557 candidates (100%). The analysis shows that 8.87 per cent of the candidates scored from 0 to 7 marks, 37.61 per cent scored from 8 to 16 marks and 53.52 per cent scored from 17 to 25 marks. Generally, the performance of the candidates in this question was good because 91.13 per cent scored 8 marks or above. The summary of the candidates' performance is shown in Figure 12.

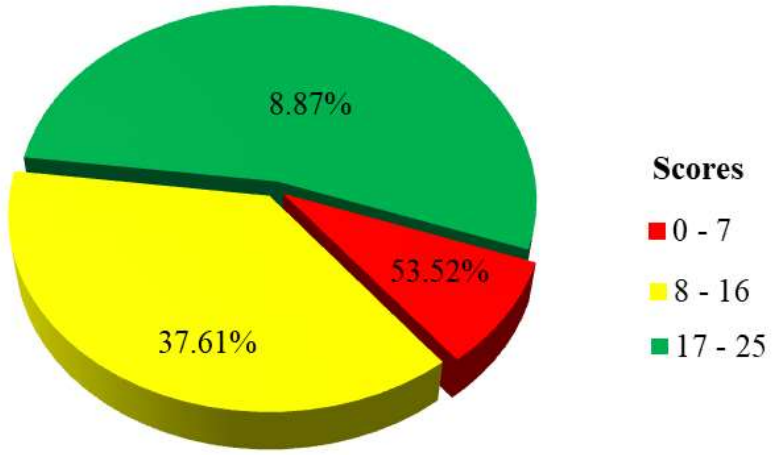


Figure 12: *Candidates' Performance in Question 2, Practical*

2.2.2.1 Alternative 2A

The candidates were required to study the reaction between sodium thiosulphate and hydrochloric acid. The chemicals provided were labeled as **RR** and **SS**, containing 0.2 M sodium thiosulphate and 1.0 M hydrochloric acid, respectively. Also, each candidate was given distilled water, a stopwatchwatch / a clock, and a sheet of white paper marked **M**. Candidates were required to proceed as follows:

*(i) Measure 4 cm^3 of **RR** and put it into the 50 cm^3 beaker. Add 6 cm^3 of distilled water.*

*(ii) Measure 10 cm^3 of **SS** and put it into the 50 cm^3 beaker containing **RR** and distilled water, and immediately start the stopwatch.*

*(iii) Swirl the contents and place the beaker on top of the letter **M** marked on the plain paper provided. Watch from above and observe the changes.*

*(iv) Switch off the stop watch when the mark **M** disappears.*

*(v) Record the time taken for the letter **M** to disappear.*

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

Table: Experimental Data

Experiment	***1***	***2***	***3***	***4***
Volume of RR (cm^3)	***10***	***8***	***6***	***4***
Volume of Distilled Water (cm^3)	*0*	*2*	*4*	*6*
Volume of SS (cm^3)	*10*	*10*	*10*	*10*
Time (s)				

Questions

(a) What is the aim of this experiment?

(b) Complete filling the table.

(c) Giving reason(s), identify the experiment in which the reaction was:

(i) slow

(ii) fast.

*(d) (i) Indicating the state symbols of the reactants and products, write a balanced chemical equation for the reaction between **RR** and **SS**.*

(ii) Write the ionic equation for the reaction.

*(e) How does the concentration of **RR** affect the time for the mark **M** to disappear?*

*(f) (i) Plot a graph of volume of **RR** against time.*

(ii) What can you conclude from the graph?

The candidates who scored high marks wrote in part (a) that the aim of the experiment was to investigate the effect of concentration on the rate of chemical reaction. Likewise, in part (b) they filled the table of results correctly. In part (c), the candidates identified that experiment number 4 was a slowest reaction. The candidates recognized that, the long time taken for the mark **M** to disappear implied low concentration of the reactant **RR** which causes decreasing of collision of molecules. Also, they observed that experiment number 1 had the fastest reaction, indicated by its short time duration. Moreover, in part (d) they wrote the correct chemical equation for the reaction between **RR** and **SS**.

Furthermore, in part (e) candidates correctly explained the effect of concentration relative to the time taken for mark **M** to disappear. Those candidates appreciably recognized that, the increase in concentration of **RR** increases number of colliding particles. This increases the chance of effective collision between **RR** and **SS** hence, high rate of chemical reaction. Also, In part (f), they correctly plotted the nature of the graph. Furthermore, they gave appropriate interpretation of the nature of the graph. This indicates that they had sufficient knowledge on the effect of concentration on the rate of chemical reaction. Extract 18.1 shows one of the correct responses in question 2 (Alternative 2A).

02.

(b) TABLE

Experimont	1	2	3	4
Volume of RR (cm^3)	10	8	6	4
Volume of Distilled water (cm^3)	0	2	4	6
Volume of SS (cm^3)	10	10	10	10
Time (s)	24	33	49	78

(a) The aim is to determine the effect of concentration on the rate of chemical reaction.

(c) (i) The reaction was slow in experiment 4 because the concentration of the reactants was lowered by diluting it with distilled water.

(ii) The reaction was fast in experiment 1 because the reactant's concentration was high since there was no lowering of the concentration as water was not used.

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

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

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

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

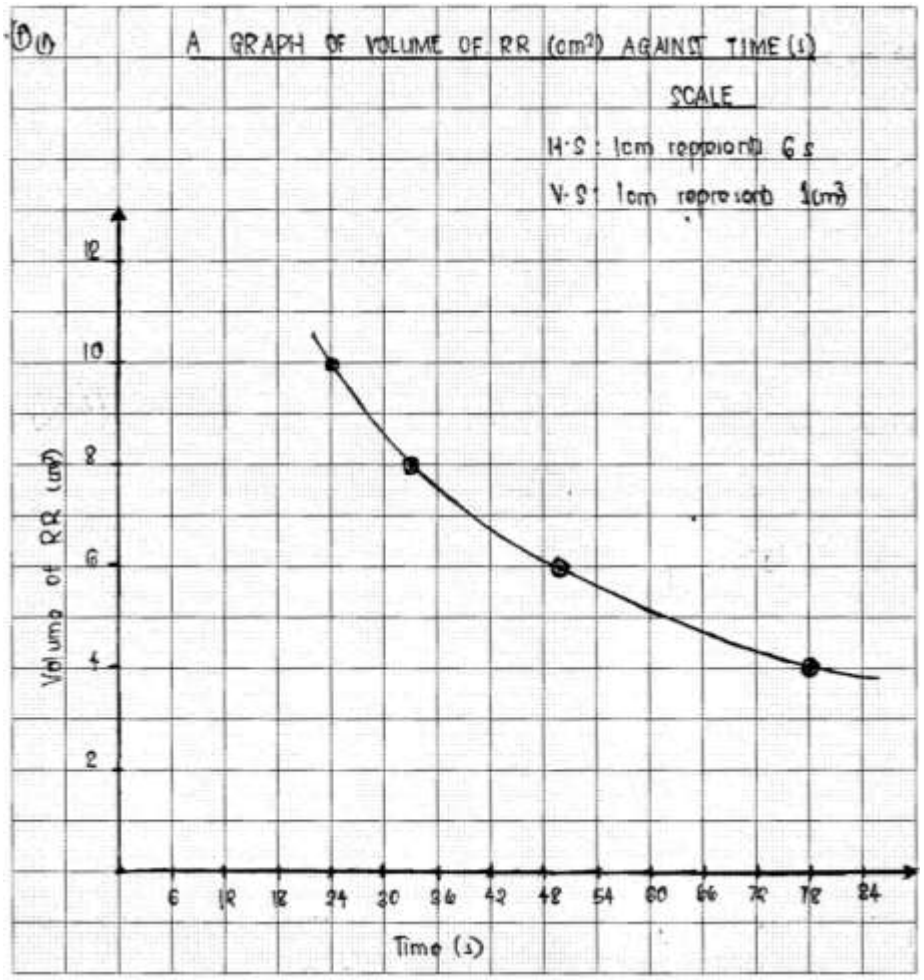
$2H^+_{(aq)} + S_2O_3^{2-}{}_{(aq)} \rightarrow S_{(s)} + SO_{2(g)} + H_2O_{(l)}$

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

02. (e) When the concentration of RR is increased it results to the speeding up of the rate of chemical reaction hence the time for letter / mark M to disappear decreases but if concentration of RR is lowered the time for mark M to disappear increases. Thus concentration of RR is inversely proportional to time.

(f)

(ii) The graph of volume of RR against time is a downward curve line. This means that as the concentration of RR is increased the time for the reaction decreases. Thus to conclude: the concentration of RR is inversely proportional to time but directly proportional to rate of chemical reaction.



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

On the other hand, the candidates who scored low failed to identify the aim of the experiment in part (a). For instance, some of the candidates identified the aim of the experiment as investigation of the effect of volume on the rate of chemical reaction instead of the effect of concentration on the rate of chemical reaction. Other candidates wrote that the aim of the experiment was to investigate the effect of surface area on the rate of chemical reaction. Likewise, in part (b), candidates filled the table of results incorrectly by writing time in minutes instead of seconds while some others left spaces unfilled. These candidates failed to follow the demand of the questions as they were required to record time in seconds. In part (c), other candidates interchangeably wrote that the slowest chemical reaction was ‘’Experiment 1’’ and the fastest reaction was ‘’Experiment 4’’. These candidates failed to realize that, long time taken for the chemical reaction to complete is due to the

presence of few reacting particles, causing the slowest chemical reaction. Likewise, they failed to notice that, short time taken for the chemical reaction indicates the fastest chemical reaction. In part (d), some candidates wrote the formula equation incorrectly thus, they failed to give correct ionic equation. For instance , one candidate wrote the formula equation as;

$Na_2S_2O_3(s) + 2HCl\,(l) \rightarrow NaCl\,(aq) + H_2O(l) + SO_2(s)$ while another wrote as $Na_2S_2O_3 + HCl \longrightarrow NaCl + HSO_4 + H_2O$. Such responses show that the candidates had inadequate knowledge about the concept of chemical equation and appropriate state symbol in each species. Moreover, in part (e) candidates gave incorrect relationship between concentration of **RR** and time taken for mark **M** to disappear. For example, one candidate wrote that concentration is directly proportion to time taken for letter **M** to disappear**.** Furthermore, in part (f), some candidates were unsuccessful in both plotting and drawing accurate conclusions from the graph.. For instance, they failed to label the axes of the graph. Others did not indicate the title of the graph. Similarly, they wrote vertical and horizontal scales without units. Likewise, they failed to draw the best line appropriately which led to the incorrect conclusion. This shows that, they had insufficient knowledge about the factors affecting the rate of chemical reactions. Extract 18.2 shows a sample of incorrect responses in this question (Alternative 2A).

Q (a). The aim of these experment it was to determi
ne concentration of affect the solutions.

(b) Consider table below.

Experiment	1	2	3	4
Volume of RR (cm^3)	10	8	6	4
Volume of Distalated water	0	2	4	6
Volume of SS (cm^3)	10	10	10	10.
Time (s)	4.67	0.05.	0.05	0.05.

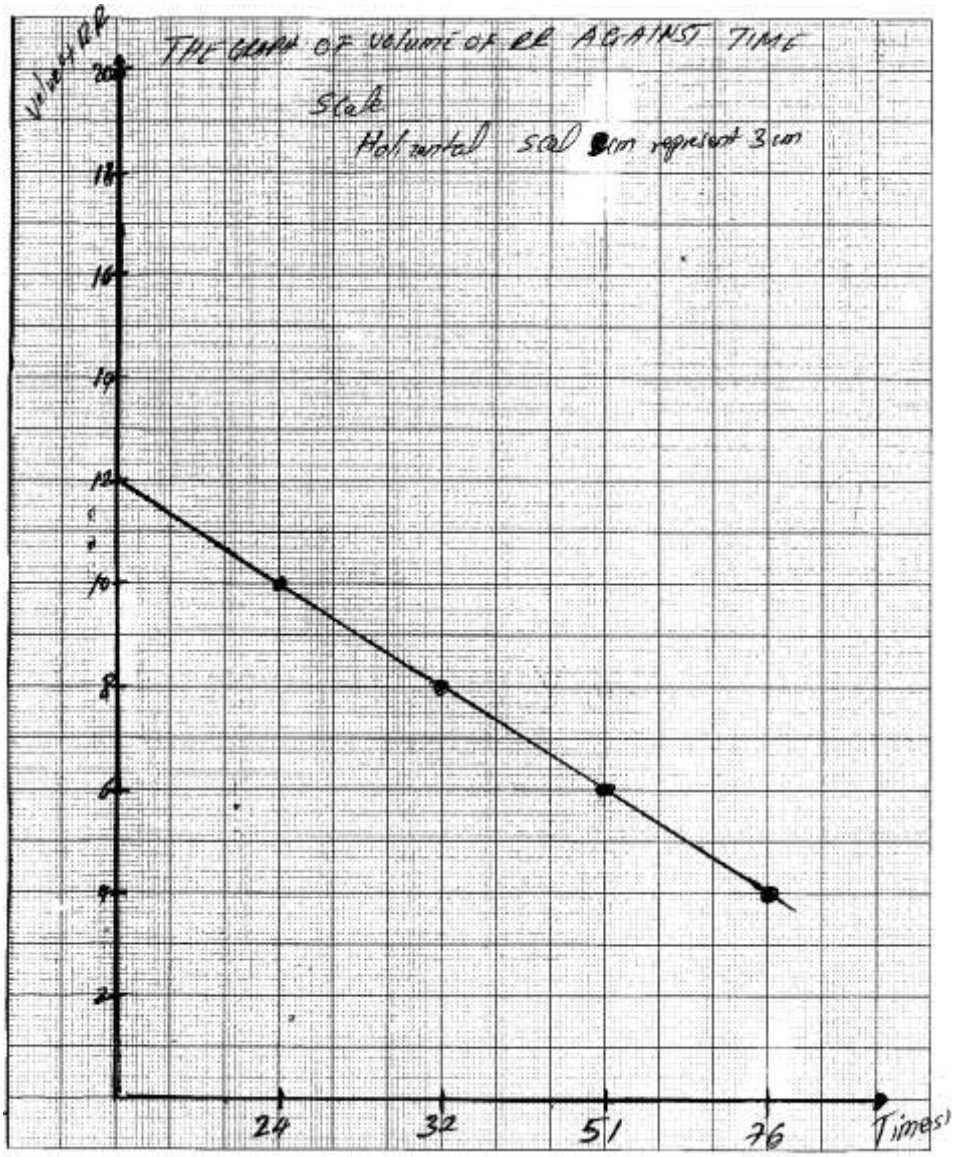
e) i) By giving reason (s) the reaction which was slow is experiment 1 because there was no plesence of distilled water hence the experiment was slow.

ii) The experiment which was fast was experiment 4 because the volume RR was few and not many hence the experiment was fast.

(d) i. from the equation.
RR is $Na_2S_2O_3$.
SS is HCl.
the reaction.
$Na_2S_2O_3 + HCl \longrightarrow NaCl_2 + H_2S_2O_3$.
$Na_2S_2O_3 + HCl \longrightarrow NaCl_2 + H_2OS_2$.
$2NaCL_2 + 2H_2O_3 + S_2$
Balance.

e) The concentration RR affect the time for mark m to disappear because the higher the concentration the more time will the mark m disappear.

f) ii) The conclution of the graph is that the time taken per each of the experiment is that the time is decreasing in each of the experiment



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

In Extract 18.2, the candidate wrote correct aim of experiment in part (a). Similarly, in part (b) he/she filled the table of results incorrectly. Likewise, in part (c) the candidate wrote incorrect molecular equation and its state symbols resulting to the incorrect ionic equation. Also, he/she interchangeably wrote slowest reaction and fastest reaction as experiment 1 and 4 respectively instead of experiment 4 and 1. Moreover, in part (e) and (f) the candidate plotted a straight line graph instead of a curved graph, and gave incorrect conclusion.

2.2.2.2 Alternative 2B

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 nitric acid. The chemicals provided were labeled as **AA**, containing 0.15 M sodium thiosulphate solution and **BB**, containing 1 M nitric acid solution. Also, they were provided with distilled water, stopwatch and a sheet of white paper marked **X**.

Candidates were required to proceed as follows:

*(i) Measure 5 cm^3 of solution **AA** and place it into the 100 cm^3 beaker. Add 15 cm^3 of distilled water.*

*(ii) Measure 5 cm^3 of **BB** and place it into the 100 cm^3 beaker containing **AA** and distilled water, immediately start the stopwatch.*

*(iii) Swirl the contents and place the beaker on top of the letter **X** marked on the paper provided. Watch from above and observe the changes.*

*(iv) Switch off the stop watch when the mark **X** disappears.*

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

(vi) Repeat the experiment using different data as shown in the following table:

Table: Experimental Data

Experiment Number	***1***	***2***	***3***	***4***
Volume of AA (cm^3)	*20*	*15*	*10*	*5*
Volume of Distilled water (cm^3)	*0*	*5*	*10*	*15*
Volume of BB (cm^3)	*5*	*5*	*5*	*5*
Time (s)				
1/Time (s^{-1})				

Questions

*(a) Why mark **X** disappeared in this experiment?*

*(b) (i) Indicating the states of the reactants and the products, write a balanced chemical equation for the reaction between **AA** and **BB**.*

*(ii) Write the corresponding ionic equation for the reaction between **AA** and **BB**.*

(c) Complete filling the experimental table.

*(d) Plot a graph of volume of **AA** (cm^3) against* $\frac{1}{\text{time}}$ (s^{-1}). *Briefly explain the shape of your graph.*

(e) How would the rate of reaction vary if the concentration of nitric acid is increased while the concentration of sodium thiosulphate is kept constant?

(f) What does the value $\frac{1}{\text{time}}$ *mean?*

The candidates who achieved high scores in this question wrote the correct reason for disappearance of **X** during the experiment in part (a). These candidates observed that the disappearance of the letter **X** was due to the formation of Sulphur precipitates, hence wrote the correct chemical equation for the reaction between sodium thiosulphate and nitric acid as well as its ionic equation in part (b). In part (c), they filled correctly the table of results and accurately plotted the graph in part (d), indicating all principle features. Likewise, in part (e) the candidates explained correctly the effect of the rate of reaction due to the increase in concentration of nitric acid. Moreover, they gave correct meaning of $\frac{1}{time}$. Extract 19.1 shows a sample of correct responses in question 2 (Alternative 2B).

	Experimental Number	1.	2.	3.	4.
02.	Volume of AA (cm^3)	20	15	10	5
Q	Volume of distilled water (cm^3)	0	5	10	15
	Volume of BB (cm^3)	5	5	5	5
	Time (s)	39	58	98	190
	1/time (s^{-1})	0.0255	0.0172	0.0102	0.0034

a) Due to the production of Sulphur which causes a milky colour that obscures letter X and makes it disappear.

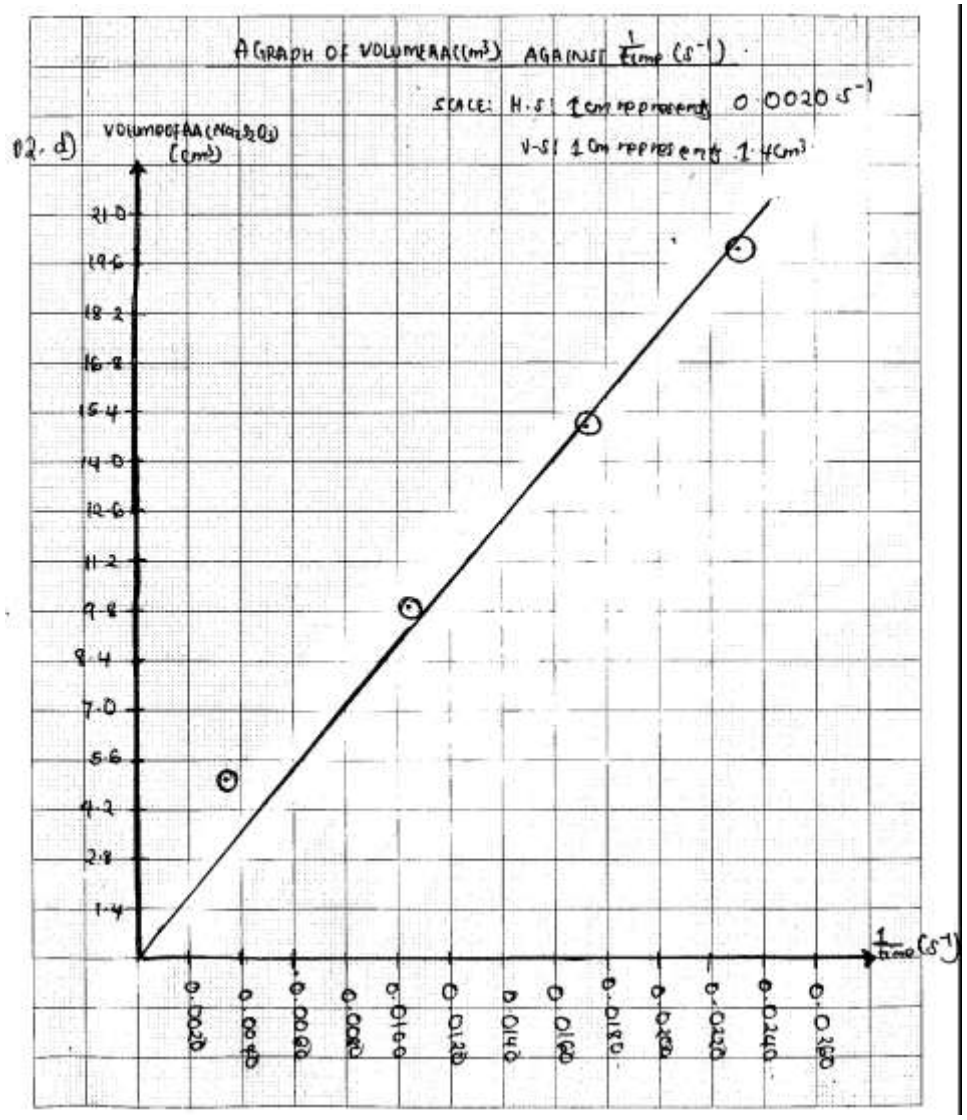
b) i) $Na_2S_2O_{3(aq)} + 2HNO_{3(aq)} \rightarrow 2NaNO_{3(aq)} + SO_{2(g)} + S_{(s)} + H_2O_{(l)}$

ii) $2Na^+_{(aq)} + S_2O_3^{2-}{}_{(aq)} + 2H^+_{(aq)} + 2NO_3^-{}_{(aq)} \rightarrow 2Na^+_{(aq)} + 2NO_3^-{}_{(aq)} + SO_{2(g)} + S_{(s)} + H_2O_{(l)}$

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

d) Refer to the graph

Q2.	d) The shape of the graph is a straight line passing through the Origin and this explains that the change in volume is directly proportional to the rate of reaction as the volume of AA reduces the rate of reaction also reduces and as the volume of AA (cm^3) increases the rate of reaction increases.
e)	The rate of reaction would ~~reduce~~ increase due to the concentration of nitric acid which is one of the reactants is increased and hence the rate of reaction will increase.
f)	$\frac{1}{time}$ means rate. which means the time at which the reaction is proceeding. The value at which the reaction is taking place.

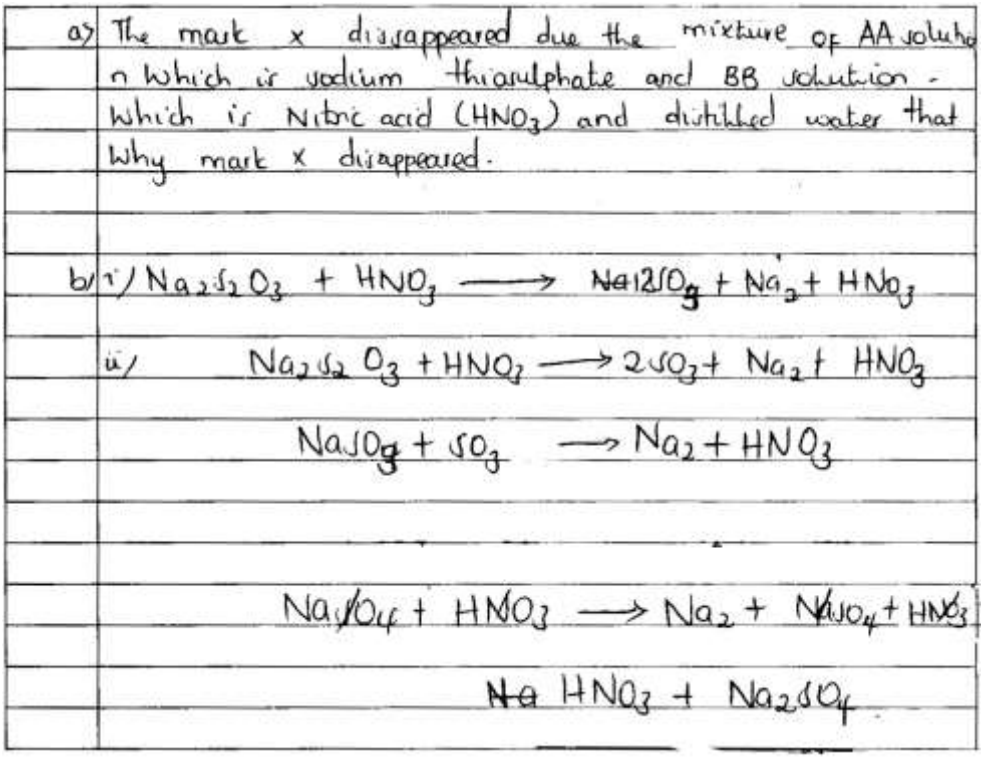


Extract 19.1: A sample of correct responses to question 2, paper 2B

On the cotrary, the candidates who achieved low scores gave incorrect reasons for the disappearance of mark **X** in part (a). For example, some candidates incorrectly associated formation of substances such as sulphur dioxide, $NaNO_3$ to the disappearance of X. These candidates had insufficient knowledge about precipitation reactions. Also, in part (b) the candidates wrote incorrect formula and ionic equations. For example, one candidate wrote the formula and ionic equations as;

$Na_2S_2O_3 + HCl \longrightarrow NaCl + SO_2 + H_2O$ and $2Na^+ + S^{2-} + O_3 \longrightarrow Na^+ + H^+ + O^{2-} + SO$ respectively. Moreover, in part (c), the candidates filled the table

incorrectly in all columns hence plotted the graph and its features incorrectly. For example, one candidate interchangeably labeled $\frac{1}{\text{time}}$ as Y-axis and volume as X-axis. In part (e) the candidates gave incorrect explanation about the rate of reaction based on changes in concentration of nitric acid, such as rate of chemical reaction will decrease, no changes in rate of chemical reaction while others did not respond to this part. These candidates had insufficient knowledge about the effect of concentration on the rate of chemical reaction. Likewise, in part (f), they gave correct meaning of $\frac{1}{time}$. For instance, one candidate wrote that $\frac{1}{time}$ represent rate of the reaction. Another candidate wrote reciprocal of time. This indicates that, the candidates had inadequate knowledge about change in quantity per unit time which represents rate of chemical reaction. Extract 19.2 shows a sample of incorrect responses in this question (Alternative 2B).


a) The mark x disappeared due the mixture of AA solution which is sodium thiosulphate and BB solution - which is Nitric acid (HNO_3) and distilled water that why mark x disappeared.

b) i) $Na_2S_2O_3 + HNO_3 \longrightarrow NaHSO_3 + Na_2 + HNO_3$

ii) $Na_2S_2O_3 + HNO_3 \longrightarrow 2SO_3 + Na_2 + HNO_3$

$NaSO_3 + SO_3 \longrightarrow Na_2 + HNO_3$

$NaSO_4 + HNO_3 \longrightarrow Na_2 + NaSO_4 + HNO_3$

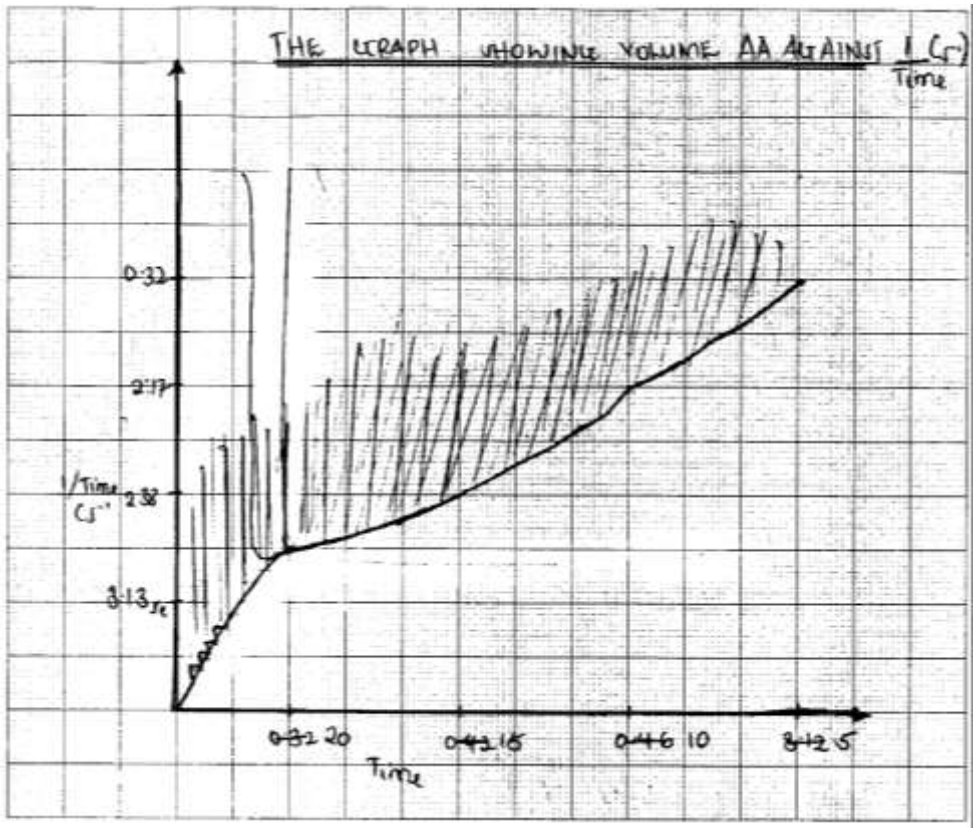
$NaHNO_3 + Na_2SO_4$

02 Table: Experimental Data

Experiment Number	1	2	3	4
volume of AA	20	15	10	5
volume of distilled water	0	5	10	15
volume of BB (cm^3)	5	5	5	5
Time (s)	00:32	00:42	00:46	03:12
1/Time (s^{-1})	3/13	2/38	2/174	0/321

e/ The rate of reaction of concentration of nitric acid is increased due to increasing and decreasing of temperature. While concentration of sodium thiosulphate is kept constant because of Minimum-Temperature of the solution during experimental.

F/ The value $\frac{1}{Time}$ mean that Time per second



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

In Extract 19.2, the candidate wrote incorrect reason for disappearance of cross **X** as the formation of nitric acid instead of the formation of sulphur. In part (b), the candidate wrote incorrect chemical equation for the reaction between HCl (acid) and $Na_2S_2O_3$ hence, led to wrong ionic equation. Also, in part (c) he/she recorded time in form of minute and seconds instead of seconds. In part (d) the candidate wrote Y-axis as $\frac{1}{time}$ instead of volume. Similarly, for the X-axis wrote time instead of $\frac{1}{time}$. Furthermore, in part (e) he/she realized that rate of reaction will increase if nitric acid is increased however, wrote incorrect reason for such changes. Moreover, in part (f) the candidate wrote $\frac{1}{time}$ represent time per second instead of rate.

2.2.2.3 Alternative 2C

The aim of the experiment was to determine the effect of temperature on the rate of chemical reaction. The chemicals provided were **EE** which contained 0.1 M of sodium thiosulphate solution and **FF** which contained 0.1 M hydrochloric acid solution. The candidates were also provided with a stopwatch and a piece of white paper marked **M** and thermometer.

The candidates were provided with the following procedures:

*(i) Place a 50 cm^3 beaker on top of a letter **M** marked on the paper provided.*

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

*(iii) Measure 10 cm^3 of **EE** and 10 cm^3 of **FF**, and then put them into two different test tubes.*

(iv) Place a thermometer in one of the test tubes, then place both test tubes into the water bath in step (ii) and warm the test tube contents to 40 ^oC.

*(v) Immediately pour the hot solutions **EE** and **FF** into the 100 cm^3 beaker in step (i) and simultaneously start the stop watch/clock. Record the time taken in seconds, for the mark to disappear completely.*

(vi) Repeat procedure (i) to (v) as indicated in the following table:

Table: Experimental Data

Temperature ($^{\circ}C$)	***Time (s)***	***Temperature (K)***
40		
50		
60		
70		
80		

Questions

(a) Record the room temperature in Kelvin (K).

(b) Complete the table by filling the blank columns.

*(c) Why does the mark **M** disappear?*

*(d) (i) Write a balanced chemical equation for the reaction taking place between **EE** and **FF**. Show all the state symbols.*

*(ii) Write the ionic equation for the reaction between **EE** and **FF**.*

(e) Plot a graph of time (s) against temperature (K).

(f) What conclusion can be drawn from the graph you plotted in (e)?

The candidates who scored high marks recorded the room temperature correctly in part (a). Likewise, in part (b) they filled the table correctly. This shows that those candidates had good understanding in recording time in seconds and converting temperature from degree Celsius into Kelvin. Similarly, in parts (c) and (d), the candidates wrote correctly the balanced chemical equation between **EE** and **FF**, and identified substances which caused letter **M** to disappear. Those candidates realized that, chemical reaction between **EE** and **FF** produces sulphur which obscured the mark **M**. In part (e), the candidates accurately plotted the graph (to obtain a curved line) and in part (f) they drew correct conclusion from the graph. Extract 20.1 shows a sample of the correct responses in question 2 (Alternative 2C).

2a) Room temperature = 37°C + 273

= 310K

Room temperature = 310 K

2b) Table : Experimental Data

Temperature (°C)	Time (s)	Temperature (K)
40	37	313
50	25	323
60	16	333
70	11	343
80	9	353

2c Mark M disappear due to the formation of yellow precipitate of sulphur

d. i. Equation

$Na_2S_2O_3(aq) + 2HCl(aq) \longrightarrow 2NaCl(aq) + H_2O(l) + SO_2(g) + S(s)$

ii. Ionic equation.

$Na_2S_2O_3(aq) + 2HCl(aq) \longrightarrow 2NaCl(aq) + H_2O(l) + SO_2(g) + S(s)$

2. d ii $2Na^+_{(aq)} + S_2O_3^{2-}{}_{(aq)} + 2H^+_{(aq)} + 2Cl^-_{(aq)} \longrightarrow 2Na^+_{(aq)} + 2Cl^-_{(aq)} + H_2O_{(l)} + SO_{2(g)} + S_{(s)}$

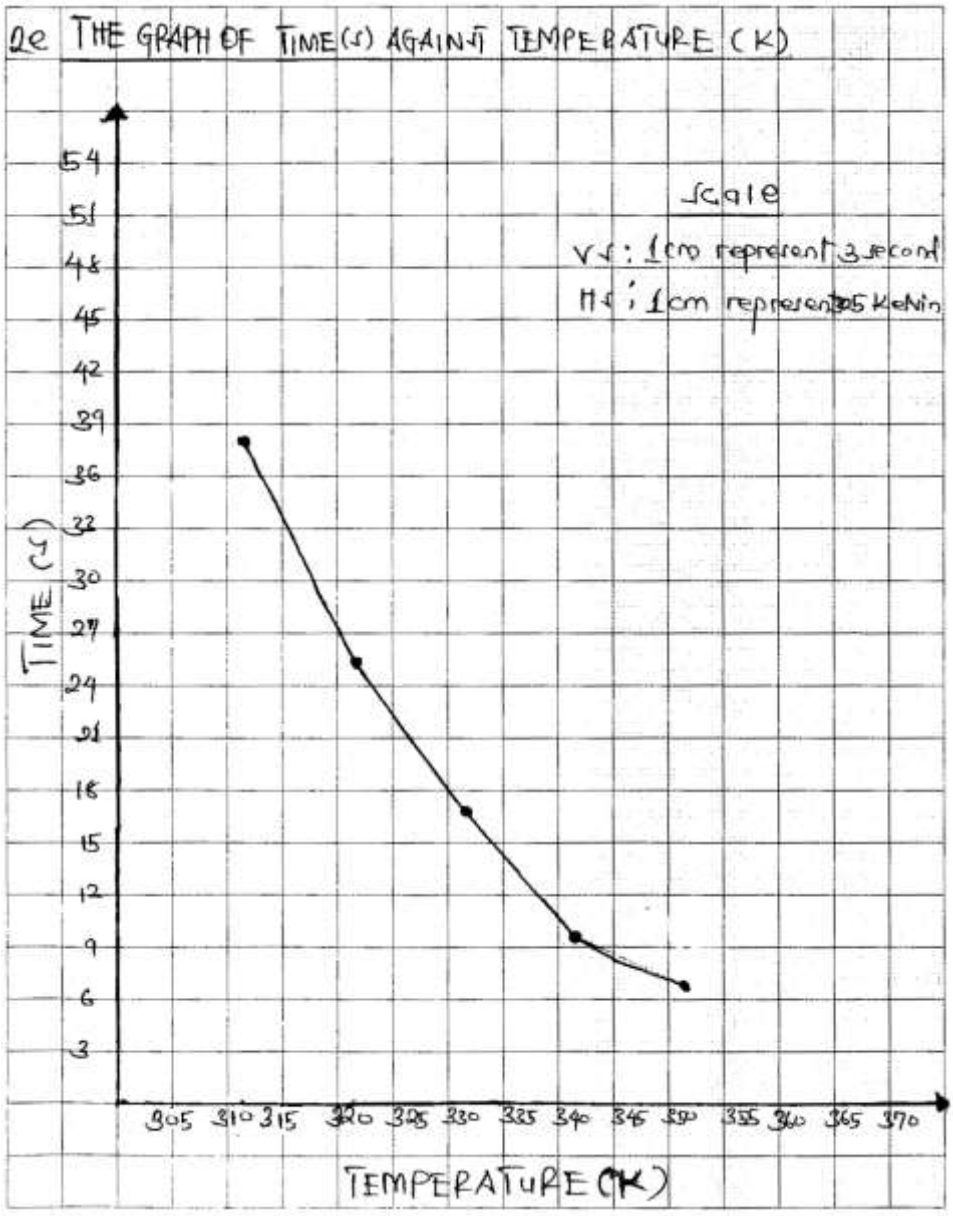
$S_2O_3^{2-}{}_{(aq)} + 2H^+_{(aq)} \longrightarrow H_2O_{(l)} + SO_{2(g)} + S_{(s)}$

Hence the ionic equation is:

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

e. A graph of time (s) against temperature (k)

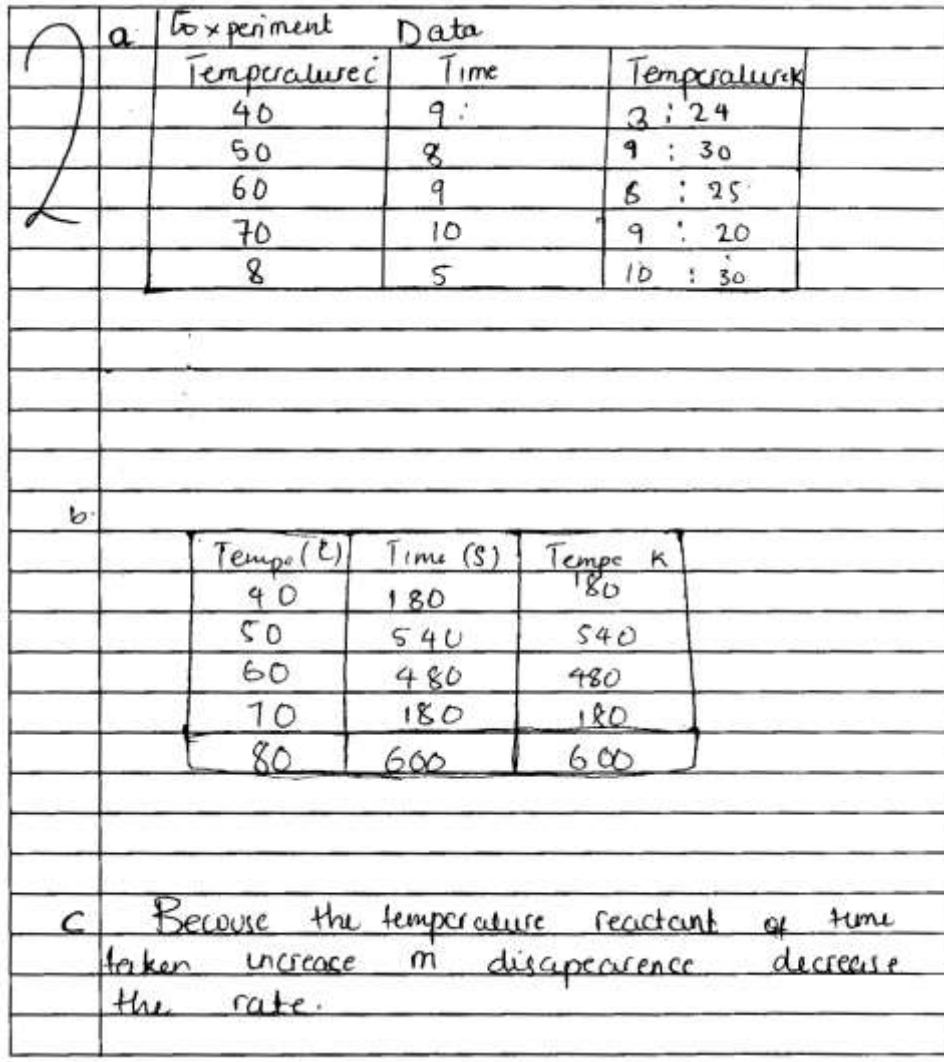
f. From the graph the increase in temperature (K) lead to the decrease in time taken for the reaction between reactant to take place.



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

On the other hand, the candidates who scored low marks failed to record the room temperature in Kelvin correctly in part (a). For instance, one candidate wrote the room temperature in kelvin as 25 K and another wrote 25˚C. There were candidates who gave values of the temperature which were very large or small compared to actual situation. The candidates had inadequate knowledge about thermometer reading as well as the conversion of temperature in degree celcius to Kelvin. In part (b), some candidates filled the table with incorrect data. For example one candidate

recorded temperature in degree Celsius instead of Kelvin. In part (c) and (d), candidates wrote incorrect chemical equation for the reaction between sodium thiosulphate and hydrochloric acid. Hence, they failed to identify the substance that caused the disappearance of mark **M.** Those candidates had inadequate knowledge about chemical reaction between **EE** and **FF** to produce sulphur, which obscured the mark **M**. Furthermore, in part (e) they incorrectly plotted the graph and its features, thus giving the incorrect conclusion in part (f). Generally, those candidates had insufficient knowledge about the effect of temperature on the rate of chemical reaction. Extract 20.2 shows a sample of incorrect responses in this question (Alternative 2C).



2

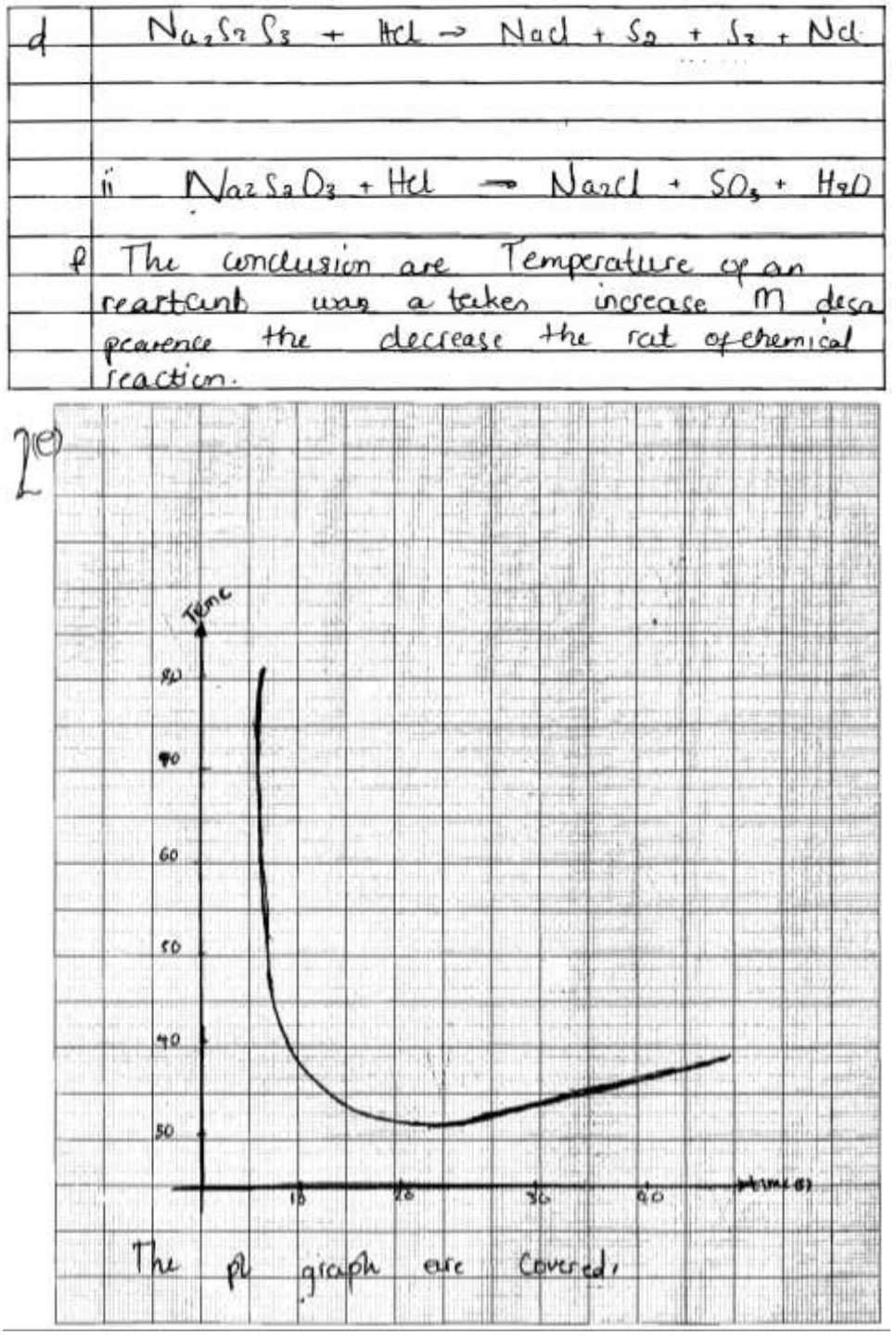
a. Experiment Data

Temperature(C)	Time	Temperature(K)
40	9:	3 : 24
50	8	9 : 30
60	9	8 : 25
70	10	9 : 20
8	5	10 : 30

b.

Tempe (C)	Time (S)	Tempe K
40	180	180
50	540	540
60	480	480
70	180	180
80	600	600

c Because the temperature reactant of time taken increase in disapearence decrease the rate.



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

In Extract 20.2, the candidate recorded the room temperature in the form of minutes and seconds instead of temperature in Kelvin in part (a). Likewise, in part (b) he/she recorded data of the temperature similarly to

those in column of time. Moreover, in part (c) the candidate wrote the reason for disappearance of mark **M** as temperature instead of production of sulphur. Furthermore, in part (d) wrote incorrect molecular and ionic equation for the reaction between sodium thiosulphate and hydrochloric acid. Likewise, in the part (e) the candidate did not write the title, vertical and horizontal scales. Similarly, in part (f) the candidate wrote increase in temperature increases the time for disappearance of mark **M** instead of the increase in temperature decrease the time for mark **M** to disappear.

3.0 ANALYSIS OF THE CANDIDATES' PERFORMANCE IN EACH TOPIC

Chemistry papers 1 and 2 had a total of 13 questions, covering 20 out of 26 topics. The analysis shows that 08 topics had good performance. Those topics were Volumetric Analysis (94.60%), Chemical Kinetics, Equilibrium and Energetics (91.13%), Air, Combustion, Rusting and Fire Fighting (89.66%), Laboratory Techniques and Safety (88.72%), Pollution (87.99%), Scientific Procedures (86.23%); Extraction of Metals (85.66%) and Chemical Equations (83.72%). Question 1 covered 10 topics which collectively had a good performance of 94.60 per cent. The question comprised the following topics: Atomic Structure; Formula, Bonding and Nomenclature; Chemical Equations; Oxygen; Periodic Classification; Organic Chemistry; Mole Concept and Related Calculations; Compounds of Metals; Hardness of Water and Acids, Bases and Salts.

Furthermore, the analysis reveals that 02 topics had average performance. Those topics were Matter (64.36%), and Energy and Fuels (57.63%).

However, the analysis indicates that the candidates performed weakly in two topics namely, Water (20.41%), and Ionic Theory and Electrolysis (13.62%). The weak performance in these topics was caused by lack of adequate knowledge and skills. The performance of the candidates in different topics is summarized in the Appendix.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

Generally, the performance in Chemistry CSEE 2023 was good as 96.14 per cent of the candidates passed the examination. The candidates performed well in eight topics, which were Volumetric Analysis (94.60%), Chemical Kinetics, Equilibrium and Energetics (91.13%), Air, Combustion, Rusting and Fire Fighting (89.66), Laboratory Techniques and Safety (88.72%), Pollution (87.99%) Scientific Procedures (86.23%) Extraction of Metals (85.66%), Chemical Equations (83.72%). The performance of the candidates was weak in the topics of Water (20.41%) and Ionic Theory and Electrolysis (13.62%).

The good performance of the candidates in Chemistry subject was contributed by adequate knowledge of subject matter and skills to carry on experiments. On the other hand, some candidates had weak performance due to the following reasons:

(a) Inadequate skills to organize scientific information. For example, in question 3, some candidates gave random steps of urban water treatment instead of sequential arrangement.

(b) Inadequate knowledge on various concepts. For example, in question 7, some candidates gave incorrect explanation regarding Ionic Theory and Electrolysis.

4.2 Recommendations

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

(a) In the topic of Ionic Theory and Electrolysis, teachers are advised to lead students perform experiments regarding Faraday's laws of Electrolysis so as to be in a position to identify products formed at electrodes.

(b) In the topic of Water, teachers are advised to organize a study tour to a nearby water purifying plant in order to learn about water treatment. Alternatively, the teacher may consider inviting an expert from a local water related authority body for a class session. This will strengthen the students' understanding on water treatment.

Appendix: Summary of Candidates' Performance in Different Topics, 2023

S/N	Topic	Question Number	Paper	% of Candidates who Scored 30% or Above	Remarks
1	Volumetric Analysis	1	Paper 2	94.60	Good
2	Chemical Kinetics, Equilibrium and Energetics	2	Paper 2	91.13	Good
3	Air, Combustion, Rusting and Fire Fighting.	8	Paper 1	89.66	Good
4	Laboratory Techniques and Safety.	4	Paper 1	88.72	Good
5	Pollution	11	Paper 1	87.99	Good
6	Scientific Procedures	5	Paper 1	86.23	Good
7	Extraction of Metals	10	Paper 1	85.66	Good
8	Chemical Equations	2	Paper 1	83.72	Good
9	Atomic Structure; Formula, Bonding and Nomenclature; Chemical Equations; Oxygen; Periodic Classification; Organic Chemistry; Mole Concept and Related Calculations; Compounds of Metals; Hardness of Water and Acids, Bases and Salts	1	Paper 1	64.60	Good
10	Matter	6	Paper 1	64.36	Average
11	Fuels and Energy	9	Paper 1	57.63	Average
12	Water	3	Paper 1	20.41	Weak
13	Ionic Theory and Electrolysis	7	Paper 1	13.62	Weak