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

CANDIDATES' ITEMS RESPONSE ANALYSIS REPORT ON THE CERTIFICATE OF SECONDARY EDUCATION EXAMINATION (CSEE) 2020

CHEMISTRY

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032 CHEMISTRY

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FOREWORD

This Candidates' Item Response Analysis Report in Chemistry subject on the Certificate of Secondary Education Examination (CSEE) 2020 has been prepared to provide feedback to teachers, students, parents, policy makers and the public in general about the performance of the candidates and the challenges they experienced in attempting the examination.

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

The analysis presented in this report is intended to contribute towards understanding of some of the reasons behind the performance of the candidates in Chemistry subject. Candidates who scored high marks had adequate knowledge of concepts in Chemistry and managed to apply mathematical skills effectively. Contrarily, those who scored low marks lacked adequate knowledge of the subject matter and failed to identify the demands of each question. In addition to that, the low achievers shown both poor mathematical skills and English language proficiency.

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

The National Examinations Council of Tanzania would like to thank all individuals who provided valuable assistance in the preparation of this report in various capacities.

Dr. Charles E. Msonde
EXECUTIVE SECRETARY

1.0 INTRODUCTION

This report analyses the performance of the candidates who sat for the Certificate of Secondary Education Examination (CSEE) 2020 in Chemistry subject. The 2020 Chemistry examination was set according to the CSEE format which was developed from the 2010 Chemistry syllabus for ordinary Level secondary education.

The examination consisted of two papers, 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 whereby question 1 consisted of ten multiple choice items and question 2 comprised five matching items. Section B consisted of ten short answer questions whereas section C comprised two essay questions. The candidates had to answer all the questions in section A and B, and only one question from section C.

The practical had 3 alternative papers; 032/2A Chemistry 2A, 032/2B Chemistry 2B and 032/2C Chemistry 2C. Each alternative consisted of two questions carrying 25 marks each, making a total of 50 marks.

A total of 154,881 candidates sat for the Chemistry examination, and the analysis of the results shows that the overall performance was good (87.09%). The results show that the candidates' performance in 2020 has increased by 10.33 compared to the performance in 2019 which was 76.76. (see the Appendix).

2.0 ANALYSIS OF CANDIDATES' PERFORMANCE ON EACH QUESTION

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

2.1 032/1 CHEMISTRY 1

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

2.1.1 Question 1: Multiple Choice Items

The question consisted 10 items set from 9 topics as follows: *Water; Fuels and Energy; Air, Combustion, Rusting and Firefighting; Organic Chemistry; Laboratory Techniques and Safety; The Scientific Procedures; Oxygen; Hydrogen;* and *The Mole Concept and Related Calculations*. In each item, the candidates were required to choose the correct answer from the given alternatives A to E and write its letter beside the item number in the answer booklet provided.

This question was attempted by 154,770 (99.9 %) candidates. The analysis of the candidates' performance indicates that 12.8 percent scored 0 to 2 marks, 70.1 percent scored 3 to 6 marks while 17.1 percent scored 7 to 10 marks. Generally, the performance on this question was good in which 87.2 percent of the candidates scored 3 marks or above of which 0.35 percent scored all 10 marks. The statistics are displayed in Figure 1.

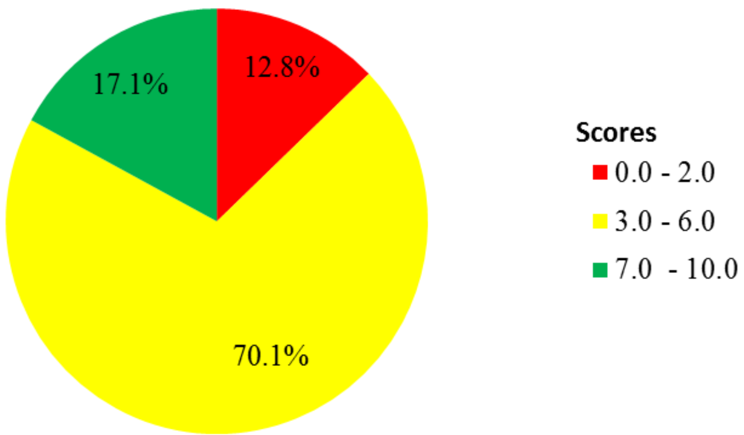


Figure 1: *Candidates' performance on question 1.*

The candidates who scored high marks answered correctly most items of the question. This implies that the candidates had adequate knowledge of different concepts across topics from which the items were composed.

On the other hand, the candidates who scored low marks (12.8%) failed to attempt most of the items correctly and hardly scored at most 2 marks in this question. Principally, the candidates had inadequate knowledge of different concepts tested. The general analysis of the candidates' responses in each item is as follows:

In item (i), the candidates were required to identify the pair that constituted the best methods for treatment and purification of water. The correct answer was *E, Chlorination and distillation.* Candidates who chose the correct answer had satisfactory knowledge that chlorination kills germs in water (treatment) and distillation enables to obtain pure water (purification). The candidates who opted for *A*, *Chlorination and aeration* failed to know that aeration is the removal of gases from water and that it does not purify the water. The candidates who chose *B, Chlorination and decantation* did not realize that decantation enables water to settle but does not guarantee purification. Similarly, those who chose alternative *C*, *Chlorination and filtration* failed to know that filtration process enables removal of solid particles from water and does not make the water pure. Those who chose *D*, *Chlorination and sedimentation* did not realize that sedimentation process itself does not assure purity of water.

In item (ii), the candidates were asked to identify the characteristic of a good fuel. The correct answer was *B, A high energy value supplied*. Candidates who chose the correct answer knew that a good fuel should release high amount of energy once burned. Those who chose *A*, *high speed of continuous energy supply* were not aware that a good fuel should have a *continuous low energy supply*. Candidates who selected *C, low carbon supply* lacked the understanding that fuels are not supposed to have any carbon dioxide content. Those who chose *E, high content of combustible material*, failed to know that a good fuel should have little or no non-combustible material.

In item (iii), the candidates were required to name a rapid chemical reaction that releases energy in form of light and heat. The correct answer was *A, Combustion*. Candidates who chose the correct answer had clear understanding about the process of combustion. Candidates who chose *B*, *decomposition* were not aware that decomposition is a chemical reaction in which a compound breaks into two or more substances. Also, candidates who chose *C, Displacement* did not understand that during displacement reactions, atoms are replaced by other atoms. Alternative *D, Neutralization* was an incorrect response because neutralization is the reaction between acid and base. Those who chose *E, Precipitation* failed to know that a precipitation reaction is the one in which products of different state(s) from the reactant(s) are formed.

In item (iv), the candidates were required to identify the molecular formula of prop-1-yne. The correct answer was *C,* C_2H_4. Candidates who opted for A, C_3H_6 regarded prop-1-yne as an alkene instead of alkyne. Those who selected B, C_3CCH regarded the compound as one with multiple triple bonds instead of one multiple bond. Candidates who chose *D,* HCH_2CCH confused structural formula with molecular formula. Those who chose *E,* CH_3CHCH_2 failed to realize that such a structural formula does not exist because the IUPAC rules of bond formation have been violated.

In item (v), the candidates were ought to identify the material which is not among the components of the First Aid Kit. The correct answer was *C, Dropper*. Candidates who chose the correct answer realized that dropper is a laboratory apparatus while the rest are components of the First Aid Kit. Candidates who chose *A*, *Goggles* were not aware that the instrument is among the components of the First Aid Kit. Similarly, those who chose either *D, Gloves* or *E, Razor blade* failed to understand that those items are inclusive in the First Aid Kit.

In item (vi), the candidates were required to give the correct sequence of the last two steps of the scientific procedure. The correct answer was *E, Interpretation of data and conclusion*. Candidates who got the correct answer were knowledgeable about the sequential order of the steps to follow during scientific procedure. Those candidates who lacked adequate knowledge about the scientific procedure chose either of the distractors *A, Hypothesis formulation and conclusion*, B, *Observation and problem identification*, *C*, *Experimentation and conclusion*, or *D*, *Problems identification and hypothesis formulation*.

In item (vii), the candidates were provided with the following reagents:
1. H_2O_2, *2.* H_2O, *3.* MnO_4 *and 4.* MnO_2. They were then required to select the pair of the reagents which are involved in the preparation of oxygen gas.
The correct answer was E, *1 & 4* but some of the candidates chose either of the alternatives *A, 1 & 2, B, 3 & 4, C, 1 & 3* and *D, 2 & 3*. Those candidates confused the chemicals which are used to prepare oxygen with H_2O and MnO_4. They were supposed to know that although H_2O and MnO_4

have got oxygen atoms, they can not be used in the preparation of oxygen gas.

In item (viii), the candidates were required to identify the peculiar property of oxygen gas. The correct answer was *B, It support combustion but does not burn*. Those who chose alternative *A*, *It neither burns nor support combustion* had a misconception that oxygen does not support combustion. Candidates who chose *C*, *It burns but does not support combustion* did not understand that oxygen gas does not burn and that it support combustion of materials such as charcoal burning. Those who opted for *D*, *It burns and support combustion* were not aware that oxygen gas does not burn. Others chose *E*, *It explodes and support combustion* indicating that they were not aware that oxygen gas do not explode, however it supports burning/combustion.

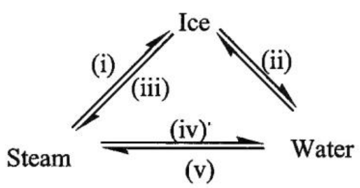
In item (ix), the candidates were required to give the best way of preparing hydrogen gas in the laboratory. The correct answer was *D*, *By reacting moderate metals and dilute acids*. Candidates who gave the correct answer had understanding that metals of moderate reactivity such as zinc react with dilute acids to give hydrogen gas. Those who chose *A*, *By reacting strong metals and dilute acids* did not realize that such reactions are violent and thus not suitable for preparation of hydrogen. Candidates who chose *B*, *By reacting metals and acids* did not realize that some metals such as gold cannot be used to prepare hydrogen gas. Those who chose *C*, *By reacting moderate metals and concentrated acids* failed to understand that concentrated acids are not suitable for preparing hydrogen gas. Candidates who wrote *E*, *By reacting strong metals and strong acids* were not aware that such reactions are not suitable for laboratory preparation of hydrogen gas.

In item (x), the candidates were required to give the volume of hydrogen gas that would be produced by reacting 1 g of zinc granules completely with excess dilute sulphuric acid at s.t.p. The correct answer was *E, 448* cm^3. Candidates who chose the correct answer had adequate skills of writing balanced chemical equations and applying the stoichiometric ratios to calculate the volume of hydrogen gas. Candidates who chose either of the alternatives *A, 130* cm^3, *B, 224* cm^3, *C, 440* cm^3 or *D, 220* cm^3 lacked skills of writing chemical equations and carrying out calculations related to mole concept.

2.1.2 Question 2: Matching Items

The question was based on the topic of *Matter* and consisted of five matching items in List A which were to be matched with seven responses, A - G in List B. The question was as follows:

Match the physical processes represented by arrows (i) – (v) in ***List A*** *with the corresponding terms in* ***List B*** *by writing the letter of the correct response beside the item number in the answer booklet provided.*

List A	List B
 	A Freezing B Condensation C Deposition D Sublimation E Melting F Evaporation G Conversion

The question was attempted by 154,705 (99.9%) candidates and skipped by 176 (0.01%) candidates. Those who scored low (0 to 1 mark) were 28.0 percent while those who scored average (2 to 3 marks) were 31.9 percent. Candidates who scored high (4 to 5 marks) were 40.1 percent, out of which 32.5 percent scored a full mark. Generally, the performance on this question was good as 72.0 percent of the candidates scored at least 2 marks. Summary of the performance on this question is represented in Figure 2.

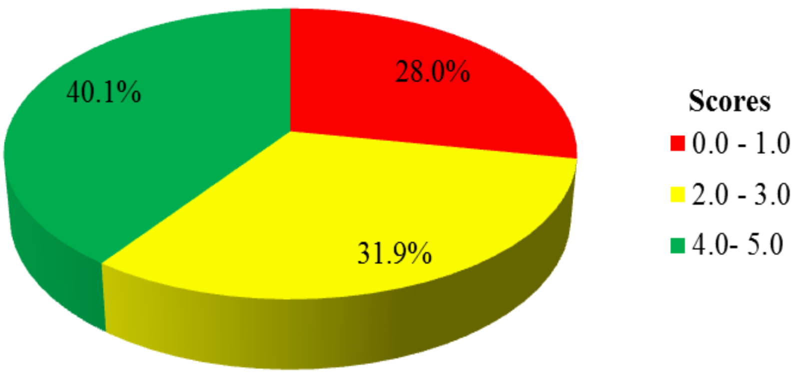


Figure 2: *Candidates' performance on question 2.*

The candidates who scored high marks in this question matched correctly at least 4 of the items. This implies that they had sufficient knowledge of the inter-conversion processes of matter specifically water in this regard. Extract 2.1 indicates a sample of correct responses from one of the candidates.

2.	i	ii	iii	iv	v
	C	E	D	B	F

Extract 2.1: A sample of good responses to question 2.

On the other hand, 28 percent of the candidates scored lower marks because they failed to identify the changes of states of matter. Those candidates confused the stages of change of water from one state to another. Those candidates lacked sufficient knowledge of the physical change of matter from one state to another. Extract 2.2 indicates a sample of incorrect responses from one of the candidates.

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

Extract 2.2: A sample of poor responses to question 2.

In Extract 2.2, the candidate wrote incorrect responses to all five items.

2.1.3 Question 3: Matter

The question consisted of two parts, (a) and (b). In part (a), the candidates were required to provide four uses of matter giving examples. In part (b), they were required to justify the importance of chemical symbols in Chemistry by giving three reasons.

A total of 153,369 (99.0%) candidates attempted this question which was skipped by 1,512 candidates. The statistics of performance indicated that 34 percent of the candidates scored 0 to 2 marks, with 18,738 (12.2%) candidates scoring a zero mark. Candidates who scored 2.5 to 4.5 marks were 45.0 percent. The remaining 21.0 percent of the candidates scored above 4.5 marks with 5.7 percent scoring a full mark. The general performance was average in which 66.0% of the candidates scored 2.5

marks or above. Figure 3 gives summary of candidates’ performance on question 3.

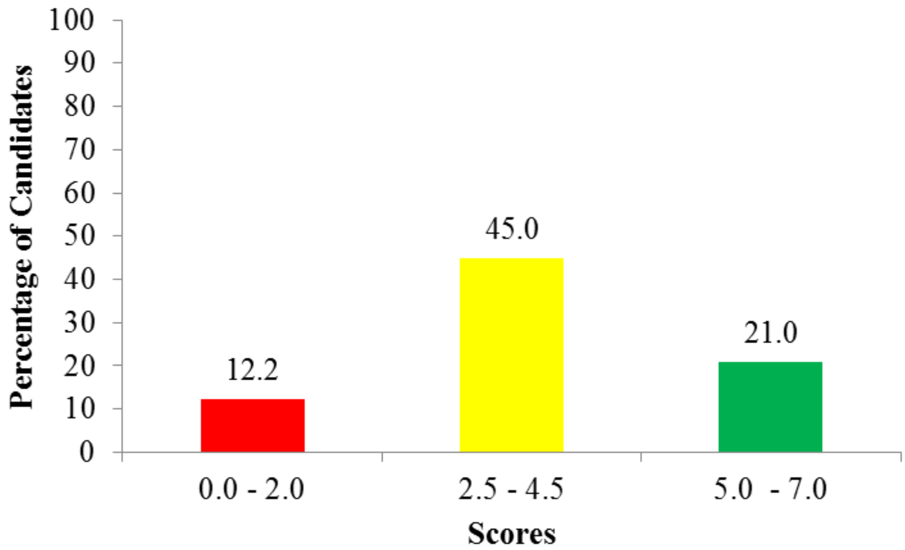
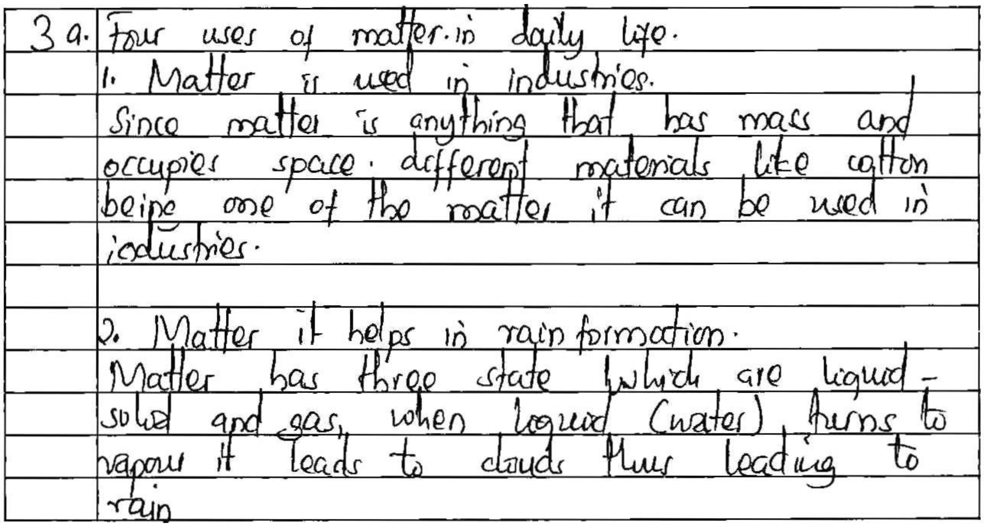


Figure 3: *Candidates’ performance on question 3.*

Candidates who scored high marks in this question gave four correct uses of matter in daily life. They also explained the usefulness of chemical symbols in Chemistry. This gives an implication that they had adequate knowledge of the concept of matter and appreciated the use of chemical symbols in Chemistry. Extract 3.1 shows a sample of correct responses from one of the candidates.



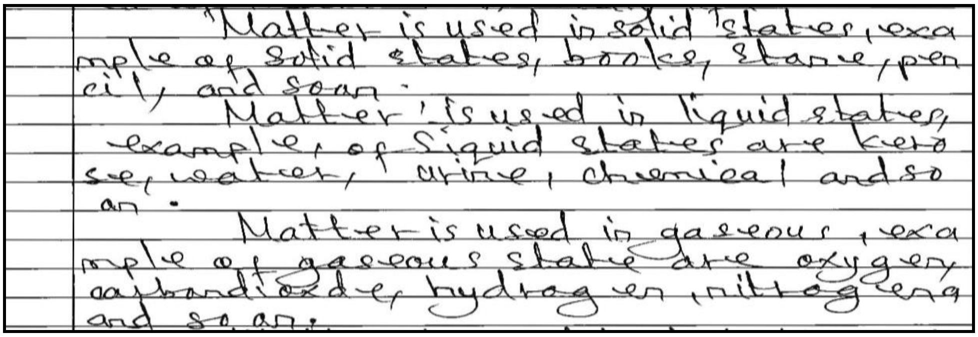
3 a.	Four uses of matter in daily life.
	1. Matter is used in industries.
	Since matter is anything that has mass and
	occupies space. different materials like cotton
	being one of the matter it can be used in
	industries.
	2. Matter it helps in rain formation.
	Matter has three state which are liquid -
	solid and gas, when liquid (water) turns to
	vapour it leads to clouds thus leading to
	rain

3 a.	3. Matter can be used as cooking materials. Forexample flour is a matter, which is used in our homes for cooking food like Ugali which is also a matter.
	4. Matter can be used in studying activities. Forexample for a student to study, he or she need books which are also matter. Therefore through different kind of matter like pen, pencil one can get his or her studies well.
b.	Chemical symbol is useful because
	1. It helps to show the correct proportional of the chemical element reacted.
	2. It saves time when chemical symbol is used. Forexample instead of writting Magnesium one uses Mg.
	3. It helps a person to balance the chemical equation when it is written in words it cannot be balanced.

Extract 3.1: A sample of good responses to question 3.

Candidates who scored low marks failed to give uses of matter in daily life in part (a). Some of them responded to the question by giving the three states of matter with examples. Others cited places where matter is being used (such as schools, home and hospitals) without giving the exact uses of matter in those areas. There were few candidates who wrote the changes of states of matter in this part. For instance, one candidate responded that: *the four uses of matter in daily life are solid example charcoal and coal, liquid example water and kerosene, gas example oxygen, carbon dioxide and steam*.

Similarly, the candidates failed to explain the usefulness of chemical symbols in part (b). Some of them defined chemical symbols while others gave examples of chemical symbols. Others confused chemical symbols with the warning signs. For instance, one candidate responded to this part by writing *corrosive*, *flammable* and *toxic*. Furthermore, others explained the importance of warning signs in Chemistry instead of chemical symbols. For example, one candidate wrote *They are used to minimize accidents in* *the laboratory, help us to be careful with chemicals, helps us to label the containers of chemicals*. Cases of candidates who gave laboratory rules were also found. Failure of the candidates to give correct answers implies that they had inadequate knowledge of the concepts of matter and chemical symbols. Extract 3.2 shows a sample of incorrect responses from one of the candidates.


Matter is used in solid states, exa
mple of solid states, books, stone, pen
cil, and soap.
Matter is used in liquid states,
example of liquid states are kero
se, water, urine, chemical and so
on.
Matter is used in gaseous, exa
mple of gaseous state are oxygen,
carbondioxde, hydrogen, nitrogen
and so on.

Extract 3.2: A sample of poor responses to question 3.

In Extract 3.2, the candidate explained the three states of matter instead of giving uses of matter in daily life.

2.1.4 Question 4: Laboratory Techniques and Safety

The question comprised parts (a) and (b). In part (a), the candidates were required to give four laboratory apparatuses that are made up of ceramic materials. In part (b) the candidates were required to outline three steps of administering First Aid to a person having a minor bruise on his/her leg.

The question was attempted by 151,514 (97.8%) candidates whereas 3,367 (2.2%) candidates skipped it. Candidates who scored 0 to 2 marks were 77.9 percent including 60,474 (39.9%) candidates who scored a zero mark. Those who scored 2.5 to 4.5 marks were 19 percent while only 3.1 percent scored 5 to 7 marks. In general, the performance of candidates in this question was weak since only 22.1 percent scored 2.5 marks or above. The summary of the candidates' performance is displayed in Figure 4.

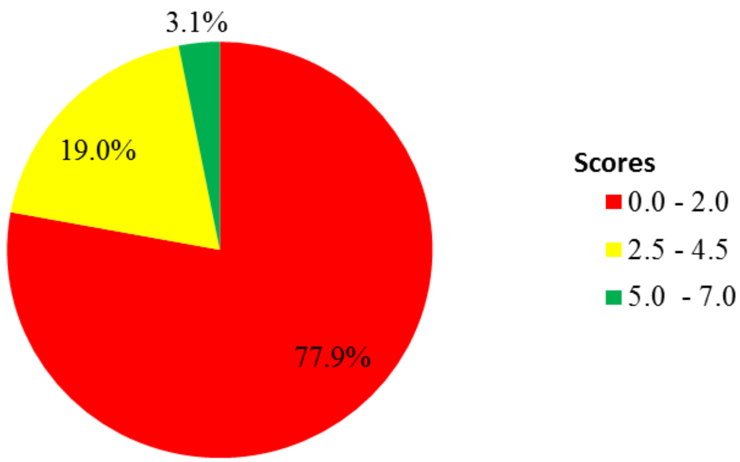
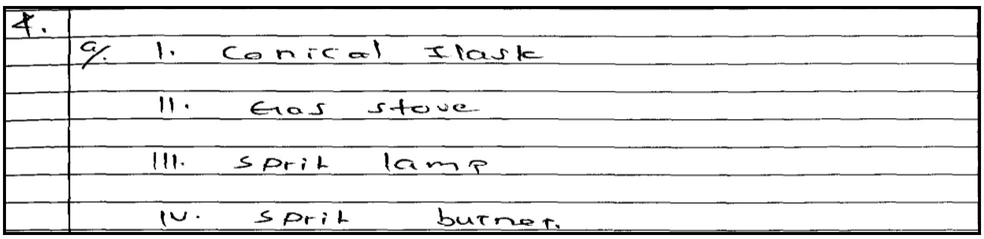


Figure 4: *Candidates' performance on question 4.*

Candidates who scored low marks gave incorrect responses while some of them skipped either part of the question. In part (a), most of the candidates listed apparatuses made of glass instead of ceramic materials, for example, *burette, beaker, conical flask and test-tubes*. Other candidates in this category mentioned components of the First Aid Kit such as *pair of scissors, razor blade, pain-killer and torch* instead of ceramic laboratory apparatuses. There were few candidates who gave laboratory rules in this part. For instance, one candidate wrote *do not enter or drink without permission of the teacher, do not eat in the laboratory*. The candidate confused between laboratory rules and laboratory apparatuses.

In part (b), some of the candidates gave incorrect steps of administering First Aid to the victim. For example, one candidate outlined the steps as: *neutralizing with base, washing the wound with clean cloth, covering the wound with bandage* which are steps for administering First Aid to a victim of acid spills. Others responded by defining First Aid while others gave the correct steps to follow however not in the sequential order. Failure of the candidates to attempt the question correctly is an indication of inadequate knowledge of laboratory apparatuses and safety. Extract 4.1 shows sample of incorrect responses from one of the candidates.


4.
a. i. Conical flask
ii. Gas stove
iii. Sprit lamp
iv. Sprit burner.

b/. I. Come down the victim

II. take victim to cover.

III. take the victim.

Extract 4.1: A sample of poor responses to question 4.

In Extract 4.1, the candidate wrote substances which are not made of ceramic in part (a) while in part (b) he/she wrote unclear procedures.

On the other hand, candidates who scored high marks (77.9%) correctly gave four ceramic apparatuses. The apparatuses referred to in most cases were *motor*, *pestle*, *petri dish*, *evaporating dish*, *funnel* and *white tiles*. Moreover, the candidates correctly outlined three steps of administering First Aid to a victim bruised on his/her leg as shown in Extract 4.2.

04. a/ Apparatuses made of porcean includes;
i/ Crucible
ii/ A white tile
iii/ Mortar and pestle
iv/ Evaporating dish.
b/ i/ Washing hands and wearing gloves before administering first aid to a bruised victim.
ii/ Using a wet/damp cloth (clean one) or tie a piece of ice in a cloth.
iii/ Press the cloth with ice or which is damp on a bruised area for a while until the victim's pains are relieved.

Extract 4.2: A sample of good responses to question 4.

2.1.5 Question 5: Volumetric Analysis

The question comprised parts (a) and (b). In part (a) the candidates were required to determine the molarity of a solution containing 10% by mass of calcium hydroxide in 0.5 dm^3. In part (b), the candidates were tasked to calculate the concentration of sodium hydroxide solution formed by diluting 25 cm^3 of its molar solution to 85 cm^3.

This question was attempted by a total of 141,315 (91.2%) candidates and skipped by 13,566 (8.8%) candidates. Candidates who scored 0 to 2 marks were 89.8 with 66.6% candidates scoring a zero mark. Those who scored 2.5 to 4.5 marks were 6.7 percent while the remaining 3.5 percent of candidates scored 5 to 7 marks. Generally, this was the least performed question with only 10.2 percent of the candidates scoring 2.5 marks or above. Summary of performance is shown in Figure 5.

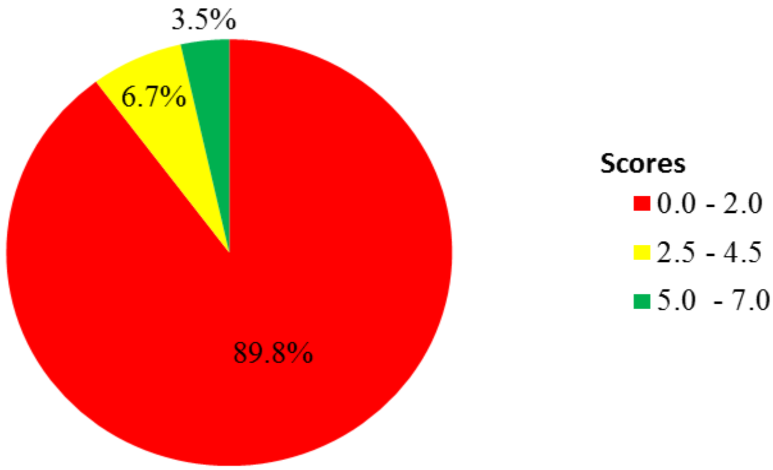


Figure 5: *Candidates' performance on question 5.*

Candidates who scored low marks failed to solve the concentration required in part (a). Majority of them wrote incorrect formula of calcium hydroxide as Ca(OH) instead of $Ca(OH)_2$. Consequently, they computed the molar mass by taking $40 + (16 + 1) = 57$ instead of $40 + (16 + 1)2 = 74$. They carried the next stage of calculation by substituting 57 g/mol instead of 74 g/mol and thus ended up getting incorrect answer. The candidates who applied the appropriate formula $Ca(OH)_2$ failed to multiply the molar mass (74 g/mol) by 10% to get the exact mass of calcium hydroxide (7.4 g) while others introduced incorrect formulae and associations. For instance, one candidate used the formula for calculating percentage purity of which was not valid. Another candidate tried to solve the concentration by applying dilution law formula which was to be applied in part (b) after proper establishment of appropriate data from the question.

In responding to part (b), some of the candidates divided erroneously by taking the molar mass of sodium hydroxide (40 g/mol) over the volume of the diluted solution (0.085 dm^3). Thus they got 47.6 g/dm^3 which was incorrect value. The use of molar volume of gases at s.t.p (22.4 dm^3) was another misconception which appeared in both parts (a) and (b). Those candidates divided the volume of the solution of NaOH in part (b) by 22.4 dm^3 which was not appropriate. Molar volume of gases is only applied for gases at standard temperature and pressure.

Other candidates wrote a wrong formula to calculate the concentration of the solution by dividing volume over molar mass which was inappropriate. The incorrect responses of candidates in this category imply insufficient knowledge and poor numerical skills. Extract 5.1 is one of the incorrect responses.

05 a) Solution
Given.
Molarity of solution = 10 %
mass of calcium hydroxide = 0.5 dm^3
From
Molarity = Concentration / Molecular mass
M = con / Mr
10% = 25 cm^3 / 0.5 →
∴ Molarity of solution containing 10 % is 50

(b) Solution
Given
Molarity of solution = 25 cm^3
Volume of solution = 85 cm^3
concentration = Required
From
concentration = Mole / Molar mass
Concentration = 25 cm^3 / 57 g/dm^3
Conc =
∴ The concentration is

Extract 5.1: A sample of poor responses to question 5.

In Extract 5.1, the candidate used wrong formulae and substituted unrelated data in both parts (a) and (b). However, he/she did not finish the calculation in part (b).

On the contrary, the candidates who scored high marks (3.5%) in this question applied correct and appropriate formulae and worked out the molarity of calcium hydroxide solution in part (a). Similarly, in part (b) they calculated the concentration of sodium hydroxide solution after diluting 25 cm^3 of 1 M to 85 cm^3. They managed to deduce molarity of concentrated sodium hydroxide which was 1 M from the term molar solution. This implies that they had adequate knowledge of Volumetric Analysis. Ability to manipulate the variables involved also indicates good mathematical skills. Extract 5.2 shows a sample of good responses in question 5.

5. a) solution,

V. of solution = $0.5 dm^3$

Molar mass = $Ca(OH)_2$

$= 40 + 17 \times 2 = 40 + 34 = 74 g/mol$

Mass = 10% of molar mass

$= \frac{10}{100} \times 74 = 7.4 g$

Concentration = Mass/volume

$= 7.4/0.5 \ g/dm^3$

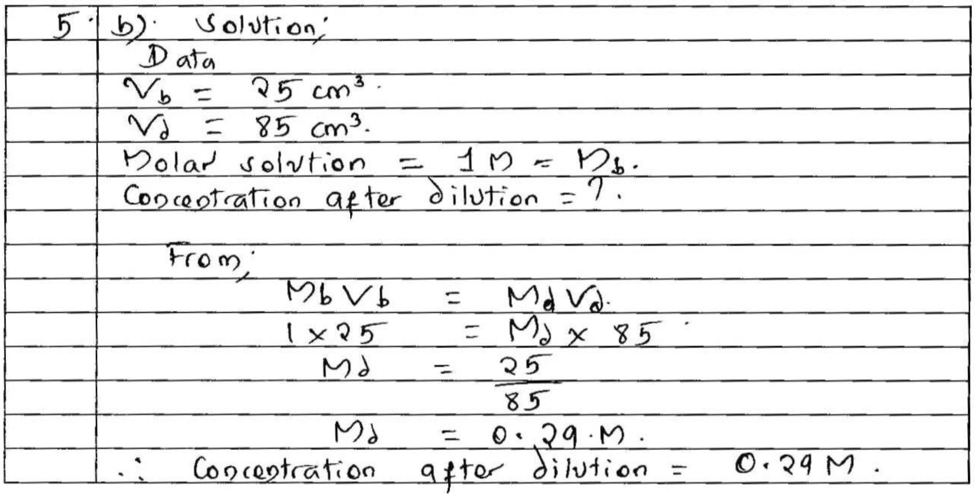
$= 14.8 \ g/dm^3$

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

$= \frac{14.8}{74}$

$= 0.2 M$

∴ Molarity of solution = 0.2 M.



5. b). Solution;

Data

$V_b = 25\ cm^3$.

$V_d = 85\ cm^3$.

Molar solution = 1 M = M_b.

Concentration after dilution = ?.

From;

$M_b V_b = M_d V_d$.

$1 \times 25 = M_d \times 85$

$M_d = \frac{25}{85}$

$M_d = 0.29\ M$.

∴ Concentration after dilution = 0.29 M.

Extract 5.2: A sample of good responses to question 5.

2.1.6 Question 6: Water

Question 6 consisted of parts (a) and (b). It required the candidates the candidates to (a) explain the basic steps in water treatment and (b) give confirmatory test for pure water.

A total of 139,997 (90.4%) candidates attempted this question while 14,904 (9.6%) candidates skipped it. Statistics of performance indicate that the percentage of the candidates who scored from 0 to 2, 2.5 to 4.5 and 5 to 7 marks were 73.9, 20.3 and 5.8 respectively. The candidates who scored a zero mark were 46.4 percent while those who scored a full mark were only 0.6 percent. Generally, the performance of the candidates in this question was weak with only 26.1 percent scoring 2.5 marks or above. Summary of the performance is shown in Figure 6.

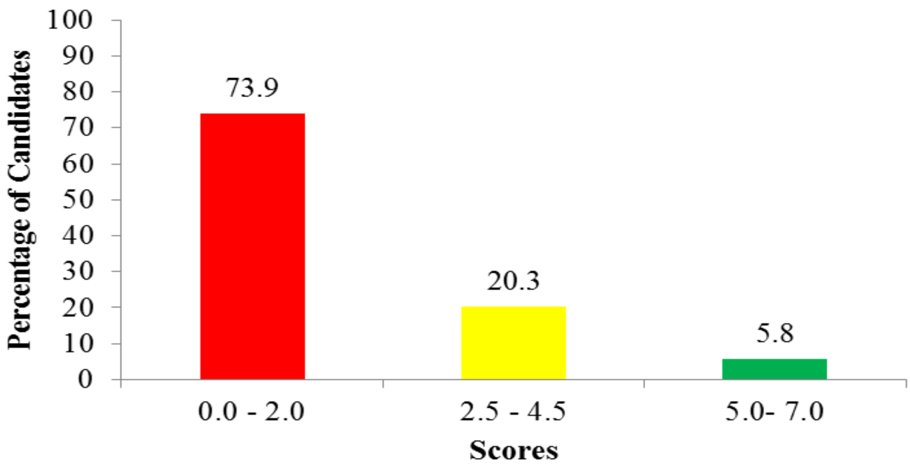


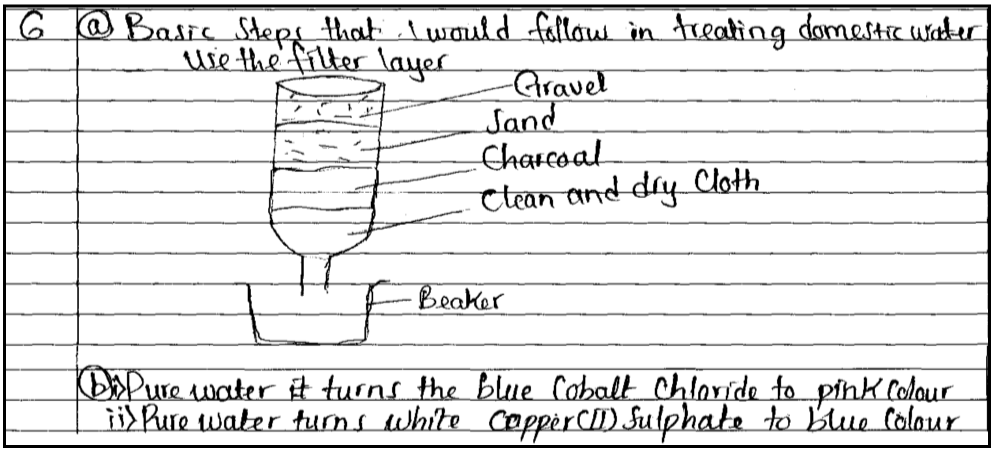
Figure 6: *Candidates' performance on question 6.*

Figure 6 shows that very few candidates (5.8%) scored high marks while majority (73.9%) scored low marks.

The candidates who scored low marks in this question failed to give the basic steps of water treatment in part (a). Some few candidates gave the importance of water treatment instead of the stages of water treatment. Other candidates gave ways of assuring that treated water is kept safe. For instance, one candidate wrote the water must be kept in a refrigerator all the time before use.

In part (b), some of the candidates gave tests for the presence of water in a substance instead of confirmatory test for pure water. For instance, one of the candidates wrote; *water purity can be tested using anhydrous copper (II) sulphate which when comes into contact with water turns blue* which is a test to indicate the presence of water in a substance (no matter pure or impure). It was also observed that, some of the candidates focused their answers on the physical characteristics of water such as the water being colourless and tasteless while others focused on the methods of removing temporary hardness of water.

It was also identified that other candidates confused the test for pure water with the process of water treatment and purification. For example, one candidate responded; *the purity of water is tested by passing water into ion exchange in which water molecules split into hydrogen ions (H^+) and hydroxide ion (OH^-).* The candidate was not aware that ion exchange is used in purifying water rather than being a test for pure water. The candidates were supposed to know that pure water has got a neutral pH and that its boiling point is 100 ^oC at standard temperature and pressure. Extract 6.1 shows a sample of incorrect responses in question 6.

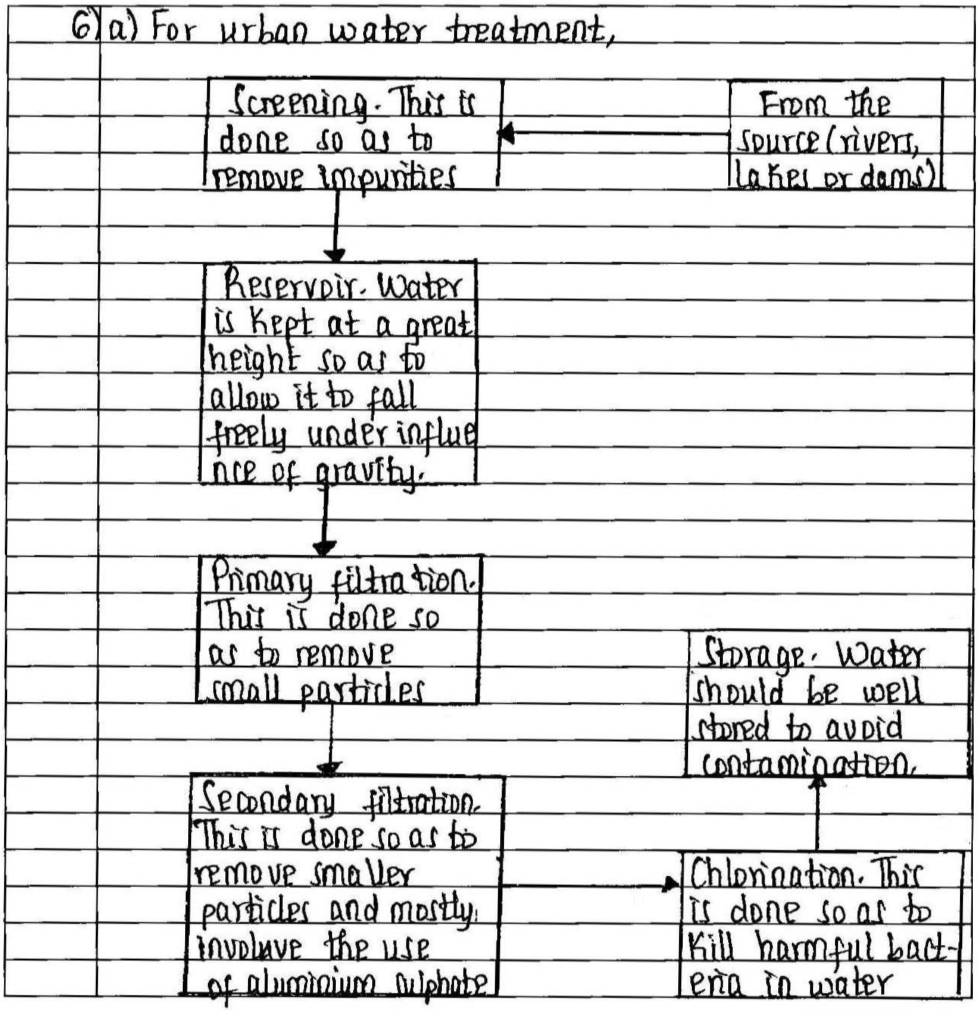

6 (a) Basic Steps that I would follow in treating domestic water
Use the filter layer

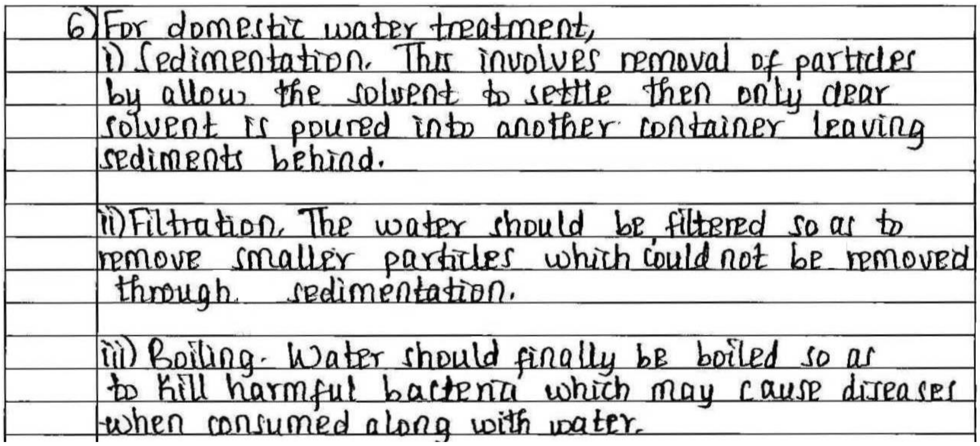
(b) i) Pure water it turns the blue Cobalt Chloride to pink Colour
ii) Pure water turns white Copper(II) Sulphate to blue Colour

Extract 6.1: A sample of poor responses to question 6.

In Extract 6.1, the candidate drew the filter layer instead of explaining the basic steps of water treatment in part (a). In part (b), he/she gave ways of testing for presence of water instead of giving the confirmatory test for pure water.

On the contrary, the candidates who scored high marks (0.6%) in this question were able to explain the basic steps to follow during water treatment in part (a). Some of the candidates explained the steps which are used in urban water treatment such as filtration, precipitation and chlorination while others based on the steps used in domestic water treatment such as boiling, filtration and use of water guard. In part (b), they were able to state that pure water boils at 100 ^{o}C and not at any other point, hence the confirmatory test for pure water. Such candidates had sufficient knowledge of water treatment and purification. Extract 6.2 shows a sample of good responses in question 6.




6) For domestic water treatment,
i) Sedimentation. This involves removal of particles by allow the solvent to settle then only clear solvent is poured into another container leaving sediments behind.

ii) Filtration. The water should be filtered so as to remove smaller particles which could not be removed through sedimentation.

iii) Boiling. Water should finally be boiled so as to kill harmful bacteria which may cause diseases when consumed along with water.

Extract 6.2: A sample of good responses to question 6.

2.1.7 Question 7: Chemical Equations

The question consisted of parts (a) and (b). In part (a), the candidates were required to explain five importance of balancing chemical equations. In part (b), they were required to give the balanced chemical equation for the reaction between sodium carbonate and hydrochloric acid.

The question was attempted by 151,551 (97.8%) candidates. Statistics show that 72.9 percent of the candidates scored 0 to 2 marks out of which 35.7 percent scored a zero mark. Those who scored 2.5 to 4.5 marks and 5 to 7 marks were 21.5 percent and 5.6 percent respectively, with 0.5 percent scoring a full mark. These data indicate weak performance on this question. Summary of the performance is shown in Figure 7.

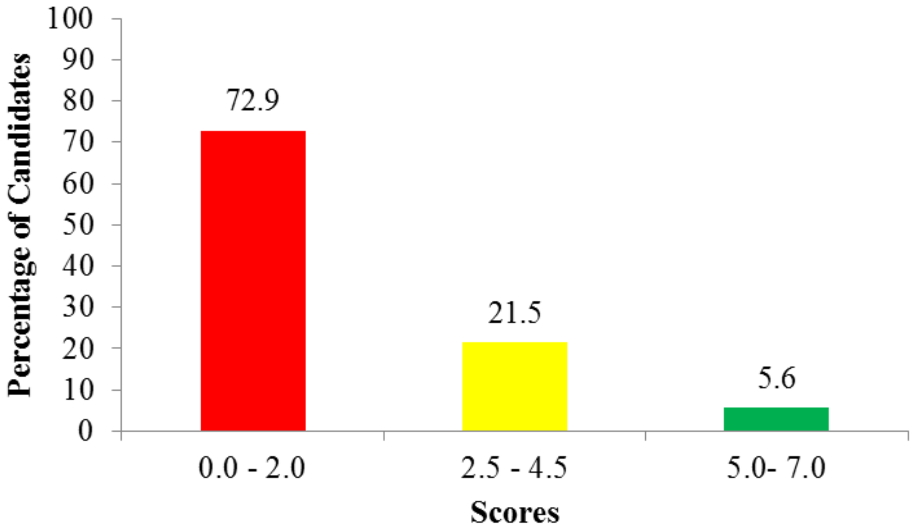


Figure 7: *Candidates' performance on question 7.*

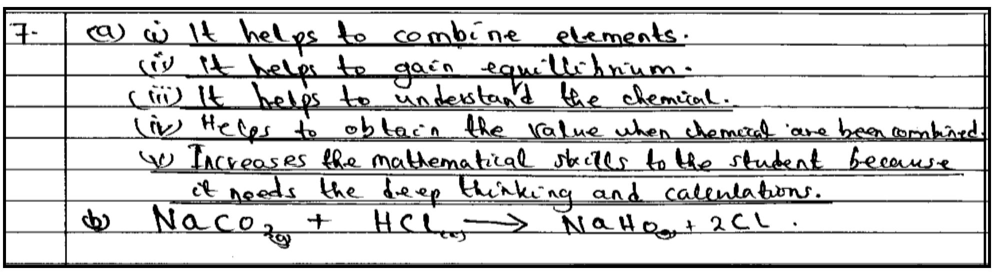
The figure shows that majority (72.9%) of the candidates had low scores (0 to 2.0 marks).

The candidates who scored low marks failed to explain the importance of balancing chemical equations in part (a). The analysis of the responses indicates that some of the candidates explained how to balance chemical equations while others gave features of balanced chemical equations instead of importance of balancing chemical equations. For instance, one candidate wrote*; must have equal atoms in every side and state symbols show clearly*. It was also observed that though some of the candidates understood the question they gave incorrect points. For example one candidate responded; *balancing chemical equation is important in that; it helps to combine different elements, it determines which element has to combine with certain element, helps in more combination of elements, helps to increase the amount of element and helps to get stable element and electrons*. All points given by the candidate were not correct.

In answering part (b), majority of the candidates wrote incorrect chemical equations for the reaction between sodium carbonate and hydrochloric acid. The analysis shows that some of them wrote incorrect molecular formulae of the compounds involved while others could not establish the products of the reaction. For example, one candidate presented the chemical equation for the reaction as; $NOH \longrightarrow HCl = NOHCl = HCl$ while another candidate wrote;

$Na_2CO_3(aq) + NaOH(aq) \longrightarrow NaCH_3CO_2(aq) + H_2O(aq)$, which are not correct chemical equations.

It was also revealed that the candidates who managed to write the equation failed to balance and write appropriate state symbols. Incorrect responses of the candidates show that they lacked adequate knowledge of how to represent chemical reactions by using chemical equations. Extract 7.1 is a sample of poor responses in question 7.


7. (a) (i) It helps to combine elements.
(ii) It helps to gain equilibrium.
(iii) It helps to understand the chemical.
(iv) Helps to obtain the value when chemical are been combined.
(v) Increases the mathematical skills to the student because it needs the deep thinking and calculations.
(b) $NaCO_{2(aq)} + HCl_{(aq)} \longrightarrow NaHO_{(aq)} + 2CL$.

Extract 7.1: A sample of poor responses to question 7.

In Extract 7.1, the candidate wrote incorrect points about the importance of balancing chemical equations in part (a) and he/she wrote incorrect chemical equation in part (b).

On the other hand, the candidates who scored high marks (5.6%) explained five points on the importance of balancing chemical equation in part (a). In part (b) they wrote correct balanced chemical equation for the reaction between sodium carbonate and hydrochloric acid (neutralization reaction). Principally, they had good understanding of chemical formulae of different compounds and chemical equations. Extract 7.2 is a sample of correct responses in question 7.

7. a) Importance of balancing chemical equation:

i) It helps to obtain accurate products formed due to a chemical reaction.

ii) It helps to calculate the accurate number of moles of the reactants or products in a chemical reaction.

iii) It helps to determine the total accurate mass of the reactants reacted to give the products.

iv) It helps to identify the total volume of the reactants and products formed.

v) It helps to determine the accurate molarity of the products formed in response to molarity of reactants used.

b) A balanced chemical equation:

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

Extract 7.2: A sample of good responses to question 7.

In Extract 7.2, the candidate gave correct points on the importance of balancing chemical equations in part (a). He/she also wrote a correct balanced chemical reaction in part (b).

2.1.8 Question 8: Volumetric Analysis

The question consisted part (a) and (b). In part (a) the candidates were required to calculate the concentration (in g/dm^3) of vinegar (CH_3COOH) if 25.0 cm^3 of 0.1 M sodium hydroxide reacts with 12.5 cm^3 of vinegar. In part (b) they were required to suggest with reasons the suitable indicator for the reaction between vinegar and sodium hydroxide.

The question was attempted by a total of 140,139 (90.5%) candidates. The candidates who scored 0 to 2 marks were 63.3 percent in which 29.3 percent scored a zero. The candidates who scored 2.5 to 4.5 and 5 to 7 marks were 16.6 and 19.6 percent respectively, including 7.5 percent who scored a full mark. These data show that 36.2 percent of the candidates scored 2.5 marks or above, indicating average performance. Summary of the performance is displayed in Figure 8.

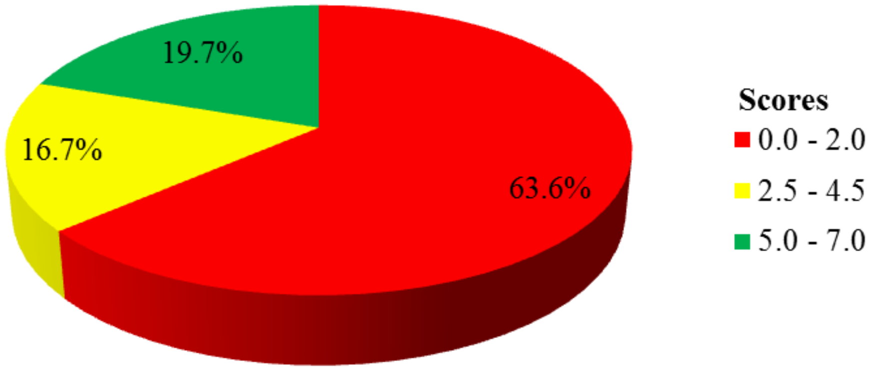


Figure 8: *Candidates' performance on question 8.*

Figure 8 shows that majority (63.6%) of the candidates scored low (0 to 2) marks and few (19.7%) scored high (5 to 7) marks. The candidates who scored high marks in this question, correctly wrote the chemical equation for the reaction of sodium hydroxide with vinegar and calculated the concentration of vinegar in part (a). With appropriate reasons, the candidates suggested phenolphthalein as the suitable indicator for the reaction of vinegar and sodium hydroxide in part (b). These candidates had adequate knowledge of volumetric analysis. Extract 8.1 shows a sample of correct responses in question 8.

8. (a). From chemical formula

$CH_3COOH_{(aq)} + NaOH_{(aq)} \rightarrow CH_3COONa_{(aq)} + H_2O_{(l)}$

1 : 1 1 : 1

M_a = required.

M_b = 0.1 mol/dm^3

V_a = 12.5 cm^3

V_b = 25.0 cm^3

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

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

$\frac{M_a \times 12.5}{n_a} = \frac{0.1 \times 25}{1}$

$\frac{M_a \times 12.5}{1} = 0.1 \times 25$.

$12.5 M_a = 2.5$

$M_a = 2.5/12.5$

$= 0.2M$.

from Molarity = $\frac{conc}{mr}$

Molarmass of CH_3COOH

$= 2 \times 12 + 4 + 16 \times 2$

$= 24 + 4 + 32$

$= 60$ g/mol.

$0.2 = \frac{x}{60}$.

$0.2 \times 60 = x$

$x = 12$ g/dm^3.

∴ The concentration of the acid is 12 g/dm^3.

(b) suitable indicator is P.O.P (phenolphthalein indicator) Because the neutralization involves Vinegar which is weak acid and sodium hydroxide which is a strong base.
i.e Weak acid + strong base.

Extract 8.1: A sample of good responses to question 8.

In Extract 8.1, the candidate calculated the concentration of the acid correctly in part (a) and suggested suitable indicator by giving a reason in part (b).

On the other hand, the candidates who scored low marks (63.6%) failed to calculate the concentration of vinegar in part (a) of the question. The analysis of the responses shows that, some of the candidates failed to write the balanced chemical equation of the reacting substances and hence could not proceed further to correctly calculate the required concentration. It was also noted that among the candidates who managed to write the correct equation, some failed to apply correct formula and others made incorrect associations and substitution of the given data. Hence, were not able to achieve to the correct answer. In part (b), some of the candidates gave function of indicators instead of naming the suitable indicator with justification while few others gave definition of indicators. These candidates did not understand the demand of the question. Also, there were candidates who named incorrect indicators and other substances which do not exist as indicators and gave inappropriate justification. For example, one candidate incorrectly suggested *blue indicator* (no indicator with such a name) with the reasons that *all the reactants are very concentrated*. Such responses signify that the candidates had inadequate knowledge of volumetric analysis. Extract 8.2 shows a sample of poor responses in question 8.

9(a) · Solution

Concetration = ?

Molarity of NaOH = 0.1

Concentration of Sodium = Molar mass x Molarity.

= 0.1 x [40 g/cm3

= 0.1 x 40g/mol

= 4g/cm3

Concentration of Vinegar = Molarity x molar mass

= 0.1M x [60g/mol]

= 0.1M x 60g/mol

= 6g/cm3

1dm3 = 1000cm3

X 6g/cm3

1dm3 x 6g/cm3 / 1000cm3 = 0.006g/dm3

∴ Concetration of Vinegar is 0.006g/dm3

(b) Mathaily Orange due to it change colour from yallow to orange which is the colour of Vinegar.

Extract 8.2: A sample of poor responses to question 8.

Extract 8.2 shows responses of a candidate who applied inappropriate formula in calculating the concentration of vinegar in part (a). He/she also gave incorrect indicator in part (b).

2.1.9 Question 9: Ionic Theory and Electrolysis

This question consisted parts (a) and (b). In part (a) the candidates were required to name the gas which was produced by decomposing certain compound using electricity that relighted a glowing splint. In part (b) candidates were tasked to calculate the electric current from the experiment conducted for 3 hours, where 4.12 dm^3 of the gas at (a) was produced at s.t.p.

The question was attempted by 133,989 (86.5%) candidates while 20,892 (13.5%) candidates skipped it. The percentage of candidates who scored 0 to 2, 2.5 to 4.5 and 5 to 7 marks were 87.0, 9.7 and 3.3 respectively. The candidates who scored zero marks were 27.1 percent while those who scored a full mark were 1.6 percent. The general performance was weak since only 13.0 percent of the candidates scored 2.5 marks or above. The summary of the performance is presented in Figure 9.

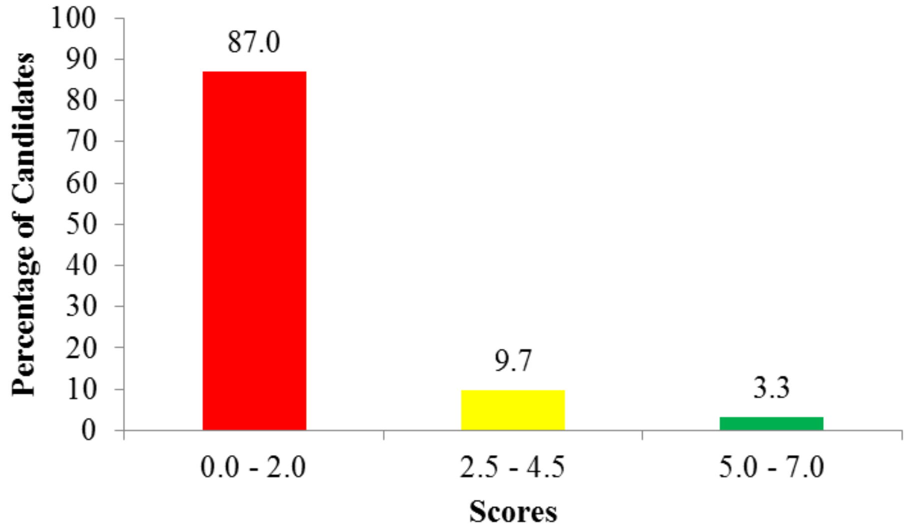
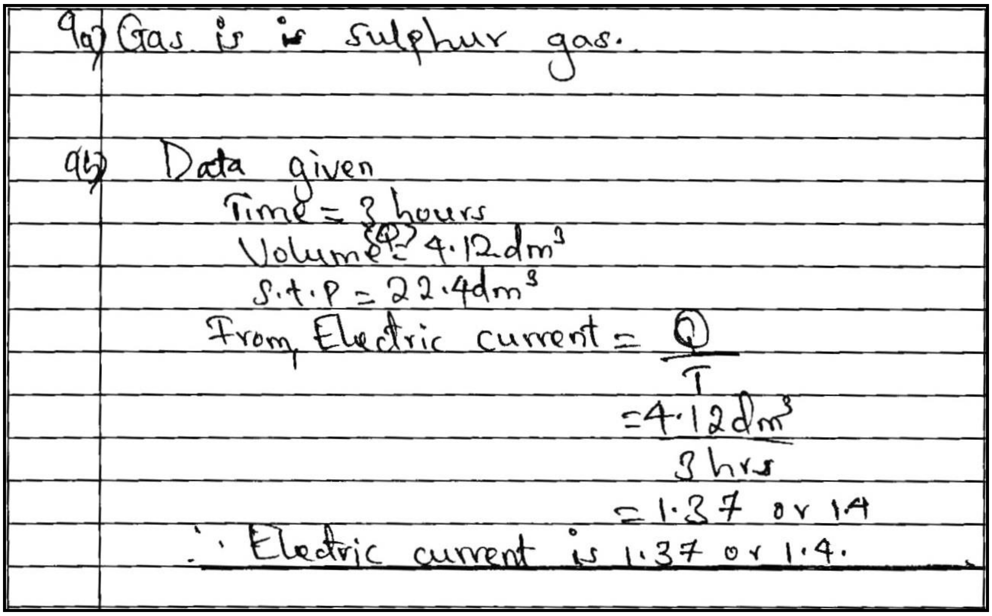


Figure 9: *Candidates' performance on question 9.*

Figure 8 shows that majority (87.0%) of the candidates scored low (0 to 2) marks and few (3.3%) scored high (5 to 7) marks.

The analysis of responses from the candidates shows that, those who scored low marks were unable to identify the gas required in part (a). Most of them named incorrect gases such as hydrogen, nitrogen, carbon dioxide and nitrogen dioxide instead of oxygen gas. In part (b), the candidates failed to calculate the electric current. Most of them wrote the data but used wrong formulae in the calculation process. Others did not write the chemical equation for the process of discharging hydroxyl ions to produce oxygen gas. By writing the chemical equation correctly, the candidates would have realized that the liberation of one mole of oxygen gas requires four Farads (4 F). Thereafter, the candidates were expected to calculate the number of Farads (quantity of charge) required to liberate 4.12 dm^3 of oxygen and finally the current. Basically, the candidates lacked adequate knowledge of the concept of ionic theory and electrolysis specifically in the Faraday's First Law of Electrolysis. Extract 9.1 is a sample of incorrect responses in question 9.


9(a) Gas is ~~is~~ sulphur gas.
9(b) Data given
Time = 3 hours
Volume (Q) = 4.12dm3
S.t.p = 22.4dm3
From Electric current = Q/T
= 4.12dm3 / 3 hrs
= 1.37 or 1.4
∴ Electric current is 1.37 or 1.4.

Extract 9.1: A sample of poor responses to question 9.

In Extract 9.2, the candidate incorrectly divided volume of oxygen gas (4.12 dm^3) with time (hours) instead of dividing quantity of charge with time (seconds). In addition, the candidate did not consider agreement of units (the standard units) of the parameters involved.

On the contrary, the candidates who scored high marks (3.3%) correctly identified the gas as *oxygen* in part (a). The candidates started by writing the data and the chemical equation for the discharge of hydroxyl ions to release oxygen gas. Then the candidates used the appropriate formulae correctly. The correct responses indicate that the candidates had adequate knowledge of application of Faraday's First Law of Electrolysis. Extract 9.2 shows a sample of good responses in question 9.

9. a) The gas produced was Oxygen gas.

b) Soln

Volume of gas produced (Vol) = $4.12 dm^3$

Time taken (t) = 3 hours. (10800 seconds)

Electric current flowed (I) = Required

$M = \frac{Q\,Mr}{VF}$; $\frac{M}{Mr} = \frac{Q}{VF}$ $n = \frac{Vol}{GMV}$

$n = \frac{Q}{VF}$

$\frac{Vol}{GMV} = \frac{Q}{V \times F}$

Quantity of charge = $\frac{Vol \times V \times F}{GMV}$

$= \frac{4.12 dm^3 \times 4 \times 96500 C}{22.4 dm^3}$

Taken that the oxidation was, $4OH^-_{(l)} \rightarrow 2H_2O_{(l)} + O_{2(g)} + 4\bar{e}$

9. b) Quantity of charge = 70996.42857 C

Quantity of charge = Current (I) × Time taken (t)

70996.42857 C = I × 10800 s

$I = \frac{70996.42857 C}{10800 s}$

I = 6.574 A

∴ The current that was flowing was 6.574 A.

Extract 9.2: A sample of good responses to question 9.

In Extract 9.2, the candidate identified the gas as oxygen in part (a) and correctly calculated the electric current in part (b).

2.1.10 Question 10: Atomic Structure

The question consisted of parts (a) and (b). In part (a) the candidates were required to draw diagrams to show atomic structures of elements with atomic numbers 1, 10, 16, and 19. Part (b) required the candidates to work out the number of each type of nucleons present in element X with 20 electrons and a mass number of 40.

The question was attempted by a total of 149,992 (96.8%) candidates. The candidates who scored 0 to 2 marks, 2.5 to 4.5 marks and 5 to 7 marks were 22.6, 38.2 and 39.2 percent respectively. Candidates who scored a full mark were 11.3 percent while 9.8 percent scored zero marks. Generally, the performance on this question was good as 77.4 percent of the candidates scored 2.5 marks or above. Figure 10 shows summary of the candidates' performance on this question.

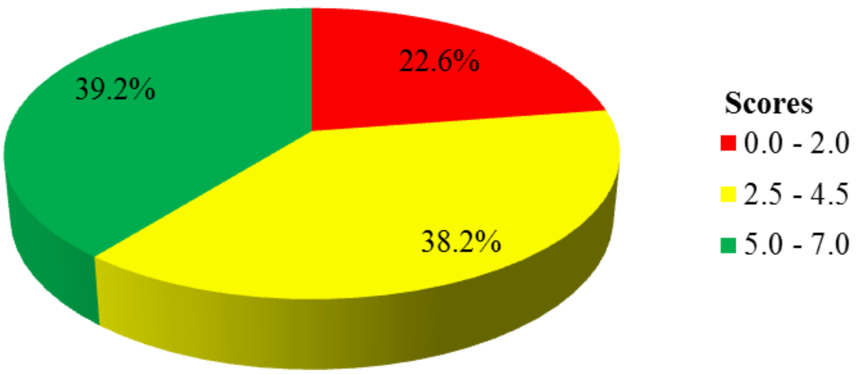
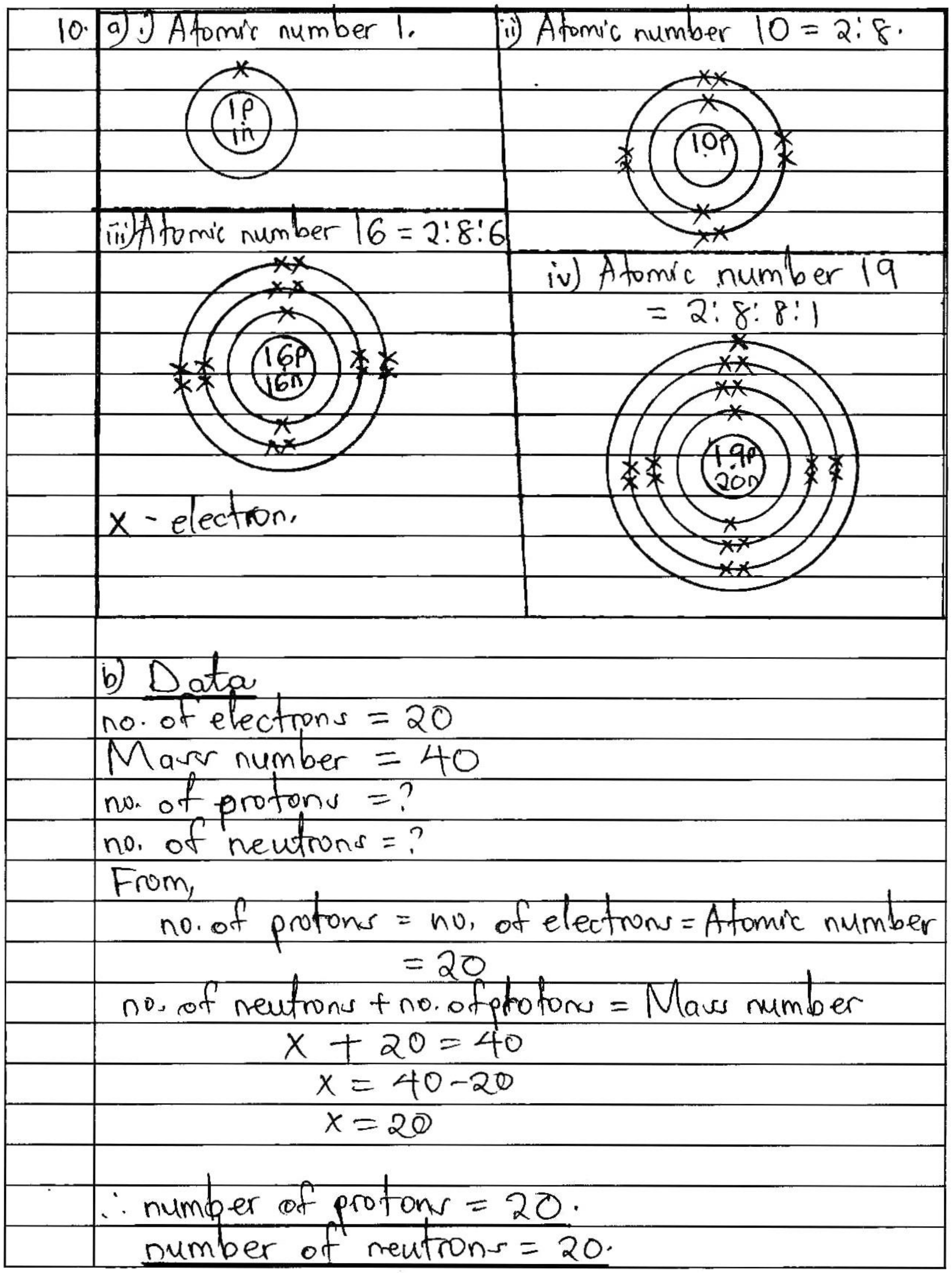


Figure 10: *Performance of the candidates on question 10.*

Figure 10 indicates that a total of 77.4 percent scored 2.5 to 7 marks, of which 39.2 percent scored high (5 to 7) marks. The analysis of the candidates' responses shows that the candidates who scored high marks translated the electronic configurations into atomic structures diagrammatically in part (a). They also managed to work out the number of each type of nucleons of the given element in part (b). The correct responses are an indication that the candidates had adequate knowledge of the relationship between electronic configurations and atomic structures. Extract 10.1 shows a sample of correct responses in question 10.



10. a) i) Atomic number 1.

ii) Atomic number 10 = 2:8.

iii) Atomic number 16 = 2:8:6

iv) Atomic number 19 = 2:8:8:1

X - electron.

b) Data

no. of electrons = 20

Mass number = 40

no. of protons = ?

no. of neutrons = ?

From,

no. of protons = no. of electrons = Atomic number = 20

no. of neutrons + no. of protons = Mass number

X + 20 = 40

X = 40 − 20

X = 20

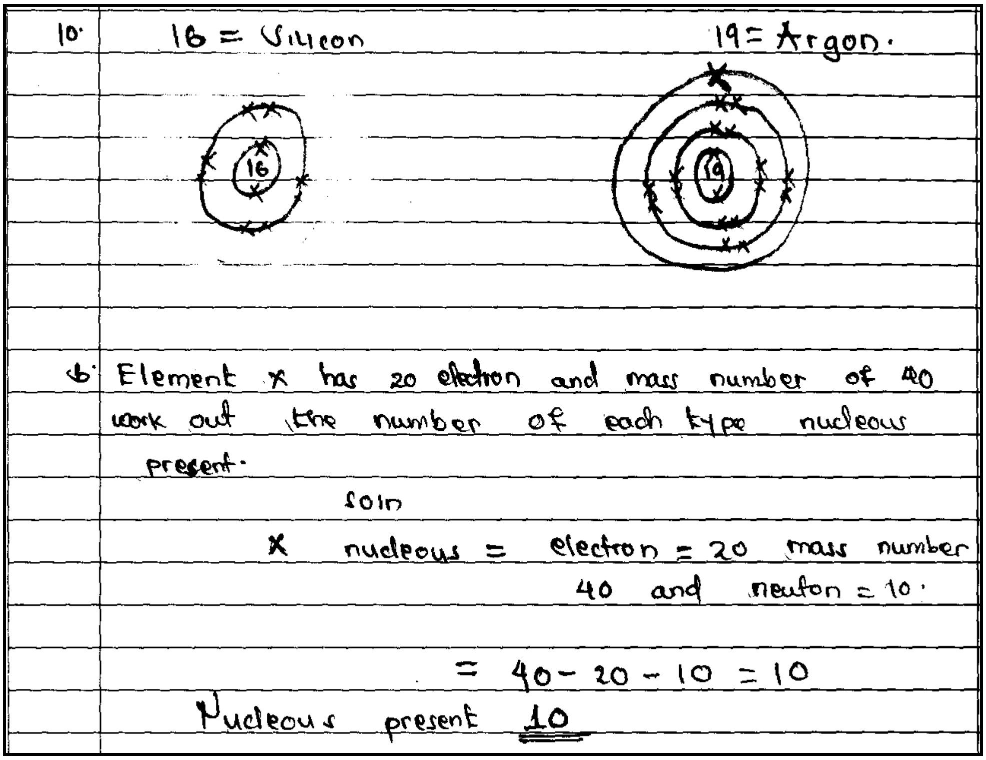
∴ number of protons = 20.

number of neutrons = 20.

Extract 10.1: A sample of good responses in question 10.

In Extract 10.1, the candidate drew correct diagrams showing atomic structures in part (a) and identified the number of each type of nucleons in part (b).

On the other hand, the candidates who scored low marks (22.6%) failed to represent the atomic structures diagrammatically. Some of them drew atomic diagrams with more or lesser number of electrons than required. Others drew diagrams with quite different number of shells. There were few candidates who instead of sketching the diagrams, responded by writing names of elements. For instance, one candidate wrote *hydrogen*, *neon*, *sulphur* and *calcium*. Another misconception is that some of the candidates showed the positions of the elements in the Periodic Table. For example, one candidate drew Periodic Table and indicated the positions of hydrogen, neon, sulphur and potassium. In part (b), the candidates gave incorrect number of protons and neutrons of element X. Others responded by writing irrelevant explanations instead of number of nucleons. For example, one candidate responded by writing *Covalent bond*. Generally, candidates in this category had inadequate knowledge of the concept of atomic structure. Extract 10.2 shows a sample of poor responses in question 10.


10. 16 = Silicon 19 = Argon.

b. Element x has 20 electron and mass number of 40 work out the number of each type nucleous present.

soln

X nucleous = electron = 20 mass number 40 and neuton = 10.

= 40 - 20 - 10 = 10

Nucleous present 10

Extract 10.2: A sample of poor responses to question 10.

In Extract 10.2, the candidate drew incorrect diagrams of atomic structure and calculated the number of nucleons incorrectly.

2.1.11 Question 11: Formulae, Bonding and Nomenclature

The question comprised parts (a) and (b). In part (a), the candidates were required to determine empirical and molecular formulae of a compound with relative molecular mass of 76 composed by sulphur (84.2) and carbon (15.8). In part (b) the candidates were required to give the IUPAC name of the compound.

The question was attempted by 146,655 (94.7%) candidates while 8,226 (5.3%) skipped it. Statistics of performance indicates that the percentage of candidates who scored from 0 to 2, 2.5 to 4.5 and 5 to 7 marks were 19.7, 19.0 and 61.3 respectively. The candidates who scored a full mark were 11.5 percent while those who scored a zero mark were 10.4 percent. Generally, the performance of the candidates in this question was good with 80.3 percent scoring 2.5 marks or above. The summary of the performance is shown in Figure 11.

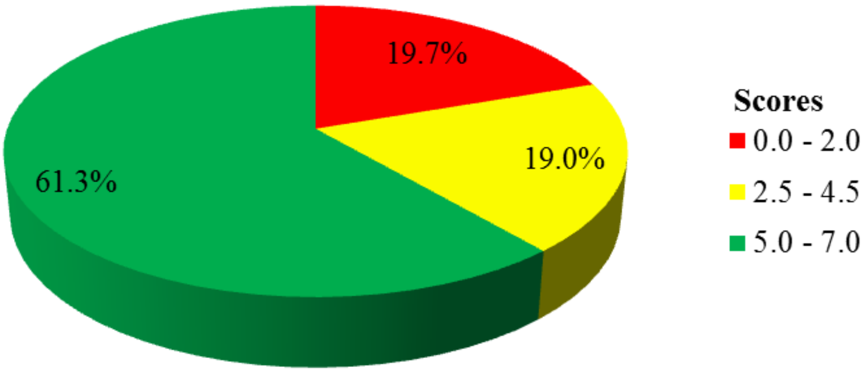
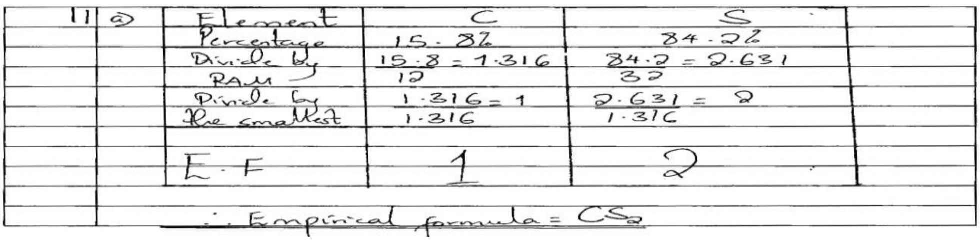
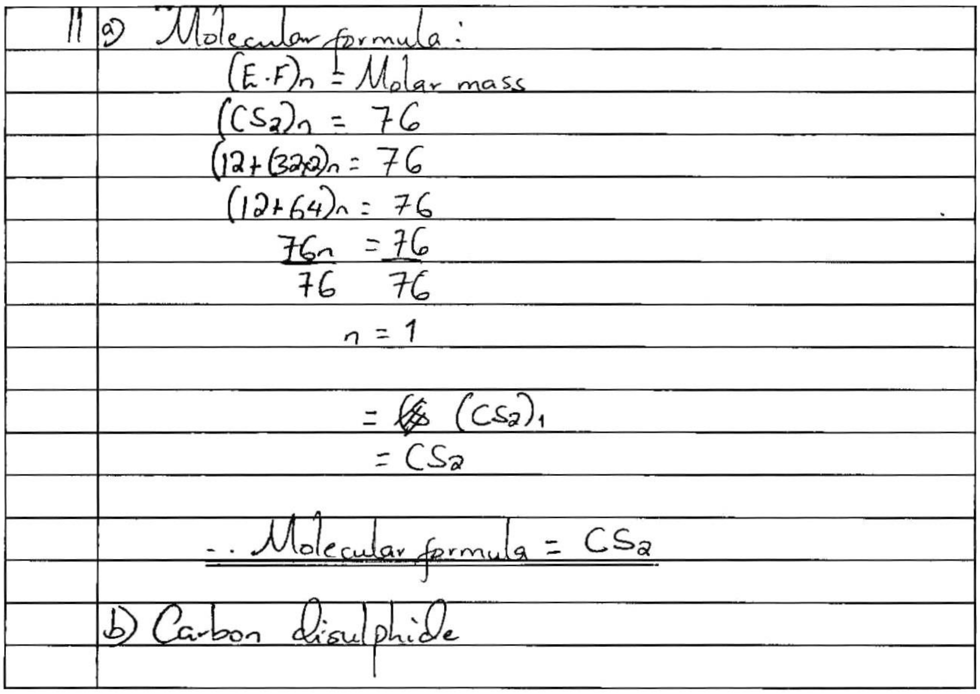


Figure 11: *Candidates' performance on question 11.*

The analysis shows that the candidates who scored high marks (61.3%) determined both the empirical and molecular formulae correctly in part (a). In part (b), also, they correctly named the compound as *carbon disulphide* (according to IUPAC system). The correct responses imply that the candidates had sufficient knowledge of determining formulae of compound and naming them. Extract 11.1 is a sample of good responses in question 11.



11	a)	Element	C	S
		Percentage	15.8%	84.2%
		Divide by RAM	$\frac{15.8}{12}$ = 1.316	$\frac{84.2}{32}$ = 2.631
		Divide by the smallest	$\frac{1.316}{1.316}$ = 1	$\frac{2.631}{1.316}$ = 2
		E.F	1	2
		∴ Empirical formula = CS_2		


11 a) Molecular formula:
$(E.F)_n$ = Molar mass
$(CS_2)_n = 76$
$(12+(32 \times 2))_n = 76$
$(12+64)_n = 76$
$\frac{76n}{76} = \frac{76}{76}$
$n = 1$
$= (CS_2)_1$
$= CS_2$
∴ Molecular formula = CS_2
b) Carbon disulphide

Extract 11.1: A sample of good responses in question 11.

In Extract 11.1, the candidate correctly calculated both the empirical and molecular formulae in part (a) and gave the IUPAC name of the compound in (b).

On the other hand, the candidates who performed poorly (19.7%) could not respond in accordance with the requirement of the question. In part (a), some of them failed to use the relative atomic masses of carbon and sulphur to determine the empirical formula. Others divided the relative atomic masses to the percentage composition of each element while others employed the mole ratio formula in determining empirical and molecular formulae. Also there were candidates who converted the percentage composition of each element into decimal number, which was incorrect operation. However, few candidates managed to divide the percentage composition by the relative atomic mass but failed to continue to perform calculation in the next steps. In part (b), some of the candidates incorrectly named the compound as carbon sulphur. Others wrote the chemical symbols of carbon and sulphur (CS). In addition, some of them incorrectly wrote *sulphur carbon* as the name of the compound instead of *carbon disuphide*. Generally, these candidates lacked adequate skills on how to determine molecular formula of compounds. Extract 11.2 shows a sample of poor responses in question 11.

11. (a) Elements	C	S
R A M	12	32
percentage composition	15.8%	82.4%
percentage ~~composition divide by Relative atomic mass~~ composition divide by Relative atomic Mass	$= \frac{15.8 \times 10}{12 \times 10}$ = 15 80 / 120 = 13.25 = 13.25	$\frac{82.4}{32}$ = $\frac{82.4 \times 10}{32 \times 10}$ = 240 / 320 = 22
To divide by smallest	$\frac{13.25}{13.2}$ $\frac{13}{13}$ = 1	= $\frac{22}{13}$ = 5
	C1	S5

The empirical formula of the Compound is C1 S5

The molecular formular of the compound

Molecular formular = Number of n (empirical formular)2.

Molecular formular = 76 (1 x 5)2

Molecular formular = 76 (2 x 10)

Molecular formular = 76 x 20

Molecular formular = 1520.

∴ The molecular formular of the compound = 1520.

(b) IUPAC name of the compound is Mono carbon penta sulphur

Extract 11.2: A sample of poor responses to question 11.

In Extract 11.2, the candidate inaccurately divided 15.8/12 and 82.4/32 getting 13.25 and 22 instead of 1.3 and 2.6 respectively. Similarly in part (b) he/she gave an incorrect name.

2.1.12 Question 12: Chemical Kinetics, Equilibrium and Energetics

The question comprised parts (a) and (b). In part (a), the candidates were required to write balanced chemical equation governing preparation of ammonia from hydrogen and nitrogen and explain the role played by the catalyst in the reaction. In part (b) they were required to classify the reaction with reason based on energetics and predict the effects of cooling the system while increasing pressure at the same time.

A total of 137,136 (88.5.0%) candidates attempted this question and 17,745 (15.5%) candidates skipped it. The statistics of performance indicates that 61.1 percent of the candidates scored 0 to 2 marks, with 36,291 (26.5%) candidates scoring a zero mark. The candidates who scored 2.5 to 4.5 marks were 24.4 percent and the remaining 14.5 percent scored 5 to 7 marks with 2.1 percent scoring a full mark. The general performance was average in which 38.9 percent of the candidates scored 2.5 marks or above. Figure 3 gives a summary of candidates' performance on question 12.

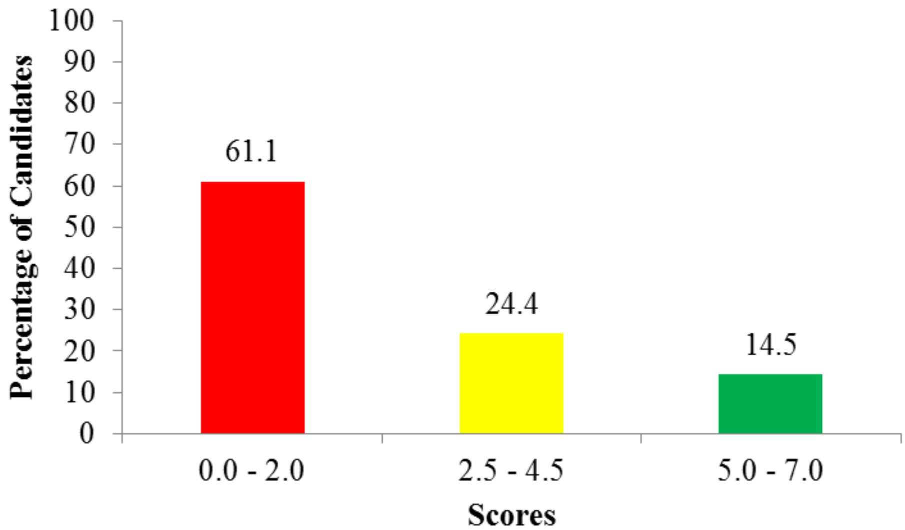


Figure 12: *Candidates' performance on question 12.*

The analysis of the candidates' responses shows that, the candidates who scored high marks (14.5%) wrote well balanced chemical equation for the preparation of ammonia (Haber process). They correctly explained the role played by the catalyst in the reaction. Furthermore, they gave appropriate reasons, classified the reaction accordingly and predicted the effects of cooling the system while increasing pressure. The correct responses are an indication that the candidates had adequate knowledge of chemical equilibrium and energetics. Extract 12.1 shows a sample of good responses in question 12.

12. a) $N_{2(g)} + 3H_{2(g)} \xrightarrow{\text{finely divided Fe}} 2NH_{3(g)}$

The role of the finely divided iron catalyst is to speed up the rate of forward reaction inorder to produce more ammonia gas.

b) The reaction is Exothermic.
Because the energy value of the reactants is greater than the products therefore there is some excess energy lost to the surrounding in form of heat in converting the reactants to the products thus it is an exothermic reaction.

By cooling the system the rate of the reaction will increase because the reaction is exothermic so it is favoured by low temperature but increasing Pressure

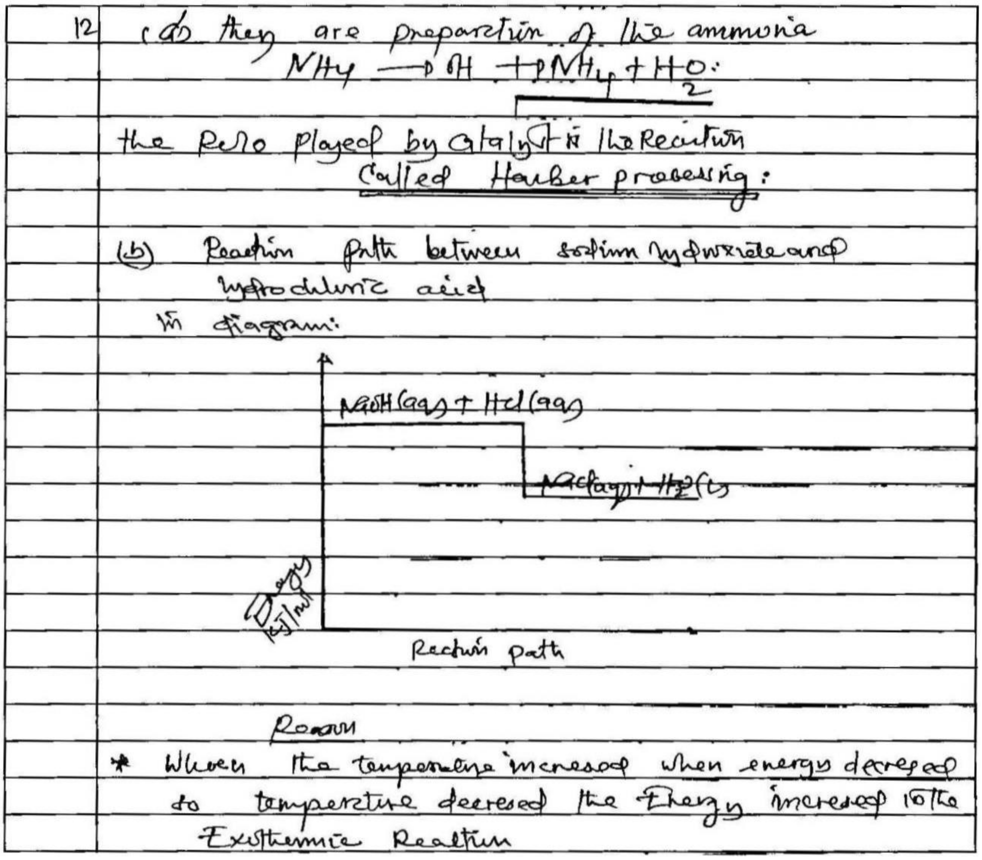
b) will have no effect on the rate of reaction because the moles on the left side of the equation and of the right are equal.

Extract 12.1: A sample of good responses to question 12.

In Extract 12.1, the candidate wrote a balanced chemical equation for the preparation of ammonia gas in part (a). He/she also gave correct explanations in part (b) about the process of preparation of the gas.

On the other hand, the candidates who scored low marks (61.1%) failed to write the balanced chemical equation for the Haber process and explain the role played by the catalyst in the reaction incorrectly. For example, one candidate incorrectly wrote the equation as:

$NH_3 + N_2 + H_2 \xrightarrow{Catalyst} NH_4 + N_2$. Other candidates incorrectly categorized the chemical reaction as *endothermic*, *displacement*, *double displacement* or *synthesis*. These candidates were supposed to know that in endothermic processes, energy is absorbed into the system which is the opposite of exothermic process such as the Haber process. They were also required to understand that the terms displacement, double displacement and synthesis are not part and parcel of energetics. Subsequently, the candidates gave inappropriate reasons for the category of the reaction based on energetics. For instance, one candidate responded that the reaction is *synthetic one because a new product is formed for business* which is incorrect as far as the candidates were limited to classify the reaction with respect to energetics. Also, the candidates failed to predict the effects of cooling the system while increasing pressure. For example, one candidate explained that *cooling the system while increasing pressure of the system decreases the reaction* instead of realizing that the rate of the reaction will increase. Such incorrect responses imply that the candidates misunderstood the requirement of the question, and that they had inadequate knowledge of chemical equilibrium and energetics. Extract 12.2 shows a sample of poor responses in question 12.



12 (a) they are preparation of the ammonia
$NH_4 \rightarrow OH + NH_4 + H_2O$:

the Role played by catalyst in the Reaction
Called Haber processing:

(b) Reaction path between sodium hydroxide and hydrochloric acid
in diagram:

Reason
* When the temperature increased when energy decreased so temperature decreased the Energy increased to the Exothermic Reaction

Extract 12.2: A sample of poor responses to question 12.

In Extract 12.2, the candidate wrote incorrect chemical equation in part (a) while in part (b) he/she drew diagram showing the reaction path of hydrochloric acid and sodium hydroxide, which were not in the question. Also, the explanation given in parts (a) and (b) were incorrect.

2.1.13 Question 13: Non-metals and Their Compounds

This question was optional and required the candidates to explain the differences between the allotropes of carbon.

A total of 35,639 (23.0%) candidates attempted this question whereas 119,242 (73.0%) candidates omitted. The statistics of performance indicates that 26.8 percent of the candidates scored 0 to 4 marks, with 4,642 (13.0%) candidates scoring a zero mark. Candidates who scored 4.5 to 9.5 marks were 30.0 percent while 43.2 percent scored 10 to 15 marks with 4.8 percent scoring a full mark. The general performance was good in which 73.2% of the candidates scored 4.5 marks or above. Figure 3 gives the summary of the candidates' performance on question 13.

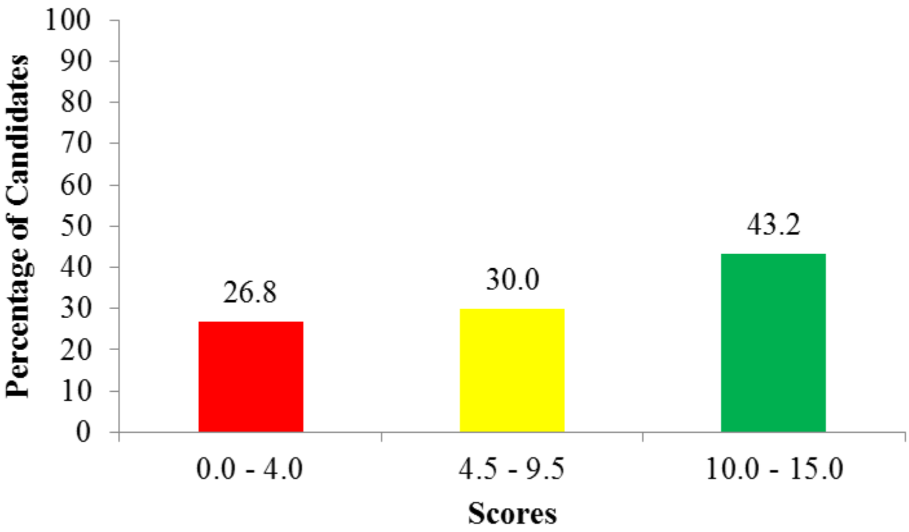
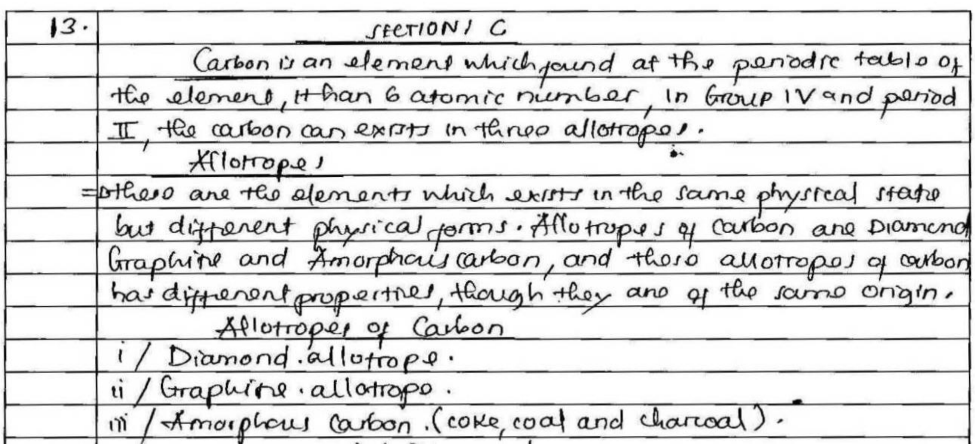


Figure 13: *Candidates' performance on question 13.*

Figure 13 shows that majority (43.2%) of the candidates scored high marks.

The candidates who scored high marks correctly explained the differences between the allotropes of carbon. In most cases, the candidates began with definitions of the terms allotropy and allotropes in the introduction. Then the candidates identified the three allotropes of carbon which are graphite, diamond and amorphous carbon. In the main body, they explained the differences between the three allotropes based on structure, properties and uses. Some of the candidates used tables to differentiate the allotropes while some wrote in paragraphs. Finally, the candidates gave commendable conclusions, an indication that they had adequate knowledge of the allotropes of carbon. Extract 13.1 is one of the correct responses in question 13.



13. SECTION C

Carbon is an element which found at the periodic table of the element, it has 6 atomic number, in Group IV and period II, the carbon can exists in three allotropes.

Allotropes

= these are the elements which exists in the same physical state but different physical forms. Allotropes of carbon are Diamond Graphite and Amorphous carbon, and these allotropes of carbon has different properties, though they are of the same origin.

Allotropes of Carbon

i/ Diamond allotrope.

ii/ Graphite allotrope.

iii/ Amorphous carbon. (coke, coal and charcoal).

i/ Diamond

this is among the allotrope of carbon, in which the ~~two~~ four - electrons found in the outermost shell of the carbon, are attached with other elements to form bond. So in this allotropy there is no movement of electrons, because all the four electrons are attached to the bond.

Properties of diamond

i/ There is no moving of electrons.

ii/ It's all four electrons are attached to the bond

ii/ Graphite

this is the allotropy of carbon in which the three of the four electrons at the outermost shell, are attached to the bond while the one remained electrons, moves, in which this electron is known as delocalized electron, in which due to it's movement aids the graphite to conduct electricity

Properties of Graphite

i/ It is greasy and slippery due to it's delocalized electron

iii/ Amorphous carbon.

This is the last allotropy of carbon in which all the four electrons of this, are involved in bond formation. Examples of these amorphous carbons are charcoal, coal and coke.

iii/ Amorphous carbon.

This is the last allotropy of carbon in which all the four electrons of their, are involved in bond formation. Examples of these amorphous carbons are charcoal, coal and coke.

The followings are the differences of the Carbon allotropes.

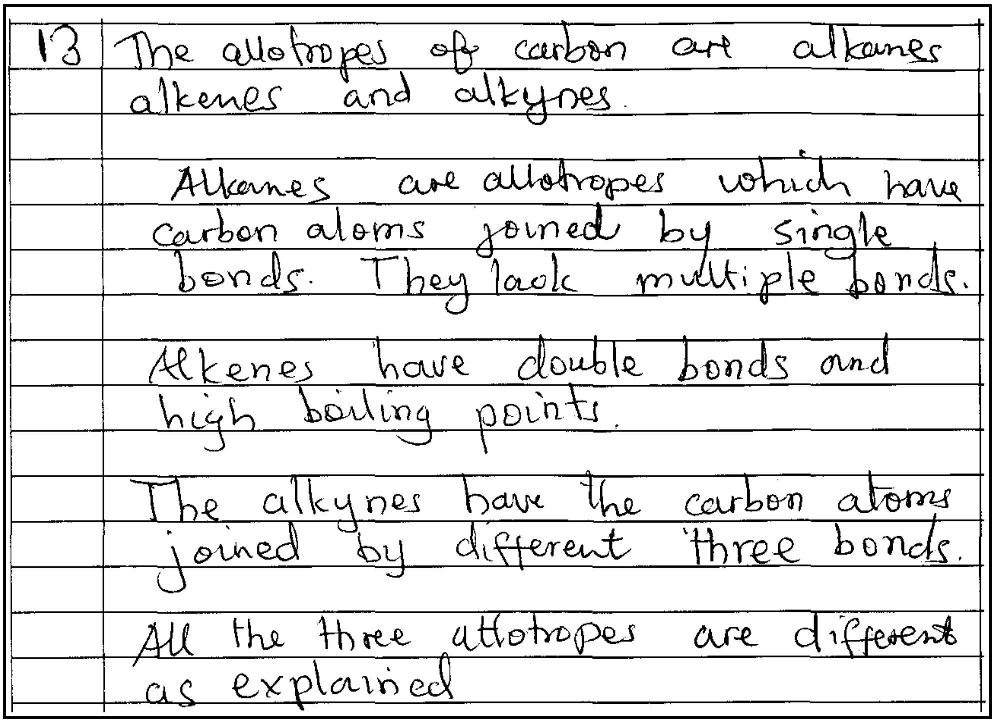
Differences

Graphite	Diamond	Amorphous carb
i) It conducts electricity due to it's delocalized electron.	Does not conduct electricity due to the absence of delocalised electron	Does not conduct electricity
ii) It is soft and slippery due to it's delocalized electron.	It is hard, thus it is used in making the glass cutters.	It is moderate hard, compared to graphite.
iii) It's four electrons at outermost shell the three of them are involved in the bond formation while one remains freely.	All it's four electrons are involved in bond formation.	All it's four electrons are involved in bond formation.
iv) used as electrodes due to conductivity	Use to cut glasses due to it's hardness	used as the fuel source.

Generally, the allotropes of carbon have differences which made them to differ from each other, though they are of the same physical state.

Extract 13.1: A sample of good responses to question 13.

On the other hands, the candidates who scored low marks failed to clearly explain the differences between the allotropes of carbon. Some of them gave incorrect definitions of allotropes. For example, one candidate defined allotropes as *different forms of a compound with the same molecular formula*. Another candidate responded that *allotropes are compounds having the same molecular weight but different structural formulae*. The two candidates confused between allotropes and isomers. Also there were candidates who confused between allotropes and isotopes of carbon. For instance, carbon 14 and carbon 13 (which are isotopes) were mentioned by some of the candidates as among the allotropes of carbon. Other candidates cited the allotropes of sulphur instead of the allotropes of carbon. The misconceptions imply that the candidates had inadequate knowledge of the allotropes of carbon. Another misconception is shown in Extract 13.2.


13 The allotropes off carbon are alkanes alkenes and alkynes.

Alkanes are allotropes which have carbon atoms joined by single bonds. They lack multiple bonds.

Alkenes have double bonds and high boiling points.

The alkynes have the carbon atoms joined by different three bonds.

All the three allotropes are different as explained

Extract 13.2: A sample of poor responses to question 13.

In Extract 13.2, the candidate described the three homologous series of hydrocarbons instead of the allotropies of carbon.

2.1.14 Question 14: Non-metals and Their Compounds

The question required the candidates to explain the importance of sulphuric acid in industries by giving six points.

A total of 108,932 (70.3%) candidates attempted this question while 45,949 (29.7%) candidates skipped it. The candidates who scored 0 to 4.0 marks were 50.2 percent including 17.0 percent who scored a zero. Candidates who scored 4.5 to 9.5 and 10 to 15 marks were 33.2 and 16.6 percent respectively. These data show that 49.8 percent of the candidates scored 4.5

marks or above, indicating average performance. The summary of the performance is displayed in Figure 14.

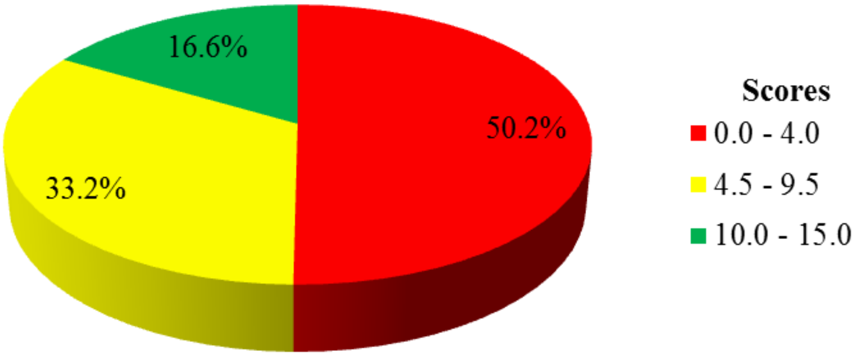


Figure 14: *Candidates' performance on question 14.*

The analysis indicates that, the candidates who scored high marks (16.6%) in this question explained correctly the importance of sulphuric acid in industries by giving six points. To mention a few, the correct points in this question include the use of sulphuric acid in manufacture of *dye stuffs, explosives, paints* and *detergents*. To each point stated, the candidates managed to give correct explanation. The correct responses imply that the candidates were conversant with the application of sulphuric acid in industries. Extract 14.1 is a sample of correct responses in question 14.

14. Sulphuric acid is a strong acid with a chemical formula of (H_2SO_4) it very strong acid it is corrosive and toxic. Sulphuric acid is dense oil liquid also known as oil of vitriol and when in concentrated form it does not have effect on litmus paper. Sulphuric acid is obtained by a so called contact process which involves series of stage until sulphuric acid is fully formed. Though sulphuric acid is corrosive and even toxic but still it has wide range of uses and importances. The following are the importance of sulphuric acid in industries;

Manufacturing of fertilizers, Sulphuric acid is widely used in manufacturing of fertilizer containing sulphate by being reacted with other compounds and lead to formation of compounds used as fertilizer, and lead to high yield in agriculture example of these fertilizers are sulphate of Ammonia commonly known as (SA).

Manufacturing of lead-acid batteries, The lead acid batteries use sulphuric acid as an electrolyte so as to produce chemical reaction in the battery and constitute electric current used to power various electrical appliances example the car batteries use sulphuric acid as of electrolyte in generating current.

Extraction of metals, Sulphuric acid is used to extract metals which have impurities and pure metals are extracted by means of sulphuric acid, hence different industrial involves use of sulphuric acid so to extract different metals, example; rusted iron sheet can be extracted again by using sulphuric acid.

Drying agent in different industrial processes, Sulphuric acid is used a drying agent in industrial processes which require drying agent so to remove traces of water such as hydrogen and oxygen as well as any moisture content, example in large scale industrial manufacture of gases sulphuric acid is used a chief drying agent.

Sulphuric acid is used in production of ethene, Sulphuric acid dehydrates ethanol at high temperature to produce ethene and water, the reaction of sulphuric acid on ethanol to produce ethene is used large scale production. example large scale production of ethene requires production of sulphuric acid on ethanol and produce high yields of ethene.

Sulphuric acid is used production gases such as hydrogen chloride gas, Production of hydrogen chloride gas commonly with its chemical formula is (HCL)g is produced by action of concentrated sulphuric acid on rock salt (NaCl) and produce hydrogen chloride gas and is governed by reaction

$H_2SO_4 + NaCl \rightarrow NaHSO_4 + HCl$ so sulphuric acid produce hydrogen chloride gas which has wide variety of uses.

Conclusively sulphuric acid has wide range of uses despite of it dangers of being high corrosive. So carelessness should be avoided when dealing with sulphuric acid since it still useful in day to day activities and manufacturing of important products, used for different activities.

Extract 14.1: A sample of good responses to question 14.

On the other hand, the candidates who scored low marks (50.2%) failed to explain the importance of sulphuric acid in industries. Some of them gave chemical and physical properties of sulphuric acid contrary to the requirement of the question. For instance, one of the candidates responded as: *sulphuric acid reacts with oxygen, sulphuric acid is the strong acid, sulphuric acid can to react with bases to form water and mineral salts*. Another candidate wrote *sulphuric acid is made up of hydrogen atoms and sulphates which is a radical*. Some of the candidates wrote on how to prepare sulphuric acid in industries while others gave uses of sulphuric acid in other fields apart from industries. For instance, one candidate wrote that *sulphuric acid is used in school laboratory for titration practicals*. Generally, most of the candidates in this category lacked sufficient knowledge of the concepts tested. Extract 14.2 is also a sample of poor responses in question 14.

14	It helps in the manufacture of table salt. Sulphuric
	acid as a strong acid it react with bases in
	the industries to produce the table salt.
	'It helps in the ~~labor~~ industrial production of
	~~of~~ harm full gases which is useful in the
	preparation of petrols and fuels
	It helps in the production of drinks such as
	soda (cocacola and pepsi) the sulphuric acid aids
	in the industrial production of some softs
	drinks such as coca cola and pepsi

Extract 14.2: A sample of poor responses to question 14.

In Extract 14.2, the candidate gave incorrect points on the industrial application of sulphuric acid such as to produce table salt, production of harmful gases and soft drinks.

2.2 032/2 CHEMISTRY 2 (PRACTICALS)

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

2.2.1 Question 1: Volumetric Analysis

The question was attempted by 154,579 (99.96%) candidates. Statistics show that 61.7 percent of the candidates scored 16.5 to 25 marks out of which 7.1 percent scored full marks. The candidates who scored 7.5 to 16 marks were 30.5 percent while those who scored 0 to 7 marks were 7.8 with 0.8 percent scoring zero marks. Generally, the candidates' performance on this question was good with 92.2 percent scoring 7.5 marks or above. The summary of the performance is shown in Figure 15.

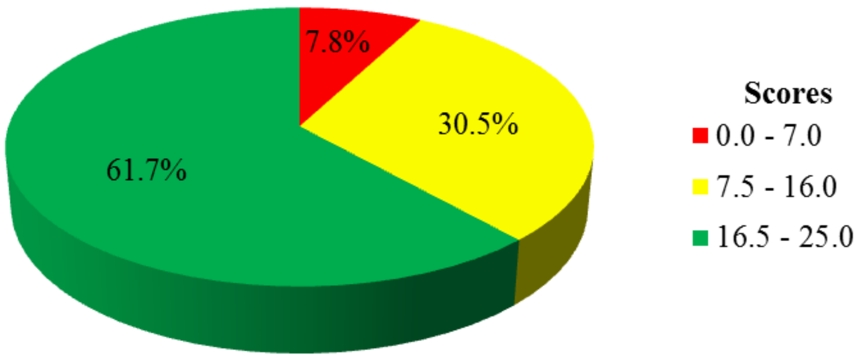


Figure 15: *Candidates' performance on question 1.*

Figure 15 shows that majority of the candidates (61.7%) scored average marks while a few (7.8%) scored low marks.

Alternative 2A

The candidates were provided with two beakers labelled AX and AY, one containing dilute hydrochloric acid and the other aqueous sodium carbonate of 0.1 M concentration. The candidates were required to identify the acid and the base in part (a) by using either phenolphthalein (POP) or methyl orange (MO) indicator. Then the candidates were required to titrate the acid (in the burette) against the base (20 cm^3 or 25 cm^3) using two drops of methyl orange (MO) indicator and obtain three volumes. They were then required to:

(b) determine the mean titre volume.
(c) write balanced chemical equation for the reaction.
(d) calculate molarity of the acid.
(e) calculate the mass of the acid dissolved in one litre of the solution.

The candidates who scored high marks (30.5%) in this question managed to respond correctly to items (a) to (e) indicating that they followed the procedures accordingly and had adequate knowledge of volumetric analysis. Extract 15.1 shows a sample of good responses.

1. (iv)

Table of Results

Burette readings (cm³)	Pilot	1	2	3
Final readings (cm³)	27.00	30.00	35.00	43.10
Initial readings (cm³)	00.00	05.00	10.00	18.00
Titre (cm³)	27.00	25.00	25.00	25.10

(a).

AX – Acid.
AY – Base

(b).

Mean titre volume of the acid.

$$M. \text{ of Acid } (cm^3) = \frac{1+2+3}{3}$$

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

$$= \frac{75.1\,cm^3}{3}$$

$$= 25.03\,cm^3$$

$$= 25\,cm^3$$

∴ The mean titre volume of the acid is $25\,cm^3$.

(c) A balanced chemical equation for the reaction.

$$2HCl_{(aq)} + Na_2CO_{3(aq)} \longrightarrow 2NaCl_{(aq)} + H_2O_{(l)} + CO_{2(g)}$$

1. (d) Molarity of the acid.

Solution

Given

Molarity of base (Mb) = 0.1M.

Volume of base (Vb) = 25cm3.

No of moles of base (nb) = 1 moles

Molarity of acid (Ma) = ?

Volume of acid (Va) = 25cm3.

No of moles of acid (na) = 2 moles

from

$$\frac{MaVa}{na} = \frac{MbVb}{nb}$$

$$Ma = \frac{MbVbna}{Va\,nb}$$

$$Ma = \frac{0.1 \times 25 \times 2}{25 \times 1}$$

$$Ma = 0.1 \times 2$$

$$Ma = 0.2\ M.$$

∴ The molarity of the acid is 0.2 M.

(e) Solution.

Mass of the acid dissolved in one litre of solution (g/dm3) (g/L)

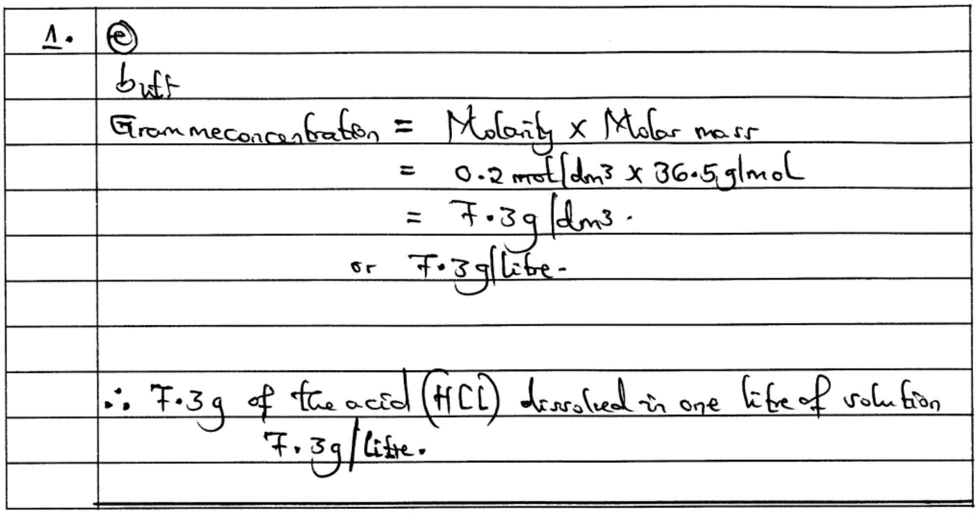
From: Molarity of acid, (Ma) = 0.2M.

Molar mass (HCl) = ~~1×2~~ (1+35.5) ⇒ 36.5g/mol.

Gramme concentration = ?

from

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



1. (e)

Soln

Grammeconcentration = Molarity x Molar mass

= 0.2 mol/dm3 x 36.5 g/mol

= 7.3 g/dm3.

or 7.3 g/litre.

∴ 7.3 g of the acid (HCl) dissolved in one litre of solution

7.3 g/litre.

Extract 15.1: A sample of good responses in question 1.

In Extract 15.1, the candidate correctly filled the table and identified solutions AX and AY in part (a). He/she also attempted parts (b) to (e) correctly.

On the other hand, the candidates who scored low marks (7.8%) failed to attempt most parts of the question correctly. The analysis of their responses showed that in recording experimental data, some of them filled the table of results partially, for instance by not adhering to filling in data with two decimal places or filling two columns instead of three. Others did not indicate cm^3 as the unit of volume and the volume of the pipette used. In this case, results obtained by using a pipette marked 20 cm^3 were expected to be in the range of 20 ± 0.5 cm^3 different from those obtained by using a pipette marked 25 cm^3 which ranged from 25 ± 0.5 cm^3. It was observed that majority obtained incorrect data of volume of the acid.

In part (a), only few candidates failed to use either of the indicators provided to identify dilute hydrochloric acid which was labelled AX and aqueous sodium carbonate (the base) which was labelled AY. Those candidates lacked skills of interpreting colours of indicators in acidic and basic media.

In part (b), some of the candidates got incorrect average titre volumes. In most cases those candidates exceeded the end point during titration although some ended titrating before reaching the end point. For instance, one student who used a pipette rated 20 cm^3 got a titre volume of 17 00 cm^3 instead of 20.0 ± 0.5 cm^3 while another candidate who used a pipette of 25 cm^3 got 27.5 cm^3 instead of 25.0 ± 0.5 cm^3. Those candidates lacked adequate observational skills.

In part (c), most of the candidates wrote incorrect chemical equations with some failing to balance the chemical equation and others not able to give products of the reaction. It was also noted that some of the candidates did not put the state symbols appropriately. Failure of the candidates in this part signifies that they lacked adequate skills of writing chemical equations.

In attempting part (d), the candidates failed to calculate the molarity of the acid due to substitution of incorrect data obtained from previous steps and inability to write the chemical equation for the reaction between the acid and the base. For example one candidate used the formula $Ma = \frac{MbVb}{Va} \times \frac{na}{nb}$ and substituted as:

$$Ma = \frac{0.1 \times 20}{22} \times \frac{1}{1}$$

$$Ma = 0.09\,M$$

In the calculation, the candidate substituted 1 as number of moles of acid instead of 2 and he/she used incorrect volume of acid (22 cm^3).

In the last part (e), the candidates incorrectly calculated concentration of the acid. Some of them used incorrect molar mass of the acid while others used wrong value of the molarity obtained in part (d). There were also candidates who applied incorrect formulae and hence ended with wrong answers. Extract 15.2 shows examples of incorrect responses in this question.

1. a) AX is Base
AY is Acid

b)

Burette reading	Pilot	1	2	3
Final volume	25.2	25.1	23.3	24.1
Total volume	25.2	25.1	23.3	24.1

Mean titre of acid

$$\therefore \frac{25.2 + 23.3 + 24.1 = 72.6}{3}$$

$$= \frac{72.6}{3}$$

b) $= 23.2\ cm^3$ volume of acid

c) $Hcl_{(l)} + Na(CO_3)_{2(aq)} + MO \rightarrow HCO_3 + Nacl_{(}$

~~$Hcl_{(l)} + Na(CO_3)_{2(aq)} + MO \rightarrow H(CO_3)_{2(aq)} + Nacl$~~

d) To find Molarity of acid
soln

Data given
0.1 M of $NaC(CO_3)_2$
M of Hcl = ?

$\therefore \frac{(45.5)(24.2)}{(286)(vb)} = \frac{Ma}{0.1}$

vb = 3.497

Ma = 1101.1

Molarity of acid =

1101.1 cm³/mol

e) M = Concentration / Molar mass

M = 0.1 / 286 = 3.496

$\therefore \frac{Ma Va}{Mb Vb} = \frac{Ma}{Mb}$

$\frac{(3.496)(24.2)}{(286)(3.496)} = \frac{Ma}{0.1}$

84.6032

Mass of acid dissolved in one litre of the solution = 86.6032

Extract 15.2: A sample of incorrect responses in question 1 paper 2A.

In Extract 15.2, the candidate interchanged the identity of AX (the acid) and AY (the base) in part (a). He/she also presented incorrect data in part (b) and consequently gave incorrect responses in the subsequent parts (c), (d) and (e).

Alternative 2B

The candidates were required to determine the purity of sulphuric acid made by dissolving 7.0 g of impure acid in distilled water to make 1 dm^3 of solution (labelled **K**) by reacting it with solution **L** made by dissolving 4.0 g of sodium hydroxide in distilled water to make 1 dm^3. The candidates were guided to carry out the titration using either phenolphthalein (POP) or methyl orange (MO) indicator, obtain three titre volumes and tabulate the results.

The candidates were required to answer the following questions:

(a) Why both phenolphthalein (POP) and methyl orange (MO) indicators are suitable for the titration?

(b) How much volume of the acid was required for complete neutralization with 20 cm^3 or 25 cm^3 of the base?
(c) Write a balanced chemical equation for the reaction.
(d) Calculate the molarity of the acid and the base.
(e) Calculate the percentage purity of the acid.

Candidates who scored high marks in this question properly followed all the procedures (i) to (iii) during the titration and indicated the volume of the pipette used. They also gave correct explanation in part (a), the titre volume of the acid in part (b) and wrote balanced chemical equation in part (c). Furthermore, they correctly calculated the molarity of the acid and base in part (d) and finally the percentage purity of the acid in part (e). The candidates' correct responses imply that they had adequate knowledge of titration as a method of determining the amount of reacting substances. Extract 16.1 shows a sample of the correct responses.

1\. TABLE OF RESULTS

Titration	Pilot (cm³)	I (cm³)	II (cm³)	III (cm³)
Final Volume	20.40	20.20	40.30	20.30
Initial Volume	00.00	00.00	20.20	00.00
Titre Volume	20.40	20.20	20.10	20.30

(a) Both phenolphthalein (POP) and methyl Orange (MO) indicator are suitable in this titration because the titration process involves Strong acid which is Sulphuric acid and Strong base which is Sodium hydroxide.

(b) $$\text{Titre Volume} = \frac{V_1 + V_2 + V_3}{3}$$

$$= \frac{20.20 + 20.10 + 20.30 \text{ cm}^3}{3}$$

$$= \frac{60.60 \text{ cm}^3}{3}$$

$$= 20.20 \text{ cm}^3$$

∴ The Volume of 20.20cm³ of acid was required for Complete neutralization reaction with 20cm³ of the base

(c) Chemical Equation

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

(d) i) Molarity of the Impure acid

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

$$\therefore \text{Molarity of Impure acid} = \frac{\text{Concentration of Impure acid}}{\text{Molar mass of Acid}}$$

But Concentration of Impure Acid $= \frac{\text{Mass in (g)}}{\text{Volume in (dm}^3)}$

$= \frac{7.0 \text{ g}}{1 \text{ dm}^3}$

$= 7 \text{ g/dm}^3$

Molar mass of Acid (H_2SO_4)

$= (2\times1) + 32 + (4\times16)$

$= 2 + 32 + 64$

$= 98 \text{ g/mol}$

∴ Molarity of Impure acid $= \frac{7 \text{ g/dm}^3}{98 \text{ g/mol}}$

$= 0.07 \text{ mol/dm}^3$

iii) Molarity of Base

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

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

$= \frac{4.0 \text{ g}}{1 \text{ dm}^3}$

$= 4 \text{ g/dm}^3$

Molar mass of base (NaOH) $= 23 + 16 + 1$

$= 40 \text{ g/mol}$

∴ Molarity of base $= \frac{4 \text{ g/dm}^3}{40 \text{ g/mol}}$

$= 0.1 \text{ mol/dm}^3$

(e) <u>Percentage purity of the Acid</u>

Formula: Percentage purity = $\frac{\text{Mass / Concentration of pure}}{\text{Mass / Concentration of Impure}} \times 100\%$

But Concentration of pure Acid = Molarity of pure Acid × Molar Mass of Acid

Then: <u>Molarity of Pure Acid</u> =

From the Formula: $\frac{M_1V_1}{M_2V_2} = \frac{n_1}{n_2}$

Where:

M_1 = Molarity of Acid = T

M_2 = Molarity of Base = 0.1 mol/dm^3

V_1 = Volume of Acid = 20.20 cm^3

V_2 = Volume of Base = 20 cm^3

n_1 = Number of moles of Acid = 1

n_2 = Number of moles of Base = 2

$$\therefore \frac{M_1V_1}{M_2V_2} = \frac{n_1}{n_2}$$

$$M_1 = \frac{n_1 \times M_2 \times V_2}{n_2 \times V_1}$$

$$M_1 = \frac{1 \times 0.1 \times 20 \cancel{cm^3}}{2 \times 20.20 \cancel{cm^3}}$$

$$= \frac{0.1 \times 20}{2 \times 20.20}$$

$$= \frac{2}{40.4}$$

$$= 0.05 \text{ mol/dm}^3$$

∴ Molarity of Pure Acid = 0.05 mol/dm³

Then: Concentration of pure Acid = Molarity of pure Acid x Molar mass of Acid

= 0.05 x 98

= 4.9 g/dm³

∴ Percentage purity of Acid = $\frac{\text{Concentration of pure Acid}}{\text{Concentration of Impure Acid}} \times 100\%$

= $\frac{4.9 \text{ g/dm}^3}{7 \text{ g/dm}^3} \times 100\%$

= 70%

∴ The Percentage purity of Acid = 70%

Extract 16.1: A sample of good responses in question 1.

In Extract 16.1, the candidate correctly filled the table in part (a) and answered the remaining parts of the question correctly.

On the contrary, the candidates who scored low marks failed to answer the question correctly. Some of them skipped some parts of the question. In filling the table of results, some of the candidates did not present the data in decimals (two decimal places) while others included two columns instead of three (after the column for pilot). Other few candidates interchanged the data for final volumes and those for initial volumes.

In answering part (a), some of the candidates failed to justify the suitability of phenolphthalein and methyl orange indicators. They gave improper reasons for instance, one candidate wrote *because the indicators are universal*. Another candidate responded *the indicators are suitable because they show different colours in acids and bases* while another wrote *they are suitable because both the phenolphthalein and methyl orange indicators are strong ones.* Those candidates did not realize that the indicators were suitable because the reaction involved a strong acid and a strong base (in such a case any indicator can be used).

In part (b), the candidates obtained incorrect mean titre volumes because of lack of skills in titration hence could not get the expected volumes. Those candidates failed to observe to stop titrating close to the end point.

In part (c), most of the candidates gave incorrect chemical equations including those who failed to balance the chemical equation. For instance, one candidate wrote incorrect chemical equation without indicating the state symbols and at the same time violating bonding rules by writing $NaSO_4$ instead of Na_2SO_4 as follows:

$$H_2SO_4 + 2NaOH \longrightarrow 2NaSO_4 + H_2O$$

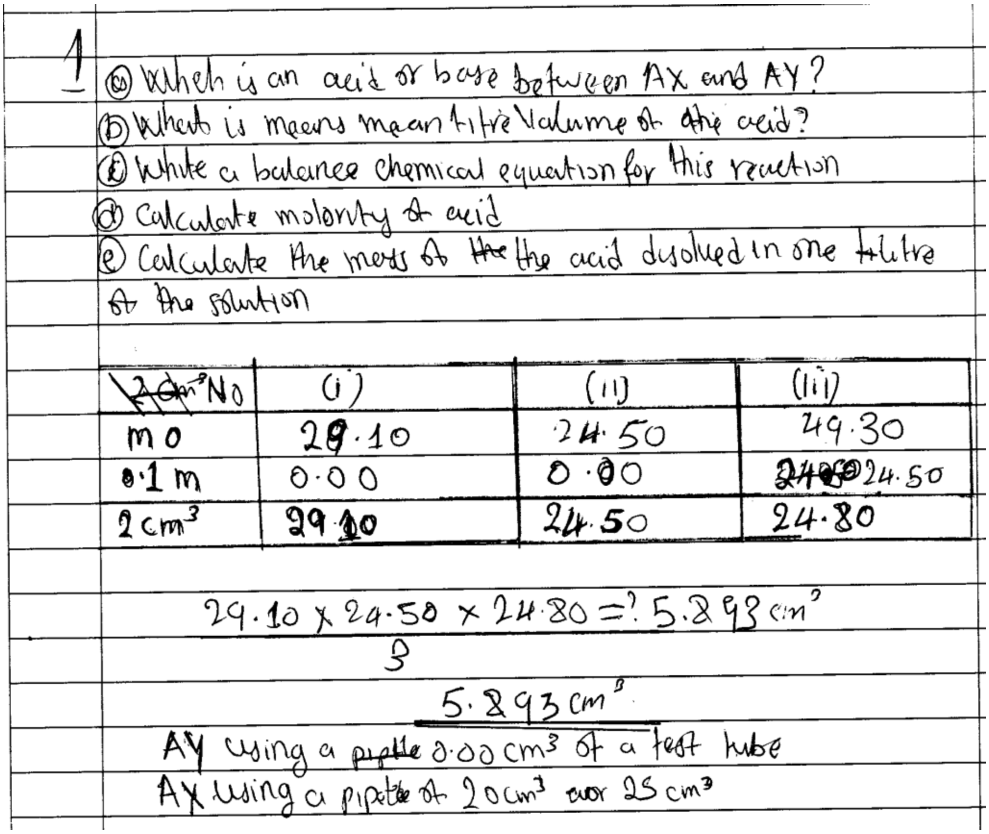
Those candidates lacked adequate skills of writing balanced chemical equations.

In part (d), prior to calculating the molarity of the base, the candidates were supposed to divide the mass of sodium hydroxide (4.0 g) by the volume of the solution (1 dm^3) to get the concentration of the base (4.0 g/dm^3). However, some of the candidates divided the mass of sodium hydroxide by the volume of the pipette and thus got wrong values of concentration of the base. Since concentration is also the product of molarity and molar mass, the incorrect concentrations led the candidates to getting incorrect molarity of the base. Furthermore, most of them failed to calculate the molarity of the acid due to incorrect substitution of data or use of incorrect approaches. For example, one candidate used the mass of impure acid to calculate concentration and subsequently molarity of the acid, which was not appropriate. The suitable formula for molarity of the acid was supposed to be:

$$\text{Molarity of acid (Ma)} = \frac{MaVa}{MbVb} = \frac{na}{nb}$$

In part (e), the candidates failed to calculate the percentage purity of the acid. Those candidates failed to get the mass of pure acid which was to be calculated by taking the molarity of the acid multiplied by the molar mass of the acid (98 g/mol). In order to get the percentage purity of the acid, they were ought to take a fraction of the pure mass out of the mass of impure acid, then multiply by 100. However, the candidates incorrectly calculated the percentage purity of the acid. Some of them went astray by using incorrect mass of the pure acid while others interchanged the positions of the pure and impure mass of the acid

The candidates who scored low marks in this question failed to follow every step carefully in the course of calculation. Generally, candidates who failed to attempt most parts of the question lacked adequate skills in applying titrimetric technique. Extract 16.2 shows a sample of incorrect responses in question 1 in paper 2B.


1 (a) Which is an acid or base between AX and AY?
(b) What is means mean titre Volume of the acid?
(c) Write a balance chemical equation for this reaction
(d) Calculate molority of acid
(e) Calculate the mass of ~~the~~ the acid dusolved in one titre of the solution

~~Xdn~~ No	(i)	(ii)	(iii)
m o	29.10	24.50	49.30
0.1 m	0.00	0.00	~~2400~~ 24.50
2 cm³	29.10	24.50	24.80

$\frac{29.10 \times 24.50 \times 24.80}{3} = ?\ 5.893\ cm^3$

5.893 cm³

AY using a ~~piptte~~ 0.00 cm³ of a test tube
AX using a pipette of 20 cm³ or 25 cm³

Extract 16.2: A sample of incorrect responses in question 1.

In Extract 16.2, the candidate copied the question, incorrectly filled the table of results and answered the remaining parts incorrectly.

Alternative 2C

The aim of the experiment was to determine an unknown univalent element in a carbonate. The candidates were provided with the following solutions:

(i) **P** containing 2.65 g of the univalent element carbonate (X_2CO_3) dissolved in a 250 cm^3 of an aqueous solution.

(ii) **H** containing 12.6 g of nitric acid dissolved in a litre of an aqueous solution.

Procedure:

The candidates were required to titrate nitric acid from the burette against carbonate solution using two drops of methyl orange indicator and record the end point. The candidates were required to repeat the procedure to obtain three burette readings and tabulate the results. They were then required to:

(a) calculate the average titre volume.

(b) find the volume of the acid which was required to complete neutralization.
(c) write balanced chemical equation for the reaction.
(d) calculate the molarities of the acid and base.
(e) determine the molar mass of the univalent element carbonate and name of the univalent element.
(f) write the chemical formula of the univalent element carbonate.

The candidates who scored high marks in this question managed to correctly tabulate the data collected. They also attempted well most parts of the question implying that they had adequate knowledge and skills of in applying titration method to determining amount of reacting substances. Extract 17.1 shows sample of correct responses in this question.

1.

	Pilot	I	II	III
Final burette reading (cm^3)	20·50	20·30	20·20	20·40
Initial burette reading (cm^3)	0·00	0·00	0·00	0·00
Volume of Nitric acid used	20·50	20·30	20·20	20·40

(a) Average titre volume

Average Titre Volume (Nitric acid) $= \frac{20.30 + 20.20 + 20.40}{3}$

$= 20.30\ cm^3$

∴ Average titre volume (Nitric acid) is $20.30\ cm^3$

(b) $20.30\ cm^3$ of Nitric acid (HNO_3) is used to complete neutralization

(c) Base (univalent element Carbonate) → X_2CO_3

Acid (Nitric acid (HNO_3)) → HNO_3

∴ Base + acid → Salt + Water.

but base contain "CO_3"

→ Base + acid → Salt + Water + Carbon dioxide

→ Metal Carbonate + acid → Salt + Water + CO_2

$$X_2CO_{3(aq)} + 2HNO_{3(aq)} \longrightarrow 2XNO_{3(aq)} + H_2O_{(l)} + CO_{2(g)}$$

1. (d) Mass of acid (m_A) = 12·6g disolved in 1 litre of an aqueous solution

Mass of X_2CO_3 = 2·65g dissolved in 250 cm^3 of an aqueous solution

Volume of acid (HNO_3) = 20·30 cm^3 → 0·0203 dm^3
Volume of Base (X_2CO_3) =

Solution

(i) Finding Molarity of acid

From,

$$\text{Molarity} = \frac{\text{Concentration of substance in } g/dm^3}{\text{Molar Mass of a substance}}$$

but, Concentration in g/dm^3 of acid is given by

$\frac{12.6g}{1dm^3}$ (since 12·6g of acid is dissolved to make 1 litre of a solution)

Also, Relative molecular mass of acid is given below

HNO_3

1 + 14 + (16×3)

15 + 48

63

Now, Molarity of acid = $\frac{12.6\ g/dm^3}{63\ g/mol}$

= 0.2 mol/dm^3 → 0.2 M

∴ Molarity of Nitric acid is 0.2 M

1. (ii) Finding Molarity of base

Since, volume of acid used (HNO_3) is $0.0203\,dm^3$

Molarity of HNO_3 is $0.2\,M$

Number of Mole of HNO_3 is given by

$$\text{Mole of } HNO_3 = \text{Molarity of } HNO_3 \times \text{Volume of } HNO_3$$

$$= 0.2\,M \times 0.0203\,dm^3$$

$$= 0.00406\,mol$$

∴ Mole of HNO_3 is 0.00406 mol

- From balanced equation mole ratio between Nitric acid and Metal Carbonate is 1:2

1:2

→ By using mole ratio, finding no of mole of base

$$1 \text{ mole of } X_2CO_3 \equiv 2 \text{ mole of } HNO_3$$

$$\equiv 0.00406\,mol$$

$$\text{Mole of } X_2CO_3 = \frac{0.00406\,mol}{2}$$

$$= 0.00203\,mol$$

∴ Number of mole of Base (X_2CO_3) is 0.00203 mol

Volume of Base used in titration is $20\,cm^3 \rightarrow 0.02\,dm^3$

From, $\text{Molarity of Base} = \frac{\text{Mole of Base}}{\text{volume of Base}}$

$$\text{Molarity of substance} = \frac{\text{number of mole of substance}}{\text{Volume of solution}}$$

$$= \frac{0.00203\,mol}{0.02\,dm^3}$$

1. $= 0.1015 \simeq 0.1$ mol/dm^3

∴ Molarity of base (X_2CO_3) is 0.1 M

(e) Molar mass of the univalent element Carbonate

Mass of univalent element Carbonate = 2.65 g dissolved in ~~1 litre~~ 250 cm^3

∴ 2.65 g of X_2CO_3 gives 250 cm^3

but about 1 litre will require amount of X_2CO_3

2.65 g of X_2CO_3 = 250 cm^3
? = 1000 cm^3

$$= \frac{2.65\text{ g} \times 1000\text{ cm}^3}{250\text{ cm}^3}$$

= 10.6 g

∴ 10.6 g of X_2CO_3 will dissolve to make 1 litre of a Solution

1 litre = 1 dm^3

Concentration in g/dm^3 of X_2CO_3 is given by

$$\frac{10.6\text{ g}}{1\text{ dm}^3} \Rightarrow 10.6\text{ g/dm}^3$$

(i) Concentration of X_2CO_3 = 10.6 g/dm^3
Molarity of X_2CO_3 = 0.1 M
Find Relative molecular mass of X_2CO_3 (RMM) = ?

1. From, Molarity of X_2CO_3 = $\frac{\text{Concentration of } X_2CO_3 \text{ (g/dm}^3\text{)}}{\text{Relative Molecular Mass (RMM)}}$

$$0.1M = \frac{10.6 \text{ g/dm}^3}{RMM}$$

$$RMM = \frac{10.6 \text{ g/dm}^3}{0.1 M}$$

$$= 106 \text{ g/mol} \quad 106 \text{ g/mol}$$

∴ Molar mass of the Univalent element Carbonate is 106 g/mol

and the ~~univalent element~~ is ~~Sodium~~ Carbonate ~~since Sodium Carbonate has a RMM of 106 g/mol~~

(ii) Find the univalent element

$$X_2CO_3 = 106 \text{ g/mol}$$

$$2X + 12 + (16 \times 3) = 106$$

$$2X + 12 + 48 = 106$$

$$2X + 60 = 106 - 60$$

$$\frac{2X}{2} = \frac{46}{2}$$

$$X = 23$$

∴ Molar mass of the Univalent element is 23 g/mol and the univalent element is called SODIUM (sodium has 23 g/mo).

(f) Univalent element Carbonate is Na_2CO_3 chemical formula is

$$Na_2CO_3$$

Extract 17.1: A sample of correct responses in question 1.

In Extract 17.1, the candidate correctly filled the table of results and answered parts (a) to (f) correctly.

On the other hand, the candidates who scored low marks failed to attempt most parts of the question correctly. In filling the table of results, some of them wrote the data without indicating the unit of volume (cm^3) while others failed to label the rows of the table. The accuracy of data was also a problem since most of them deviated much from the expected volumes.

In part (a), some of the candidates failed to get correct titre volume of the acid. This is because some of them did not take average of the three titre volumes or were not able to perform correct calculation to get the average.

In part (b), some of the candidates failed to specify volume of the acid required to react with an exact volume (depending on the pipette used) of the base to complete neutralization. Few of them wrote volumes considerably greater than or smaller than the average titre volume while others skipped this part.

In part (c), most of the candidates wrote incorrect chemical equations. There were those who presented unbalanced chemical equations while others failed to indicate the state symbols correctly. Similarly, there were those who violated bonding rules by writing $NaSO_4$ instead of Na_2SO_4 in the chemical equation as follows:

$$H_2SO_4 + 2NaOH \longrightarrow 2NaSO_4 + H_2O$$

Hence could not proceed to correctly calculate the rest parts of the question.

In part (d), some of the candidates failed to use the mass and molar mass of the acid to calculate its molarity. For instance some multiplied concentration of the acid by its molar mass instead of dividing them. Others incorrectly assumed the number of moles of the acid (stoichiometric ratio) being 1 instead of 2 and hence got incorrect molarity of the base.

Part (e) was hardly attempted by the candidates who scored low marks in this equation. Only few of them managed to write the formula showing the relationship between molar mass, concentration and molarity however they could not realize the correct substitution from there. Thus the candidates could not determine the molar mass of the monovalent carbonate and hence the identity of element X.

In part (f), some of the candidates wrote the formula for potassium carbonate instead of sodium carbonate. Also, there were few cases of candidates who identified the compound as sodium carbonate, not withstanding that there was no connection with the mathematical procedures followed in the previous steps. This implies that the candidates tried to guess for the monovalent element. Extract 17.2 shows sample of incorrect responses in this question.

1

volumes	25.5	32.5	26.5
	38.5	40.6	0.00
unit cm^3	49.2	49.3	29.2
	50.3	50.2	38.3

$$\frac{50.3 + 50.2 + 38.3}{3} = ~~41.3~~ \cdot 2\ 25.3$$

$= ~~43.2~~\ 25.3$

c $HCL_{(aq)} + NaCO_{3(aq)} \rightarrow NaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$

d molarities of base = 1

molar of = acid = n_a = 2

molar of base = m_b

$\frac{m_a\ v_a\ n_a}{m_b\ v_b\ n_b}$ molar of acid = 2

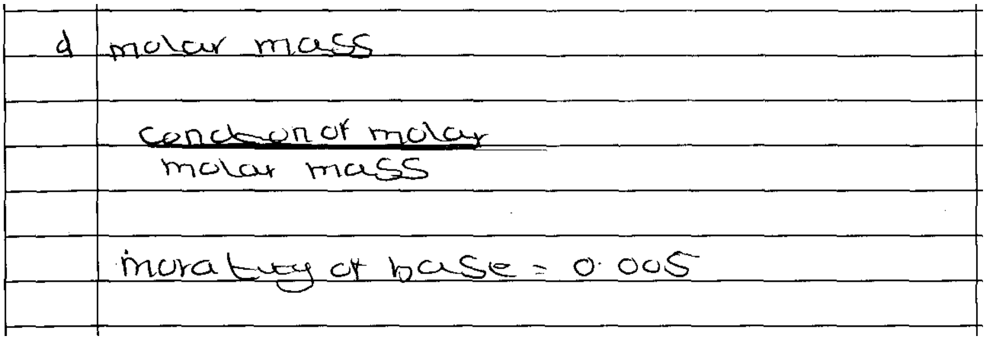
molarity of base

$m_a = \frac{n_a v_a n_a}{m_b v_b n_b} = 113.2$

f chemical formulas

$\frac{m_a\ v_a\ n_a}{m_b\ v_b\ n_b}$

$m_a = \frac{A\ v_a\ n_a}{n_b v_b\ n_b}$ molarity = ~~43.2~~



d	molar mass
	cencdson of molar
	molar mass
	morality of base = 0.005

Extract 17.2: A sample of incorrect responses in question 1.

In Extract 17.2, the candidate incorrectly filled the table of results and answered the remaining parts of the question incorrectly.

2.2.2 Question 2: Rate of Chemical Reactions

The question was attempted by 154,600 (99.9%) candidates. Statistics of performance show that 52.8 percent of the candidates scored 16.5 to 25 marks out of which 3.9 percent scored full marks. The candidates who scored 7.5 to 16 marks were 36.5 percent while those who scored 0 to 7 marks were 10.7 percent with 10 percent scoring zero marks. Generally, the performance of the candidates in this question was good with 89.3 percent scoring 7.5 marks or above. The summary of the performance is shown in Figure 16.

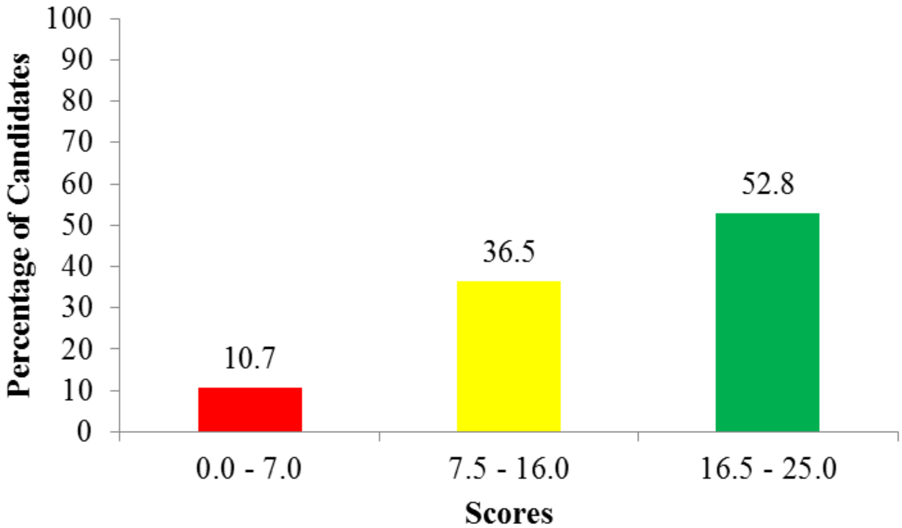


Figure 16: *Candidates' performance on question 2.*

Alternative 2A

The candidates were required to study the reaction between sodium thiosulphate and hydrochloric acid. The chemicals provided were labelled as **P_1**, **P_2**, and **P_3** for 0.5 M sodium thiosulphate, 0.10 M hydrochloric acid and distilled water respectively. The candidates were required to mix volumes of **P_1**, **P_2**, and **P_3** and at the same time to record the time taken for the reaction as shown in the table.

Table: Experimental Data

Volume of P_1 (cm^3)	**Volume of P_3 (cm^3)**	**Volume of P_2 (cm^3)**	**Time (s)**	**Rate of reaction (1/t)(s^{-1})**
5	20	25		
10	15	25		
15	10	25		
20	5	25		
25	0	25		

The candidates were required to:
(a) complete filling the table.
(b) give the aim of the experiment.
(c) write the electronic configuration of the product which causes the solution to be cloud (milky).
(d) write the balanced ionic equation for the reaction between **P_1** and **P_2** indicating all the state symbols.
(e) plot a graph of volume of **P_1** against the rate of the reaction.
(f) conclude on the nature of the graph.

Part (a) was attempted well by the candidates who scored high marks in this question. Those candidates filled in correct data for time (range ± 5 sec) and the rate of the reaction which was found by taking the inverse of time. Similarly the candidates answered parts (b) to (f) correctly as shown in Extract 18.1.

2a. TABLE: EXPERIMENTAL DATA.

Volume of P_1 (cm3)	Volume of P_3 (cm)	Volume of P_2 (cm3)	Time (sec)	Rate of Reaction 1/t (s⁻¹)
5	20	25	68	0.014
10	15	25	36	0.027
15	10	25	22	0.045
20	5	25	15	0.066
25	0	25	11	0.090

b. THE aim of the experiment is
TO DETERMINE THE EFFECTS OF CONCENTRATION ON RATE OF CHEMICAL REACTION.

c. The product is Sulphur.
S – 16 (Atomic number)
2:8:6
The electronic confugaration of the Product is 2:8:6

d. Hydrochloric adid + Sodium Thiosulphate ⟶ Sodium Chloride + Water + Sulphur + Sulphur dioxide.

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

$2H^+_{(aq)} + 2Cl^-_{(aq)} + 2Na^+_{(aq)} + S_2O^{2-}_{3(aq)} \longrightarrow 2Na^+_{(aq)} + 2Cl^-_{(aq)} + H_2O_{(l)} + S_{(s)} + SO_{2(g)}$

2 d. $2H^+_{(aq)} + 2Cl^-_{(aq)} + 2Na^+_{(aq)} + S_2O_{3(aq)}^{2-} \longrightarrow 2Na^+_{(aq)} + 2Cl^-_{(aq)} + H_2O_{(l)} + S_{(s)} + SO_{2(g)}$

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

∴ The net equation is

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

e. The graph of P_1 against the rate of reaction.

f. From the graph It Shown that as the Concentration of Solution P_1 Increase the rate of Chemical reaction also Increase and as the Concentration decrease also the rate of reaction decrease

Extract 18.1: A sample of good responses in question 2.

In Extract 18.1, the candidate correctly filled the table in part (a) and answered the remaining parts correctly.

On the contrary, the candidates who scored low marks failed to attempt most parts of the question correctly. In part (a), most of those candidates filled the table by incorrect data of time. They recorded individual data of time with greater range from each other. Others filled the column for the rate of reaction by using fractions instead of decimals while others left some gaps in the table.

In part (b), the candidates gave incorrect responses concerning the aim of the reaction. Some responded supposing the experiment being to investigate *the effect of water on the reaction*. Others incorrectly assumed the objective of the experiment being to investigate *hydrochloric acid and sodium thiosulphate* while others regarded the experiment aiming at investigating volume (instead of concentration of sodium thiosulphate) on the rate of the reaction.

In part (c), there were candidates who gave incorrect electronic configurations. The common misconceptions were writing electronic configurations of other elements rather than sulphur. For instance some of the candidates attempted this part by writing the electronic configuration of sodium, oxygen, hydrogen or chlorine. Such responses indicate that the candidates did not realize sulphur as the product which causes the reaction mixture to turn milky.

In part (d), the candidates failed to write the ionic chemical equation by not indicating the state symbols and charges while others did not balance the chemical equation. Others responded by writing the complete chemical equation which is different from the ionic equation.

In plotting the graph in part (e), there were candidates who failed to label the axes of the graph while others did not indicate the title of the graph. Some of the candidates used inappropriate vertical and horizontal scales while others plotted the graph using wrong data or failed to draw the best line.

In part (f), majority of the candidates who scored low marks gave inappropriate conclusions. For instance, one candidate who obtained a curve instead of a straight line graph incorrectly concluded that *the reaction increases in a curve way*. Few others incorrectly commented that the rate of reaction is inversely proportional to the volume/ concentration of sodium thiosulphate. Extract 18.2 shows sample of incorrect responses in this question.

2. Table: Experimental Data.

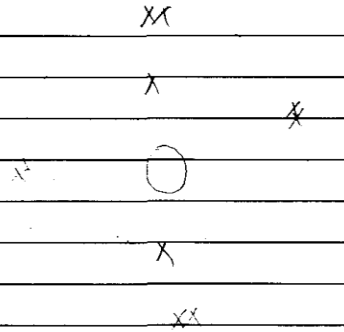
a).

Volume of P_1 (cm³)	Volume of P_3 (cm³)	Volume of P_2 (cm³)	Time(s)	Rate of reaction (1/t)(s⁻¹)
5	20	25		20
10	15	25	10	
15	10	25		5
~~15~~ 20	5	25		
~~20~~ 25	0	25		
~~25~~				

b). Aim of the experiment to determine the concentration to reaction chemical

c). Write the electronic configuration of the product which causes the solution to be cloudy (milky).

Electronic configuration ~~of~~



d).

d. Write the balance ionic equation for the reaction between P_1 and P_2 indicating all the state symbols.

$Na_2S_2O_3$ → Sodium siosulphate.

HCL → Hydrochloric acid.

2HCL + $Na_2S_2O_3$ → 2NaCL + S + SO + H_2O

The chemical equation balanced

~~e)~~ Ionic equation

2H + ~~CL~~ + ~~Na~~ + S^{2+} + CL⁻ → 2Na + ~~CL~~ + ~~SO~~ + O

Extract 18.2: A sample of incorrect responses to question 1.

In Extract 18.2, the candidate filled the table in part (a) partially and answered the remaining parts incorrectly.

Alternative 2B

The candidates were required to study the reaction between sodium thiosulphate and hydrochloric acid. The chemicals provided were labelled as $\mathbf{N_1}$, $\mathbf{N_2}$, and $\mathbf{N_3}$ for 0.13 M sodium thiosulphate, 2.0 M hydrochloric acid and distilled water respectively. Also the candidates were provided with a piece of white paper marked **X** on which a 100 cm^3 beaker containing the reaction mixture was supposed to be placed during the experiment. The candidates were required to mix volumes of $\mathbf{N_1}$, $\mathbf{N_2}$, and $\mathbf{N_3}$ and at the same time record the time taken for the reaction as shown in the following table.

Table: Experimental Data

Volume of N_1 (cm^3)	**Volume of N_3 (cm^3)**	**Volume of N_2 (cm^3)**	**Time (s)**
2	8	10	
4	6	10	
6	4	10	
8	2	10	
10	0	10	

The candidates were required to:

(a) complete filling the table.

(b) (i) plot a graph of volume $\mathbf{N_1}$ (vertical axis) against time (horizontal axis) taken for the letter **X** to disappear completely.

(ii) comment on the shape of the graph.

(c) explain why did the letter **X** disappear.

(d) write the electronic configuration of the product which causes the solution to be cloudy (milky).

(e) write the ionic equation for the reaction between $\mathbf{N_1}$ and $\mathbf{N_2}$.

(f) explain why $\mathbf{N_3}$ was added to $\mathbf{N_1}$.

The candidates who scored high marks in this question attempted well part (a). Those candidates filled in the correct data of time which was decreasing with increase in volume of $\mathbf{N_1}$. Correspondingly, the candidates appropriately plotted the graph (obtaining a curve) and commented on its nature in part (b). Furthermore, they responded to parts (c) to (f) correctly as shown in Extract 19.1.

02. a) Experimental Data.

Volume of N_1 (cm^3)	Volume of N_3 (cm^3)	Volume of N_2 (cm^3)	Time (s) ~~210~~
2	8	10	~~142~~ 210
4	6	10	~~62~~ 102
6	4	10	~~44~~ 62
8	2	10	44
10	0	10	34.

c) letter X disappear because of the formation of sulphur which turn the solution cloudy (milk) colour.

d). Electronic configuration of sulphur.

2:8:6

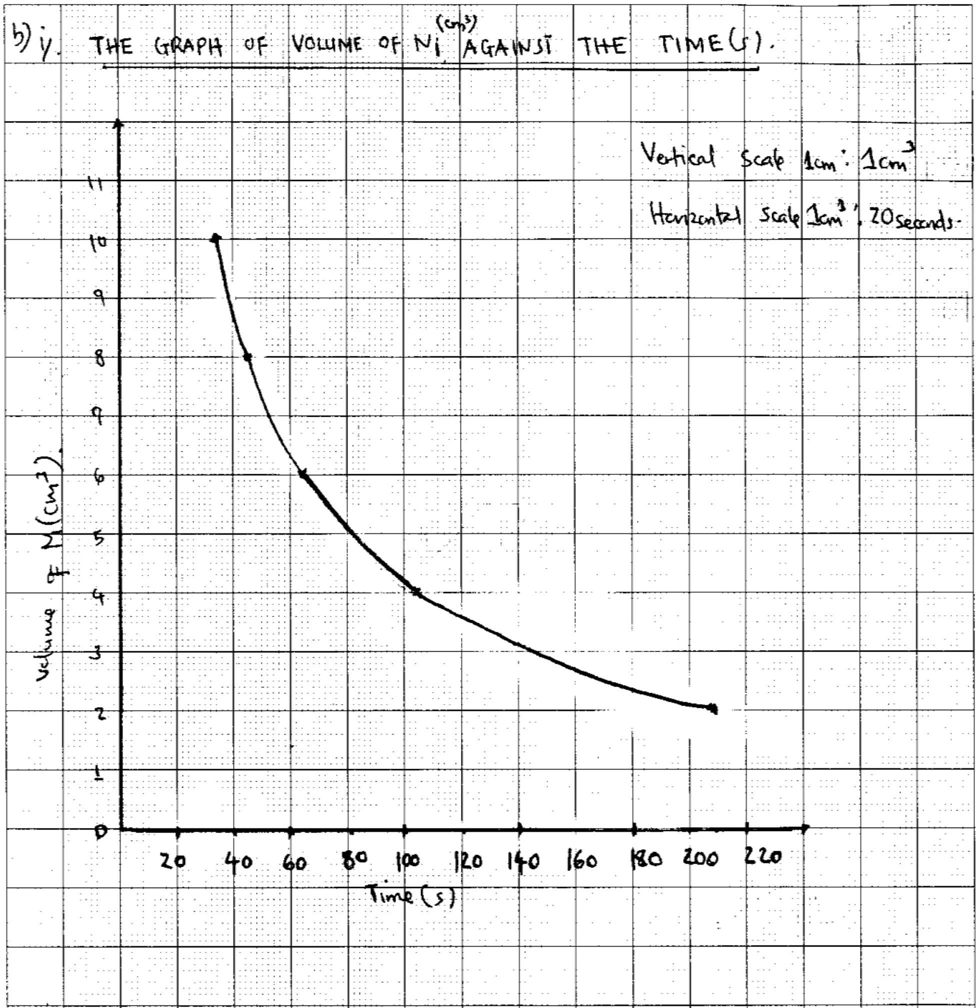
e). Ionic equation for the reaction between N_1 and N_2.

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

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

$$S_2O_3^{2-} + 2H^+ \rightarrow H_2O + S_{(s)} + SO_2$$

02 f) N_3 is added to N_1 in order to lower or to decrease the concentration of N_1.



b) iv The shape of the graph is curve this indicate that When the ~~volume~~ concentration of N_1 is lower then the reaction will take ~~More~~ much time for letter X to disappear

or

Decreasing or lowering the concentration of Ni led to use more time for completing reaction and viceversa.

Extract 19.1: A sample of correct responses in question 2.

In Extract 19.1, the candidate correctly plotted the graph using data obtained in part (a) and answered the remaining parts correctly.

On the other hand, the candidates who scored low marks incorrectly attempted most parts of the question. In part (a), those candidates filled incorrect data in the table, in most cases providing time beyond the expected accuracy. Also, they recorded individual data differing greatly from each other. Others recorded time in minutes (instead of seconds) however, by converting back to seconds, the data were still incorrect.

In plotting the graph in part (b)(i), some of the candidates did not label the axes of the graph while others interchanged the axes of the graph which was contrary to the instructions provided. Some few candidates used inappropriate vertical and horizontal scales while others failed to locate the individual points on the curve hence drew incorrect best lines or curves. Also, the comments given by the candidates on the nature of the graph in part (b)(ii) were mostly irrelevant.

In part (c), some of the candidates gave incorrect reasons for the disappearance of the mark X. To mention the few, the incorrect reasons given include *the indicator showed colour*, *it was the end of the reaction*, *the end point was reached* and *thiosulphate changed colour*. The candidates were supposed to know that formation of sulphur caused the mark to disappear.

In part (d), the candidates failed to give correct electronic configuration of sulphur. Some of them wrote electronic configurations of other elements such as hydrogen or chlorine. Such responses indicate that the candidates did not realize that sulphur was the product causing the reaction mixture to turn milky. In addition, there were few candidates who wrote suphur without showing its electronic configuration.

In part (e), the candidates wrote unbalanced ionic chemical equations lacking correct state symbols and charges. Others responded in this part by writing the complete chemical equation which is different from the ionic equation in which the spectator ions do not appear. Furthermore, there were cases in which candidates wrote chemical equations with irrelevant chemical species.

In part (f), the candidates gave incorrect responses concerning the addition of $\mathbf{N_3}$ (water) into $\mathbf{N_1}$ (sodium thiosulphate). Some responded supposing the role of water being to give suitable medium for the reaction, others incorrectly introduced the concept of the neutral pH of water as the aim of adding water while others connected the addition with adjustment of pressure of the reaction mixture. Extract 19.2 shows sample of incorrect responses in this question.

2 AIM OF EXPERIMENT

The aim of experiment is to determine the effect of concetration on chemical reaction

Apparatus Used

N_1: 0.1M Sodium thiosulphate

N_2: 2.0M hydrochloric acid

N_3: Distilled water

Stop watch

Piece of paper

Measuring cylinder of 10ml

Empty beaker 250ml

Volume of N_1 cm^3	Volume of N_3 (cm^3)	volume of N_2 (cm^3)	Time (s)
2	8	10	145
4	6	10	170
6	4	10	100
8	2	10	70
10	0	10	30

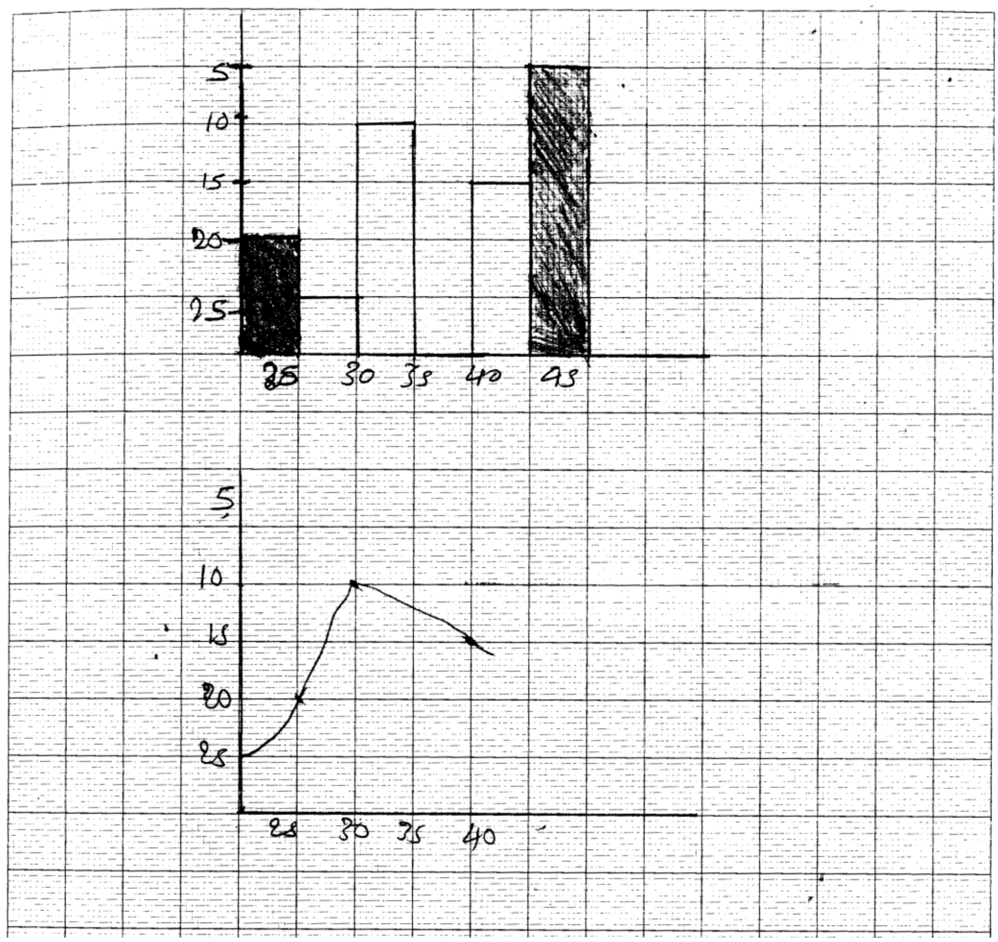
(b) the shape of the graph is Curve

(c) due to the reaction of base and acid lead to change the colour of solution

(e) $Na_2S_2O_3 + HCl \rightarrow NaCl + S_2 + SO_2 + H_2O$

$Na^+ S_2O_3 + H^+ + Cl^- \rightarrow Na^+ + Cl^- + S_2 + SO_2 + H_2O$

$S_2O_3 + H \rightarrow S_2 + SO_2 + H_2O$



Extract 19.2: A sample of incorrect responses in question 1.

In Extract 19.2, the candidate obtained random data in part (a), instead of decreasing data, plotted both a bar graph and a histogram in part (b), and responded to parts (c) and (d) incorrectly.

Alternative 2C

The candidates were required to study the reaction between sodium thiosulphate and hydrochloric acid at different temperatures. The chemicals provided were labelled as $\mathbf{A_1}$ for 0.05 M sodium thiosulphate and $\mathbf{A_2}$ for 1.0 M hydrochloric. Also, the candidates were provided with a piece of white paper marked **X** on which a 100 cm^3 beaker containing the reaction mixture was supposed to be placed during the experiment. The candidates were required to measure 30 of $\mathbf{A_2}$ and put it into the 100 cm^3 beaker placed on top of the **X** marked on the piece of paper. Then the candidates were required to measure 30 cm^3 of $\mathbf{A_1}$, put it into boiling tube, insert a thermometer into it and heat on water bath until it reaches a temperature of 40 ^{o}C. The next step required the candidates to transfer the heated solution

A_1 into the beaker containing solution **A_2** and immediately starting the stop watch. This step was followed by swirling the mixture, (while observing from above) and recording the time taken for letter **X** to disappear completely. Then the procedure was repeated by varying the temperature as shown in the table.

Table: Experimental Data

Volume of A_1 (cm^3)	Volume of A_2 (cm^3)	Temperature of A_1 (^oC)	Time (s)
30	30	40	
30	30	50	
30	30	60	
30	30	70	
30	30	80	

The candidates were required to:

(a) complete filling the table.

(b) (i) plot a graph of volume **N_1** (vertical axis) against time (horizontal axis) taken for the letter **X** to disappear completely.

(ii) state what does the shape of the graph indicate.

(c) give reason why did the letter **X** disappear.

(d) write the electronic configuration of the product which causes the solution to be cloudy (milky).

(e) write the ionic equation for the reaction between **N_1** and **N_2**.

(e) plot a graph of volume of **P_1** against the rate of the reaction.

(f) state why **N_3** was added to **N_1**.

The high scoring candidates attempted part (a) by filling in the table the time taken for the reaction at the different temperatures accurately. The trend of the data was that the time was decreasing with increase in temperature of **A_1**.

Consistently, in part (b)(i) the candidates plotted the graph of temperature against time taken indicating the title of the graph, the scales used and labeling of the axes appropriately. In part (b)(ii), the candidates commented worthily on the curve obtained in which the rate of the reaction was direct proportional to temperature.

Moreover, the candidates responded to part (c) to (f) correctly as shown in Extract 20.1.

Volume A_1 (cm^3)	Volume A_2 (cm^3)	temp of A_1	time (s)
30	30	40	38
30	30	50	34
30	30	60	27
30	30	70	25
30	30	80	22

(b) ii/ The shape of graph indicate "curved shape" which means that "an increase of temperature of solution A_1 tends to decrease the time of letter "X" to disappear.

(c) Ionic equation between A_1 and A_2

A_1 is sodium thiosulphate ($Na_2S_2O_3$)

A_2 is hydrochloric acid (HCl)

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

Then aqueous solution should be splited

$$2Na^+_{(aq)} + S_2O_3^{2-}{}_{(aq)} + 2H^+_{(aq)} + 2Cl^-_{(aq)} \longrightarrow$$

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

Cancel out all spectator ions to get Net ionic equation:

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

∴ The ionic equation for reaction between A_1 and A_2 is:

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

(d) The letter X disappear due to the formation of Sulphur (S) during the reaction which cause the Mixture to become milky in colour or cloudy.

(e) The substance deposited at the bottom of the flask is Sulphur (S)

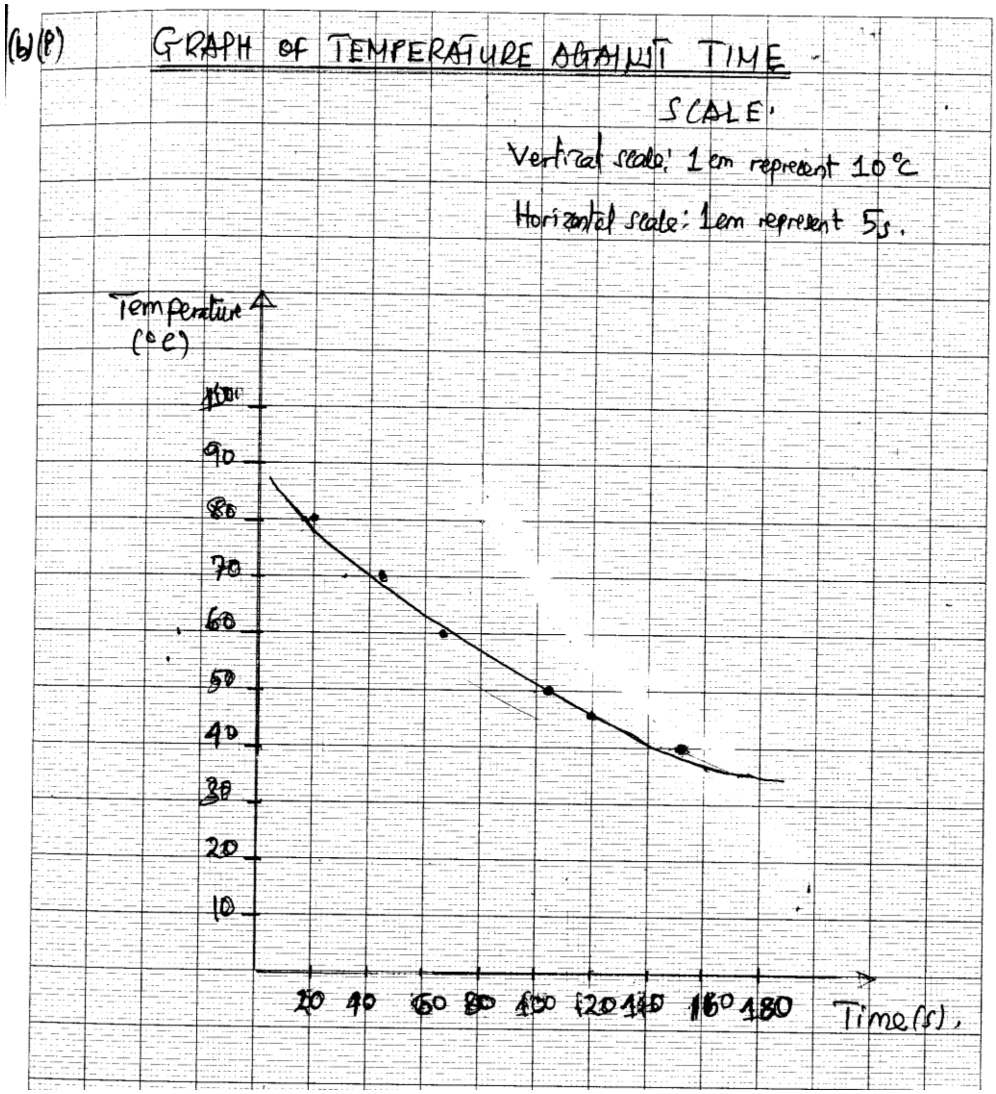
Atomic number of Sulphur is 16

then,

$S = 2:8:6$

∴ The electronic configuration of Sulphur is 2:8:6.

f) The rate will remain constant because the reaction is not reversible.



Extract 20.1: A sample of correct responses in question 2.

In Extract 20.1, the candidate correctly plotted the graph in part (b) using data obtained in part (a) and he/she answered the remaining parts of the question correctly.

On the other hand, the candidates who scored low marks failed to attempt most parts of the question. In part (a), they filled inaccutate data of time taken in the table. Furthermore, they recorded inconsistent data differing from each other significantly. Few others recorded time in minutes (instead of seconds) however, by converting back to seconds, the data were still incorrect.

In plotting the graph in part (b)(i), some of the candidates did not label the axes of the graph while others did not indicate the title of the graph. Some few candidates used inappropriate vertical and horizontal scales while others drew incorrect best lines or curves as they failed to locate the individual points on the graph. Likewise, the comments given by the candidates on the shape of the graph in part (b)(ii) were irrelevant. For example, one candidate incorrectly commented temperature is direct proportional to time of the reaction. Another candidate remarked incorrectly that, *the time varies the same as the temperature*. The incorrect responses are an indication that the candidates failed to interpret the graph (in this case the curve) appropriately.

In part (c), some of the candidates wrote incorrect ionic chemical equations without indicating the state symbols and charges correctly. Others responded in this part by writing the complete chemical equation which is different from the ionic equation in which the spectator ions do not appear. Furthermore, there were cases in which candidates wrote chemical equations with irrelevant chemical species.

Part (d) was also attempted incorrectly by most of the candidates in this category. Few of them gave incorrect reasons for the disappearance of the mark X. To mention the few, one candidate wrote *the indicator showed colour change* while another wrote *it was the end of the reaction*. Another candidate incorrectly responded that *the equivalency point was reached by the indicator*. Those candidates confused concepts studied in volumetric analysis with concepts in chemical kinetics.

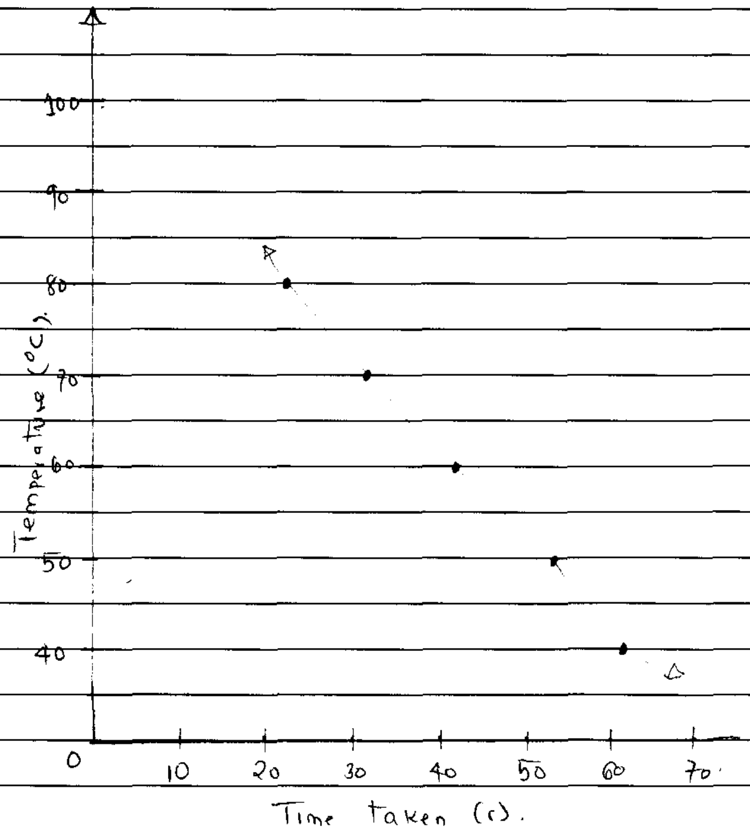
In part (e), the candidates failed to recognize sulphur as one among the products and hence gave incorrect electronic configuration. Some of them wrote electronic configurations of other elements such as oxygen and chlorine. Other candidates responded by writing names of irrelevant compounds such as sulphates and chlorine gas. Such responses indicate that the candidates lacked adequate knowledge of the properties of products of chemical reaction between $\mathbf{N_1}$ and $\mathbf{N_2}$. In addition, some of the candidates wrote the symbol for suphur without showing its electronic configuration which is 2:8:6.

In part (f), most of the candidates responded that the rate of the reaction will change (either by increasing or decreasing) not realizing that the rate of the reaction would remain the same. The candidates gave reasons which were not based on factual information. Some of those reasons include *decrease in pressure in the system* and *decrease in concentration*. The incorrect responses indicate that the candidates confused the concept of simple reactions with the concept of reactions at equilibrium. Extract 20.2 shows sample of incorrect responses in this question.

2. (a) Complete a table.

Volume of A_1 (Cm^3)	Volume of A_2 (cm^3)	Temperature of (A_1) °C)	Time (s).
30	30	40	21
30	30	50	31
30	30	60	41
30	30	70.	52
30	30	80.	61

(b) (i) Graph of temperature against time taken for the letter X.



2. (ii) Shape of the graph indicated is linear shape.

(c) Ionic equation for the reaction between A_1 and A_2.

The equation is → $NaSO_3$ + HCl → $NaCl$ + $H.SO_3$

(d) letter X disappear ~~because~~ due to the formation of thiosulphate (base)

(e) Electronic configuration of substance Mercury.

(f) If the deposited substance could be removed from the reaction mixture the temperature device

Extract 20.2: A sample of incorrect responses in question 1.

In Extract 20.2, the candidate incorrectly plotted the graph using data obtained in part (a) and answered the remaining parts of the question incorrectly.

3.0 THE ANALYSIS OF THE CANDIDATES' PERFORMANCE ON EACH TOPIC

The Chemistry paper 1 and paper 2 consisted of a total of 16 topics in a total of 16 questions. The analysis shows that, question 1 had the best performance of 87.2 percent. The question comprised the following topics: *Hardness of Water; Fuels and Energy; Air, Combustion, Rusting and Firefighting; Organic Chemistry; Laboratory Techniques and Safety; The Scientific Procedures; Oxygen and Hydrogen;* and *The Mole Concept and Related Calculations*.

Furthermore, the analysis revealed that 2 topics attained good performance. Those topics were: *Formulae, Bonding and Nomenclature (80.3%)* examined in question 11, *Atomic Structure (77.4%)* in question 10 and *Matter (69.0%)* which was examined in both questions 2 and 3.

The topics which had average performance were: *Volumetric Analysis (64.5%)* examined in questions 5, 8 (paper1), and question 1 in paper 2;

Chemical Kinetics, Equilibrium and Energetics (64.1%) examined in question 12 and question 2 (paper 2); and *Non-metals and Their Compounds (61.5%)* which was examined in question 13 and 14.

Weak performance was observed in the topics of: *Chemical Equations (27.1%), Water (26.1%), Laboratory Techniques and Safety (22.1%)*, and *Ionic Theory and Electrolysis (13.0%).*

The weak performance in the topics stated was caused by inadequate knowledge of the candidates about the tested concepts, failure to identify the requirements of the respective questions, poor English language proficiency and lack of adequate mathematical skills. The performance of the candidates in different topics is summarized in the attached appendix.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

Generally, the performance of the candidates in Chemistry CSEE 2020 was good in which 87.09 percent of the candidates passed. The analysis of the candidates' performance revealed that the questions which had good performance in paper 1 were: 1 (87.2%) from mixed topics, 2 (72.0%) from *Matter*; 10 (77.4%) *Atomic Structure*; 11 (80.3%) from *Formulae, Bonding and Nomenclature;* and 13 (73.2%) from *Non-metals and Their Compounds*. Questions which had average performance were: 3 (66.0%) from *Matter*; 8 (36.2%) from *Volumetric Analysis*; 12 (38.9%) from *Chemical Kinetics, Equilibrium and Energetics*; and 14 (49.8%). Questions which had weak performance were: 4 (22.1%) from *Laboratory Techniques and Safety*; 5 (10.2%) from *Volumetric Analysis*; 6 (26.1%) from *Water*; 7 (27.1%) from *Chemical Equations* and 9 (13.0%) from *Ionic Theory and Electrolysis*. Both questions which were examined in the practical paper had good performance. Question 1 (92.2%) was from the topic of *Volumetric Analysis* and question 2 (89.3%) was from the topic of *Chemical Kinetics, Equilibrium and Energetics*.

Further analysis revealed that the good performance of candidates in Chemistry subject was contributed by adequate knowledge and good understanding of demands of the questions. On the other hand some of the candidates had weak performance due to the following factors:

(a) Lack of adequate knowledge of various concepts. For instance, some of the candidates failed to explain five importance of balancing chemical equations in question 7.

(b) Inability to apply appropriate chemical formulae to represent compounds and chemical equations to represent chemical reactions.

(c) Failure to integrate classroom lessons with the real life situations. This was evident in responses to question 3 in which some candidates failed to give the role of matter in daily life.

(d) Lack of adequate mathematical skills: This was evident as some candidates failed to respond correctly to questions which required calculations.

(e) Poor English language proficiency: This was shown by failure to understand the demand of the questions and inability to write meaningful sentences.

4.2 Recommendations

The following recommendations are given in order to improve the candidates' performance in future examinations:

(a) Teachers are recommended to guide students to carry out experiments to verify Faraday's First and Second laws of Electrolysis. This will help towards improving performance in the topic of *Ionic Theory and Electrolysis*.

(b) Teachers to guide students on how to render First Aid in real life situations at school so as to improve performance in the topic of *Laboratory Techniques and Safety*.

(c) Teachers to lead students describe the process of water treatment for domestic uses by using locally available materials such as a clean cloth, sand, charcoal, gravel, filter paper, sauce pan (sufuria) and water guard. This will enhance performance in the topic of *Water*.

(d) The teacher to lead students in writing molecular and ionic equations based on the rules of predicting reaction products. This will help to improve performance in the topic of *Chemical Equations*.

(e) Teachers are recommended to lead students to convert masses of solids or volumes of gases to actual number of particles. This will facilitate towards addressing the weak performance in the topic of *Ionic Theory and Electrolysis* and average performance in *Volumetric Analysis*.

Appendix

ANALYSIS OF CANDIDATES' PERFORMANCE PER TOPIC

S/N	Topic	Question	% of Candidates who scored 30 marks or above	Average	Remarks
1	*Hardness of Water; Fuels and Energy; Air, Combustion, Rusting and Firefighting; Organic Chemistry; Laboratory Techniques and Safety; The Scientific Procedures; Oxygen and Hydrogen;* and *The Mole Concept and Related Calculations*.	1	87.2	87.2	Good
2	*Formulae, Bonding and Nomenclature*	11	80.3	80.3	Good
3	*Atomic Structure*	10	77.4	77.4	Good
4	*Matter*	2	72.0	69.0	Good
		3	66.0		
3	*Chemical Kinetics, Equilibrium and Energetics.*	12	38.9	64.1	Average
		2 (Paper 2)	89.3		
4	*Non-metals and Their Compounds*	13	73.2	61.5	Average
		14	49.8		
5	*Volumetric Analysis*	5	10.2	46.2	Average
		8	36.2		
		1 (Paper 2)	92.2		
6	*Chemical Equations*	7	27.1	27.1	Weak
7	*Water*	6	26.1	26.1	Weak
8	*Laboratory Techniques and Safety*	4	22.1	22.1	Weak
9	*Ionic Theory and Electrolysis*	9	13.0	13.0	Weak