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

STUDENTS' ITEM RESPONSE ANALYSIS REPORT ON THE FORM TWO NATIONAL ASSESSMENT (FTNA) 2022

CHEMISTRY

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032 CHEMISTRY

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FOREWORD

This report presents Students' Items Response Analysis (SIRA) on Form Two Chemistry National Assessment which was conducted in November 2022. The report aims to provide feedback to all educational stakeholders on the factors that contributed to the students' performance in Chemistry.

The Form Two National Assessment (FTNA) is a formative evaluation which intends to monitor students' learning in order to provide feedback that teachers, students and other educational stakeholders can use to improve teaching and learning respectively. This analysis shows justification for the students' performance in the Chemistry subject. The students who attained high scores had adequate knowledge of the concepts tested and managed to explain scientific facts. Contrarily, those who scored low marks lacked adequate knowledge of concepts and failed to respond according to the demands of the questions in justifying scientific facts. Additionally, the students who scored low marks demonstrated poor skills in mathematics.

This report will help students to identify strengths and weaknesses for them to improve learning before sitting for their Certificate of Secondary Education Examination (CSEE). It will help teachers to identify the challenging areas and take appropriate measures during teaching and learning.

The National Examinations Council of Tanzania (NECTA) expects that the feedback provided in this report will shed light on the challenges for which education stakeholders should take proper measures to improve teaching and learning the Chemistry subject. Consequently, students will acquire knowledge, skills and competences indicated in the syllabus for better performance in future assessments and examinations.

The Council appreciates the contribution of all those who prepared this report.

Dr. Said Ally Mohamed
EXECUTIVE SECRETARY

1.0 INTRODUCTION

This report analyses the performance of the students who sat for the Form Two National Assessment (FTNA) 2022 in Chemistry subject. The 2022 Chemistry paper was set according to the FTNA format, which was developed from the 2007 Chemistry syllabus for Ordinary Level Secondary Education reprinted in 2017.

The paper comprised of sections A, B and C. Section A consisted of two objective questions whereby question 1 consisted of ten multiple choice items. Question 2 comprised five matching items. Section B consisted of seven short answer questions, whereas section C comprised of one essay/structured question. The students had to answer all the questions in sections A, B and C.

A total of 632,840 students sat for the 2022 Chemistry assessment, out of which 33.45 per cent passed the assessment. This indicates that the overall performance was average. The students' performance in each grade (A to F) is shown in Table 1.

Table 1: The Performance of Students in each Grade in 2022

S/N	Grade	Number of Students	Percentage of Students
1.	A	11,354	1.79
2.	B	13,582	2.15
3.	C	61,813	9.77
4.	D	124,953	19.74
5.	F	421,138	66.55

Table 1 shows that the number of students who failed the assessment amounts to 66.55 per cent, and only 1.79 per cent scored grade A.

In the year 2021, a total of 254,880 (42.37%) students out of 601,510 passed the assessment. Thus, students' performance in the year 2022 has decreased by 8.92 per cent compared to the performance in 2021.

2.0 ANALYSIS OF STUDENTS' PERFORMANCE IN EACH QUESTION

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

Section A weighed 15 marks, in which question 1 carried a total of ten (10) marks, while question 2 carried five (05) marks. Each question in section B carried ten (10) marks, and section **C** carried fifteen (15) marks. All questions in sections A, B and C were compulsory.

2.1 SECTION A: OBJECTIVE QUESTIONS

This section consisted of two objective questions, namely multiple choice and matching items.

2.1.1 Question 1: Multiple Choice Items

The question consisted of 10 items set from 9 topics, as follows: *Introduction to Chemistry; Oxygen; The scientific Procedures; Matter; Air Combustion, Rusting and Fire Fighting; Heat Sources and Flames; Atomic Structure; Periodic Classification* and *Formula, Bonding and Nomenclature*.

This question was attempted by 634,429 (100%) students. The analysis of the students' performance indicates that 19.30 per cent scored from 0 to 2 marks, 60.60 per cent scored from 3 to 6 marks, while 20.10 per cent scored from 7 to 10 marks. Generally, the performance in this question was good with 80.70 per cent of the students scoring 3 marks or above. Figure 1 gives the summary of the performance.

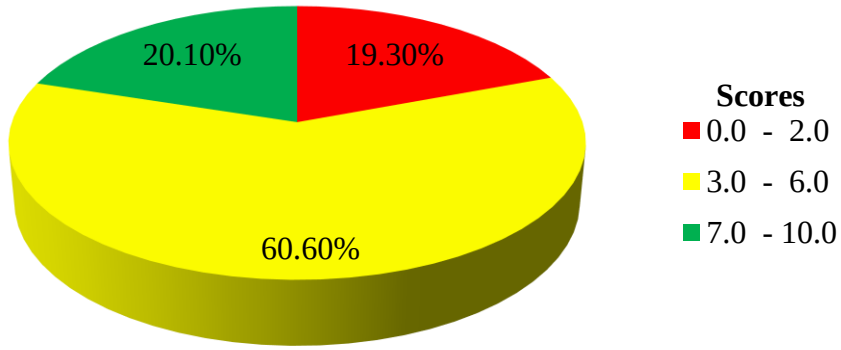


Figure 1: *Students' Performance in Question 1*

The students who scored high marks (20.10%) answered most items of the question correctly. This implies that, the students had satisfactory

knowledge of different concepts across topics from which the items were composed.

However, the students who scored low marks (19.30%) failed to attempt most of the items. Generally, the students had inadequate knowledge of the concepts. The general analysis of the student's responses to each item, is as follows:

In item (i), the students were asked to identify the set of products in chemistry which are used for domestic cleanliness. The correct answer was *C, Detergents, soap, toothpaste and deodorant.* Students who chose the correct answer had adequate knowledge on the importance of Chemistry in daily life. The students who opted for; *A, Toothpaste, oils, detergents and deodorant; B, Soap, deodorant, toothpaste and fuel; D, Drugs, toothpaste, soap and oils* failed to understand that oil is used as lubricant and fuel is used as source of heat energy. Likewise, they did not understand the role of drug which is to treat diseases rather than cleanliness.

In item (ii), the students were given the information that *"During practical work a measuring cylinder was used to prepare oxygen by decomposing hydrogen peroxide. What is the function of the cylinder in this experiment?"* The correct answer was *A, To measure volume*. Students who opted for the correct answer were knowledgeable on the uses of laboratory apparatuses. Those who chose *B, To measure weight* confused the function of spring balance with that of measuring cylinder. The students who opted for *C, To measure width* or *D, To measure volume length* confused the dimensions (length and width) which are used to calculate volume with volume itself.

In item (iii), the students were required to identify the scientific procedure which follows after data interpretation. The correct answer was *C, Conclusion*. Students who chose the correct answer had adequate knowledge on the main steps of the scientific procedure. Students who chose either *A, Observation*; *B, Hypothesis* or *D, Experimentation* did not understand that those steps come before data interpretation, as such they, lacked adequate knowledge on the steps to follow during scientific investigation.

In item (iv), the students were given information that "*The teacher was demonstrating an experiment by dissolving sodium chloride in water until the solute was not dissolving anymore. What type of the solution formed at the end of the experiment?"* The correct answer was *A, saturated.* Students

who wrote the correct answer had adequate knowledge about the classification of solutions based on the amount of solute dissolved in a solvent at a given temperature and pressure. Students who opted for; *B, Unsaturated* failed to understand that in unsaturated solution the solvent has the capacity of dissolving more amount of solute at a particular temperature. Those who chose C, *Super saturated* were not aware that if a solution holds more solutes than saturated solution at a given temperature it is termed super saturated. Similarly, those who opted for alternative *D, Suspension* lacked the knowledge that, solution is a homogeneous mixture while suspension is a heterogeneous mixture. Therefore, they failed to categorize mixtures into solutions, suspensions and emulsions.

In item (v), the students were asked to identify the gas which is the major component of air. The correct answer was *A, Nitrogen*. Students who got the correct answer had adequate knowledge about the components of air and their proportions. Those who opted for either *B, Noble gases; C, Carbon dioxide* or *D, Oxygen* had the idea that air is a mixture but lacked sufficient knowledge about the proportions of the constituents of air.

In item (vi), the students were given information that "*John and Asha were debating about the processes that are involved during simple distillation. What processes will you recommend to them?"* The correct answer was *D, Evaporation and condensation.* Students who chose the correct answer were aware that simple distillation involves two processes, heating the solution until evaporation of the liquid components followed by condensation of the vapour. Students who opted for either alternative *A, Filtration and decantation; B, Condensation and decantation;* or *C, Evaporation and filtration* lacked adequate knowledge of the respective methods of separating mixtures.

In item (vii), the students were given the statement that "*Form two students discovered that it is impossible to light fire in vacuum due to the absence of a certain gas. What comment can you give to the students?"* The correct answer was *B, Oxygen is missing.* Students who chose the correct answer had adequate knowledge of the conditions necessary to light fire (fire triangle). Students who chose either alternative *A, Nitrogen is missing* or *D, Hydrogen is missing* had no sufficient knowledge that nitrogen and hydrogen are combustible materials rather than gases which support burning or combustion. Students who opted for alternative C, *Carbon dioxide is missing* did not understand that carbon dioxide being denser than air, settles

on burning material as occluding (retaining) blanket which prevents more oxygen from lighting fire. Also, they did not comprehend that carbon dioxide does not support combustion.

In item (viii) students were provided with the statement that *"Atomic structures of all elements consist of electrons, protons and neutrons* ***except*** *that of:"* The correct answer was *A, Hydrogen*. Students who gave the correct answer had good understanding of the number of electrons, number of protons and relationship between mass number of an atom, atomic number and neutrons. Those who chose either *B, Nitrogen; C, Oxygen* or *D, Carbon* lacked mathematical skills in calculating neutrons number by using formula *Neutrons number (n) = Mass number(A) – Atomic number (Z).* They also had inadequate knowledge about the relationship between number of protons and electrons in an atom.

In item (ix), *the students were given statement that "When referring to the modern Periodic Table, the transition elements are found between:"* The correct answer was C, *group II and III*. Students who opted for the correct answer had adequate knowledge on the electronic structure of elements and electronic configuration to locate the position of elements in the modern Periodic Table. Students who chose either of alternatives; *A, group I and II; B, group I and III* or *D, group III and IV* lacked adequate knowledge about the arrangement of elements in the Periodic Table based on atomic number and electronic configuration.

In item (x), the students were required to identify the chemical formula of a compound formed by combining element **M** with electronic configuration 2:8:3 and element **G** with electronic configuration of 2:6. The correct answer was *B,* M_2G_3. Students who chose the correct answer had enough skills on how to use electronic configuration to determine the valence of elements. Thus, the students were able to write the chemical formula of the compound. Those who opted for *A,* G_3M_2 exchanged the position of the two elements erroneously. Students who opted *C,* G_2M regarded element G being a metal and element M being a non-metal instead of the vice-versa. They also assumed wrong valencies. Those who chose *D,* M_3G_2 exchanged the valencies of the two elements.

2.1.2 Question 2: Matching Items

In this question students were required to match the mixtures in **List A** with the corresponding methods of separation in **List B** by writing the letter of the correct answer below the item number in the table provided.

List A	List B
(i) Chlorophyll from leaves	A Simple distillation
(ii) Sulphur and iron fillings	B Magnetization
(iii) Sand and ammonium chloride	C Chromatography
(iv) Pure water from muddy water	D Solvent extraction
(v) Salt from the sea water	E Evaporation
	F Sublimation
	G Filtration

The question was attempted by 634,429 (100%) students. The percentage of students who scored from 0 to 1 mark was 33.43, from 2 to 3 marks was 44.73 and from 4 to 5 marks was 21.83. Generally, the performance of students in this question was good as 66.57 per cent scored 2 marks or above. Summary of the students' performance in this question is shown in Figure 2.

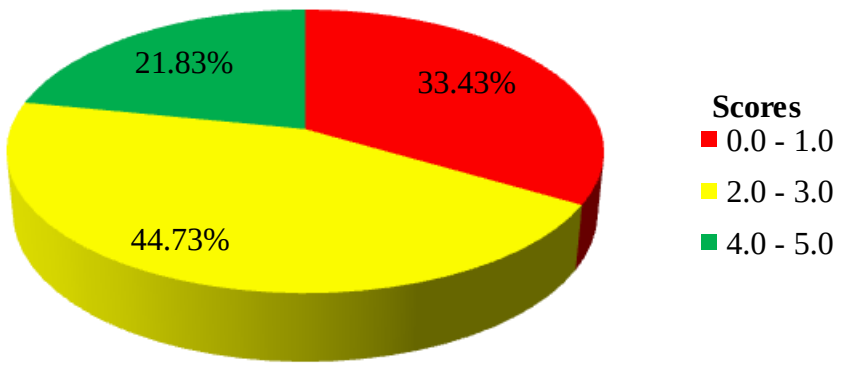


Figure 2: *Students' Performance in Question 2*

Students who scored high marks (21.83%) correctly matched the mixtures stated with their corresponding methods of separation. This indicates that, they had sufficient knowledge on the nature of components in the mixtures and their relevant methods of separation/extraction. Extract 2.1 shows a sample of correct responses given by one of the students in question 2.

2. Match the mixtures in **List A** with the corresponding methods of separation in **List B** by writing the letter of the correct answer below the item number in the table provided.

List A		List B	
(i)	Chlorophyll from leaves	A	Simple distillation
(ii)	Sulphur and iron fillings	B	Magnetization
(iii)	Sand and ammonium chloride	C	Chromatography
(iv)	Pure water from muddy water	D	Solvent extraction
(v)	Salt from the sea water	E	Evaporation
		F	Sublimation
		G	Filtration

Answers

List A	(i)	(ii)	(iii)	(iv)	(v)
List B	C	B	F	A	E

Extract 2.1: A sample of correct responses to question 2

In Extract 2.1, the student matched correctly each mixture in **List A** with its suitable method of separation in **List B.** This means that the student had sufficient knowledge about the properties of the components of the mixtures.

Conversely, students who scored low marks (33.43%) failed to attempt most of the items in this question. Most of them related the mixtures with inappropriate methods of separation. Some opted for *B, Magnetization,* as a method of separating chlorophyll from leaves in (i). Others incorrectly identified *A, Simple distillation* as the suitable method for separating a mixture of sulphur and iron fillings in (ii). The method of simple distillation cannot be used to separate a mixture of solids rather a mixture of liquids. Others incorrectly matched item (iii) Sand and ammonium chloride with response *G, Filtration* which is not correct because the two components

cannot pass through the filter. Likewise, some of the students mistakenly identified *F, Sublimation*, as the suitable method of separating pure water from muddy water in (iv) which is not practical. Also, there were students who incorrectly suggested *F, Sublimation* as a method to separate salt from sea water. Another misconception involved choosing responses A, B, C, D and E for items (i), (ii), (iii), (iv) and (v), respectively, which implies that the students guessed for the answers. Failure of the students to match the items appropriately is an indication that they had inadequate knowledge on both the properties of mixtures and their corresponding methods of separation. Extract 2.2 indicates a sample of incorrect responses from one of the students.

2. Match the mixtures in **List A** with the corresponding methods of separation in **List B** by writing the letter of the correct answer below the item number in the table provided.

List A		List B	
(i)	Chlorophyll from leaves	A	Simple distillation
(ii)	Sulphur and iron fillings	B	Magnetization
(iii)	Sand and ammonium chloride	C	Chromatography
(iv)	Pure water from muddy water	D	Solvent extraction
(v)	Salt from the sea water	E	Evaporation
		F	Sublimation
		G	Filtration

Answers

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

Extract 2.2: A sample of incorrect responses to question 2

In Extract 2.1, the student incorrectly matched the mixtures in List A with methods of separation from List B. This indicates lack of adequate knowledge on the properties of mixtures and relevant methods of separation.

2.2 SECTION B: SHORT ANSWER QUESTIONS

This section consisted of seven (7) short answer questions, weighing ten (10) marks each. Students were required to answer all questions. The pass score for each question was 3 marks.

2.2.1 Question 3: Matter

The question consisted of three parts, namely; (a), (b) and (c). In part (a), students were given the information that: *A chemist heated a mixture of ammonium chloride and sand in a test tube. After five minutes, only sand remained in the test tube. Explain the observation made by the chemist*. In part (b), students were given information that "*A gardener became sick and decided to rush to hospital. After checkup, a doctor prescribed medicines and instructed the gardener to shake the medicine well before use. What does the instruction imply basing on the types of the mixture? Give reason to support your answer"*. In part (c) students were required to differentiate mixture from compound by giving five points.

The question was attempted by 634,429 (100%) students out of which 84.24 per cent scored from 0 to 2 marks, 11.97 per cent scored from 3 to 6 marks and 3.79 per cent scored from 7 to 10 marks. The general performance in this question was weak as only 15.76 per cent of the students scored 3 marks or above. The distribution of students' scores in this question is shown in Figure 3.

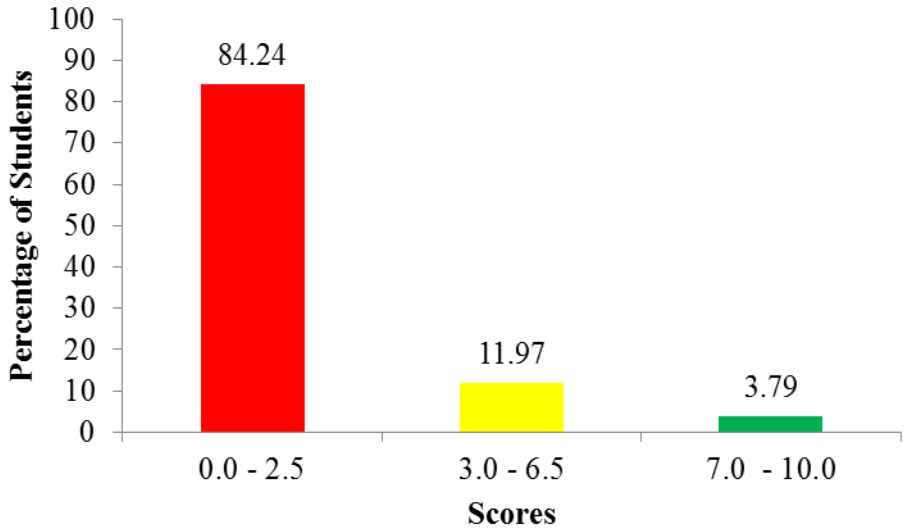


Figure 3: *Students' Performance in Question 3*

Figure 3 shows that 84.24 per cent of the students had weak performance in this question. Students who scored low marks listed some few terms instead of giving explanations or reasons. For example, some of the students wrote "evaporation" in part (a) instead of giving explanation about sublimation of ammonium chloride. This portrays that, these students lacked knowledge

about changes of state of matter. Basically, when the mixture was heated, ammonium chloride changed state directly from solid to gas (sublimation) and sand was left in the test tube as a residue. Likewise, in part (b), some students wrote "homogenous mixture" while few others wrote "homogenous solution". These students failed to understand that the medicine consisted of fine particles which settle to the bottom of container (suspension) thus, the upper part of the medicine contained less amount of solute compared to lower part of the medicine. In part (c), some students gave properties of mixture and compound interchangeably. For example, some of them wrote "compounds can be separated by physical means while mixture can be separated by chemical means". Others gave incorrect examples of mixtures and compound. For instance, one student cited *ash* as a mixture and tea solution as a compound. This implies that, the students lacked adequate knowledge on mixtures, compounds and the properties of matter. A sample of incorrect responses in question 3 is shown in Extract 3.1.

3. (a) A chemist heated a mixture of ammonium chloride and sand in a test tube. After 5 minutes, only sand remained in the test tube. Explain the observation that made by a chemist.

Because ammonium chloride is filtration distribution.

(b) A gardener became sick and decided to rush to hospital. After checkup, the doctor prescribed medicines and instructed the gardener to shake the medicines well before use. What does the instruction imply basing on the type of the mixture? Give reason to support your answer.

To move the combination in high levels.

(c) Differentiate mixture from compound by giving five points.

S/N	Mixture	Compound
(i)	It is made of two or more element	It does not have two or more element
(ii)	It is in ration	It is in ration
(iii)	It contain element	It contains atom
(iv)	It is physica state	It is physical chemical state
(v)	It is mare than two	It is mare than one

Extract 3.1: A sample of incorrect responses to question 3

In Extract 3.1, the student wrote filtration instead of sublimation in part (a). Also, in part (b) the student wrote “To move the combination in high level” instead of explaining the syrup medicine as a suspension/heterogenous mixture. Moreover, he/she wrote incorrect differences of mixtures and compounds in part (c).

On the other hand, students who scored high marks (3.79%) in this question demonstrated adequate knowledge that when ammonium chloride is heated it changes state directly from solid to gas and the sand is left in the test tube unchanged in part (a). Therefore, they were able to identify the correct method of separation (sublimation). In part (b), the students pointed out that the medicine prescribed was a suspension in nature. They gave a reason that the medicine contained fine particles which settle to the bottom of the container, hence the need to shake the medicine in order to mix well. Extract 3.2 shows a sample of correct responses from one of the students.

3. (a) A chemist heated a mixture of ammonium chloride and sand in a test tube. After 5 minutes, only sand remained in the test tube. Explain the observation that made by a chemist.

When a person heat ammonium chloride and sand, sand will not undergo any change but for ammonium chloride it will sublimate means changing from solid to gas. Therefore a chemist has observed a process called sublimation

(b) A gardener became sick and decided to rush to hospital. After checkup, the doctor prescribed medicines and instructed the gardener to shake the medicines well before use. What does the instruction imply basing on the type of the mixture? Give reason to support your answer.

It is based on suspension. In a medicine or sometimes called syrup there is a mixture of water and fine particles of solid which are not dissolved but suspended. So in order for them to mix the medicine need to be well so that solid particles may dissolve in a liquid

(c) Differentiate mixture from compound by giving five points.

S/N	Mixture	Compound
(i)	It can be separated by physical methods	It cannot be separated by physical methods
(ii)	It's properties are those of individual element	It's properties are different from those of individual elements
(iii)	It may vary widely in composition	It's composition is fixed and do not vary
(iv)	Its component may be seen separately	Its component cannot be seen separately
(v)	No new substance is formed when a mixture is formed	Involves new substances in the formation of a compound

Extract 3.2: A sample of correct responses to question 3

In Extract 3.2, the student wrote correctly the method of separating the mixture in part (a). Likewise, in part (b), he/she explained the concept of suspension and in part (c) the student differentiated mixture and compound, correctly.

2.2.2 Question 4: Air, Combustion, Rusting and Fire Fighting

This question comprised of two parts, namely (a) and (b). Part (a) had three subparts (i), (ii) and (iii). The students were required to support each of the following statements: In part (a) (i) "*Helium is used in filling balloons*

instead of hydrogen gas despite the fact that hydrogen is a lighter gas than helium. In part (a) (ii) *"When air bubbles pass through lime water, lime water turns milky".* In part (a) (iii) "*The iron and steel of bridges, ships and pipelines are protected from rusting by joining to a reactive metal such as magnesium"*. In part (b) students were required to briefly explain two processes which add carbon dioxide to the air.

The question was attempted by 634,429 (100%) students of which 93.46 per cent scored from 0 to 2 marks, 5.70 per cent scored from 3 to 6 marks and 0.84 per cent scored from 7 to 10 marks. Generally, the performance in this question was weak because only 6.54 per cent of the students scored 3 marks or above. The distribution of students' performance is summarized in Figure 4.

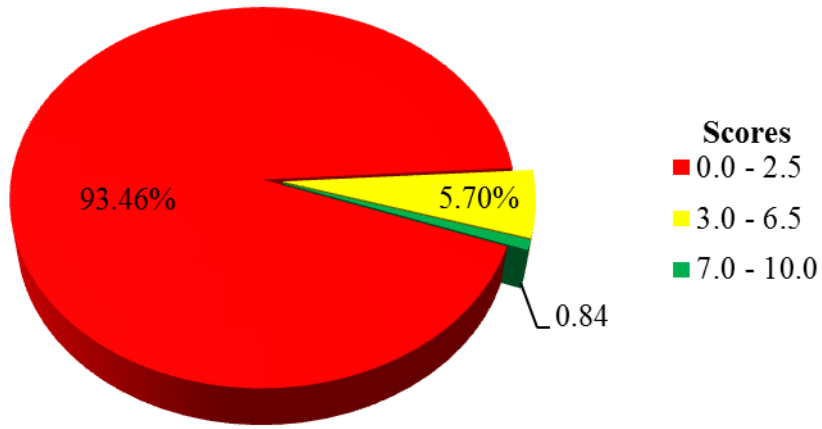


Figure 4: *Students' Performance in Question 4*

Students who scored low marks (93.46%) failed to attempt most parts of the question. For example, in part (a) (i), some of the students wrote the answer "helium is inert gas" compared to hydrogen. Those students had no adequate knowledge about the physical properties of both hydrogen and helium. Likewise in part (a) (ii) some of the students incorrectly admitted presence of nitrogen and hydrogen. Those candidates were not aware that lime water cannot turn milky in presence of nitrogen or hydrogen gas. Furthermore, some of the students provided incorrect reasons in part (a) (iii). For instance, one student wrote "magnesium does not react with air and water". Another student interpreted the use of magnesium as the application of galvanization instead of sacrificial protection. Those students were not conversant that

highly reactive metals such as magnesium protect iron by first reacting with water and oxygen, hence, no rust formation. In part (b), some students mentioned incorrect processes such as evaporation, acidic rain and afforestation which do not add carbon dioxide in air. The students did not understand that burning of fuels such as kerosene or other combustible materials cause production of carbon dioxide. Also, the students were supposed to be aware that through breathing in animals, carbon dioxide is added into air. Extract 4.1 shows a sample of incorrect responses from one of the students.

4. (a) Give reasons to support each of the following statements.

(i) Helium is used in filling balloons instead of hydrogen gas despite the fact that hydrogen is a lighter gas than helium.

Because the group VIII/0 elements are lightest gas according to their properties

(ii) When air bubbles pass through lime -water, lime water turns milky.

Because air bubbles consist of white colour so that when pass through lime- water, lime water turns milky.

(iii) The iron and steel of bridges, ships and pipelines are protected from rusting by joining to a reactive metal such as magnesium.

~~Because oxygen reacts with~~ because the iron or steel made up of metals and coloured

(b) Briefly explain two processes which add carbon dioxide to the air.

i) Fractional distillation

ii) Paper separation

Extract 4.1: A sample of incorrect responses to question 4

In Extract 4.1, the student referred to group VIII elements instead of hydrogen gas being highly flammable or explosive in part (a) (i). In part (a) (ii) he/she termed air bubbles being whitish instead of citing formation of calcium carbonate due to presence of carbon dioxide. Similarly, the student gave incorrect answer in part (a)(iii) whereas in part (b) he/she gave methods of mixture separation instead of processes which add carbon dioxide to the air.

On the other hand, students who scored high marks (0.84%) managed to write correct answers in most items in part (a). This shows that, the students had adequate knowledge about the physical properties of hydrogen, chemical test of carbon dioxide and methods of preventing rusting. In part

(b), the students explained correct processes which add carbon dioxide to the air. This implies that the students had adequate knowledge on the sources of carbon dioxide. Extract 4.2 shows a sample of correct responses from one of the students.

4. (a) Give reasons to support each of the following statements.

(i) Helium is used in filling balloons instead of hydrogen gas despite the fact that hydrogen is a lighter gas than helium.

Hydrogen is highly flammable.

(ii) When air bubbles pass through lime -water, lime water turns milky.

Because air bubbles contain carbon dioxide gas.

(iii) The iron and steel of bridges, ships and pipelines are protected from rusting by joining to a reactive metal such as magnesium.

Magnesium does not rust but is sacrificially corroded.

(b) Briefly explain two processes which add carbon dioxide to the air.

(i) Combustion: When combustion takes place, there is production of carbon dioxide, soot, vapour and heat.

(ii) Refinery of fuels: Through refinery of fuels carbon dioxide, vapour and volatile matter may be produced.

Extract 4.2: A sample of correct responses to question 4

In Extract 4.2, the student attempted part (a) by writing correctly the physical property of hydrogen gas which hinders its uses in filling balloons. Furthermore, he/she mentioned carbon dioxide which causes lime water to turn milky and pointed out sacrificial protection as the role of magnesium in preventing rusting of iron/steel. In part (b), the student stated correct processes which add carbon dioxide to the air.

2.2.3 Question 5: Formula, Bonding and Nomenclature

The question comprised two parts, namely (a) and (b). In part (a) students were required to differentiate empirical formula from molecular formula. In part (b) students were given information that "*A form two student found a*

bottle of chemical in the laboratory with a percentage composition by mass; Na = 24.4%, C = 3.12 %, O = 25.49% and H_2O = 46.92%. Determine the empirical formula of the compound".

The question was attempted by 634,429 (100%) students out of which 64.25 per cent scored from 0 to 2 marks, 30.53 per cent scored from 3 to 6 marks and 5.22 per cent scored from 7 to 10 marks. The general performance of the students in this question was average since 35.75 per cent of the students who attempted this question scored 3 marks or above. The distribution of students' scores in this question is summarized in Figure 5.

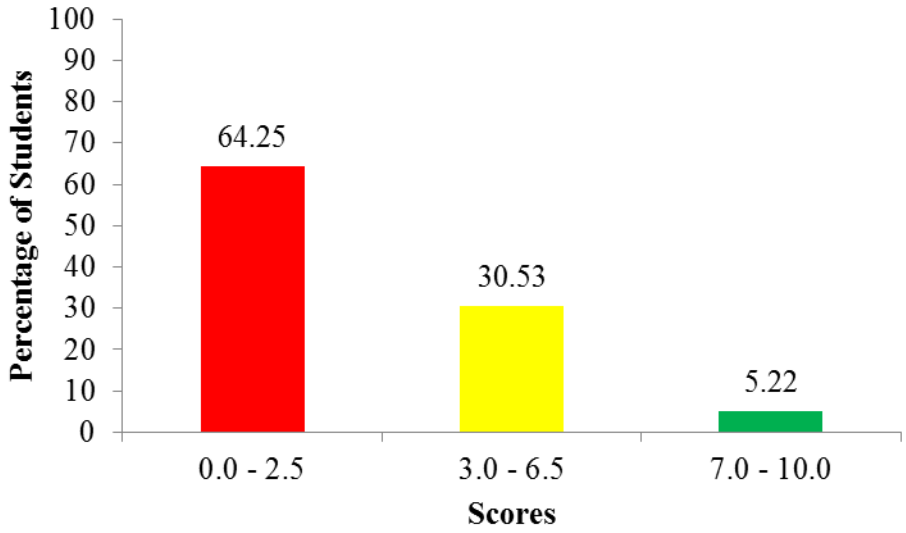


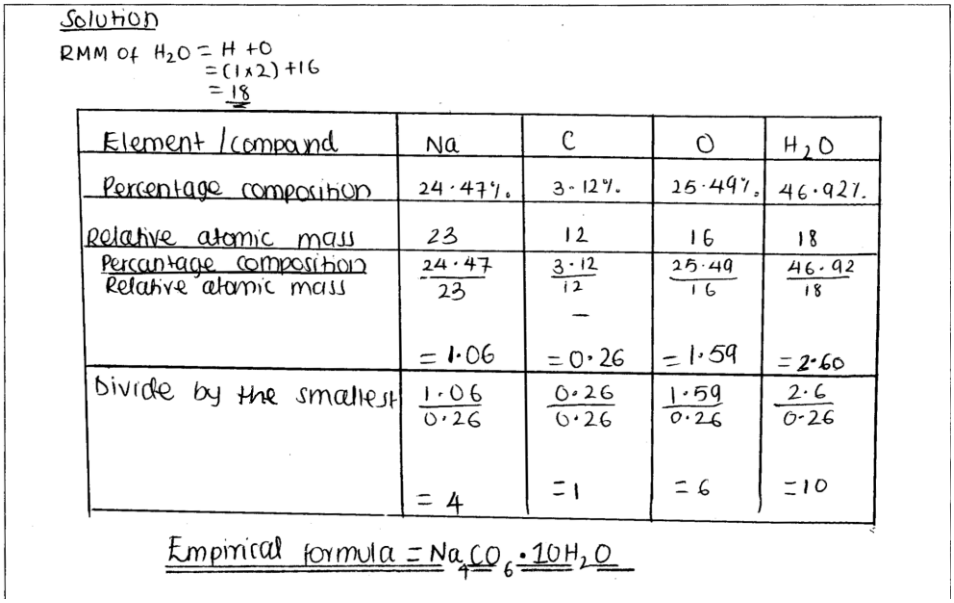
Figure 5: *Students' Performance in Question 5*

Students who scored high marks (5.22%) in this question, correctly differentiated empirical formula from molecular formula in part (a). They also followed the necessary steps together with good mathematical manipulation in calculating empirical formula of the compound in part (b). Extract 5.1 shows a sample of correct responses from one of the students.

5. (a) Differentiate empirical formula from molecular formula.

Empirical formula is the chemical formula which represents the simplest ratio of atoms in a compound WHILE, Molecular formula is the formula which represents the exact/actual ratio/proportion of atoms of an element in a compound.

(b) A Form Two student found a bottle of chemical in the laboratory with the following percentage composition by mass; Na = 24.47%, C = 3.12%, O = 25.49% and H_2O = 46.92%. Determine the empirical formula of the compound.



Solution

RMM of H_2O = H + O
= (1 x 2) + 16
= 18

Element / compound	Na	C	O	H_2O
Percentage composition	24.47%	3.12%	25.49%	46.92%
Relative atomic mass	23	12	16	18
Percentage composition / Relative atomic mass	$\frac{24.47}{23}$ = 1.06	$\frac{3.12}{12}$ = 0.26	$\frac{25.49}{16}$ = 1.59	$\frac{46.92}{18}$ = 2.60
Divide by the smallest	$\frac{1.06}{0.26}$ = 4	$\frac{0.26}{0.26}$ = 1	$\frac{1.59}{0.26}$ = 6	$\frac{2.6}{0.26}$ = 10

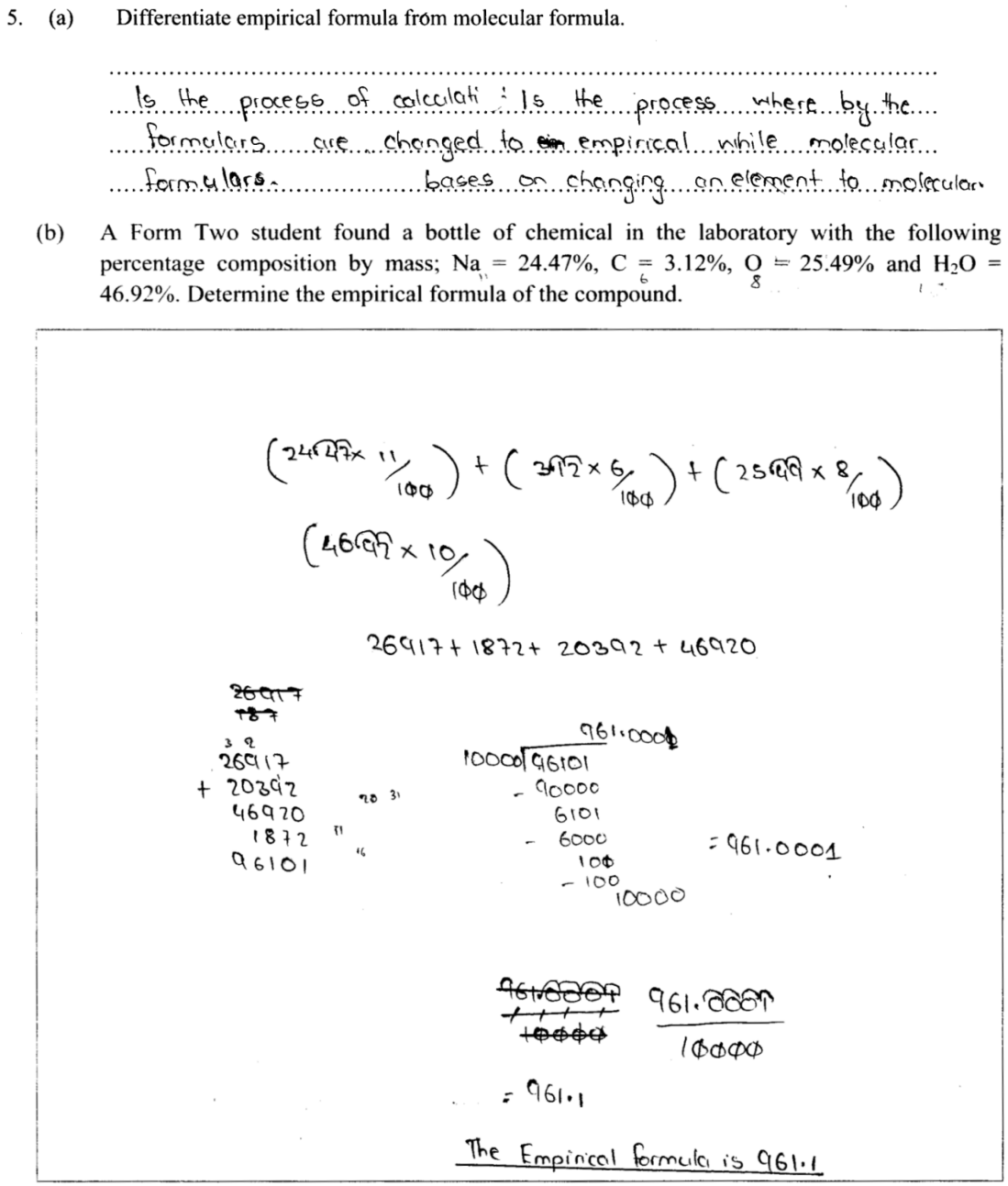
Empirical formula = $Na_4CO_6 \cdot 10H_2O$

Extract 5.1: A sample of correct answers in question 5

In Extract 5.1, the student distinguished empirical formula from molecular formula correctly. Also, he/she calculated the empirical formula of the compound correctly.

Conversely, students who scored low marks (64.25%) failed to distinguish empirical formula from molecular formula. Some of them used meaning of the two concepts interchangeably. For example, one student who swapped the meanings of the two concepts wrote that "empirical formula shows the actual number of atoms, while molecular formula shows the ratio of atoms present". Some students had a misconception that molecular formula show number of molecules in a compound such as water. Similarly, few students associated empirical formula with actual number of atoms in a substance. Also, some students used the term "ions" instead of "atoms" while trying to give differences. In part (b), the students failed to calculate the empirical formula due to lack of adequate knowledge on the concept and computation skills. Similarly, there were students who added the percentage composition of sodium, carbon, oxygen and water, thus, getting 100, the procedure which was not appropriate. Also, some students subtracted the percentage of oxygen (25.49%) from the percentage of water (46.92%), a step which was wrong. Most students skipped part (b). However, few ended up writing data

without further attempt to calculate the empirical formula. Extract 5.2 shows a sample of incorrect responses from one of the students.



Extract 5.2: A sample of incorrect responses to question 5

In Extract 5.2, the student incorrectly considered empirical and molecular formulae as changes in part (a) while in part (b) he/she calculated product of percentage composition and atomic number for each element per 100. Then, the student added the values obtained to get 96101. Furthermore, the student

carried a wrong procedure as he/she was first supposed to calculate mole ratio from the given percentage composition and relative atomic masses. Thus, he/she ended up getting 961.1 instead of the correct empirical formula of the compound.

2.2.4 Question 6: Air, Combustion, Rusting and Fire Fighting

The question comprised two parts, namely (a) and (b). In part (a), students were required to briefly explain each of the following phenomena: *(i) A ship in sea water rust very fast compared to the ship in fresh water. (ii) Rusting will not occur when anhydrous copper(II) sulphate is placed on the top of dry cotton wool in the test tube containing nail and left for four days. (iii) Carbon dioxide is used as fire extinguisher.* In part (b) the students were instructed that *"A Form Two student dipped a clean iron road into cold distilled water in a test tube and left it for 2 days. (i) State what will happen to the iron rod after two days. (ii) Explain the observation if the iron rod is replaced by a painted nail in the same test tube and left there for two days. (iii) Explain the observation if cold distilled water will be replaced by a mixture of hot water and oil.*

The question was attempted by 634,429 (100%) students, out of which 79.20 per cent scored from 0 to 2 marks, 15.67 per cent scored from 3 to 6 marks, while 5.13 per cent scored from 7 to 10 marks. The general performance of students in this question was weak in because only 20.8 per cent of the students scored 3 marks or above. The students' performance in this question is summarized in Figure 6.

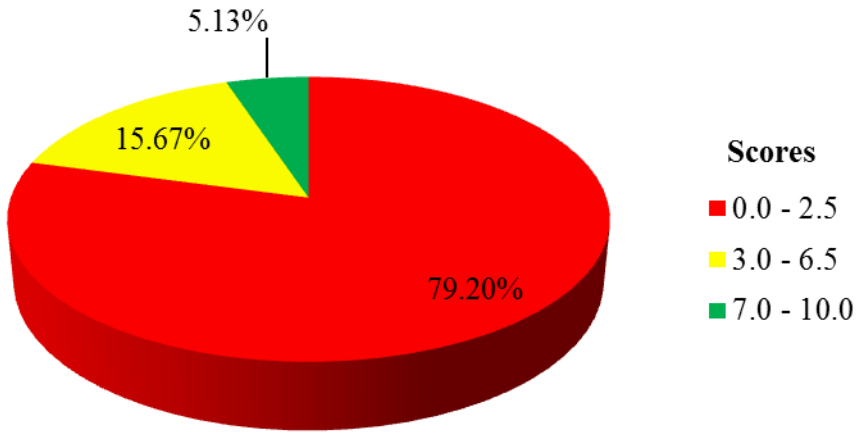


Figure 6: *Students' Performance in Question 6*

Students who scored low marks (79.20%) failed to attempt most parts of the question. For instance, in part (a) (i), some of them compared the density of sea water with that of fresh water, a concept which is not relevant in the rusting process. Others had a misconception that both salt and rust react with iron or steel. The students were supposed to know that the presence of salts (NaCl, $MgCl_2$) in sea water catalyze the rusting process thereby enabling iron to easily loose electrons. Other students in part (a) (ii) wrote that the nail will rust instead of giving a reason that anhydrous copper(II) sulphate acts as a drying agent that prevents water from contact with nails. In item (a) (iii) the students gave incorrect reasons as well. For instance, one student wrote that carbon dioxide is used as a fire extinguisher because it react with oxygen. The students had no adequate knowledge that carbon dioxide does not support combustion. In item (b) (i), some of the students responded that there will be no rust formation, instead of accepting that rust will be formed. In part (b) (ii), the students could not predict that a painted nail do not rust because painting prevents rusting. Likewise, in part (b) (iii), some of the students wrote that rusting will take place, which implies that they did not understand that hot water dissolves oxygen, thus, no rust formation. Generally, students in this category lacked adequate knowledge about conditions necessary for rusting. Extract 6.1 shows a sample of incorrect responses from one of the students.

6. (a) Briefly explain each of the following phenomena.

(i) A ship in sea water rust very fast compared to a ship in fresh water.

Because the ship in fresh water does not ru.
st very fast if the ship does not moved in fr.
esh water it moved in sea water.

(ii) Rusting will not occur when anhydrous copper(II) sulphate is placed on top of a dry cotton wool in the test tube containing nails and left for 4 days.

Rusting it occur in Electro painting. oiling and grazing so that it can not occur rusting.

(iii) Carbon dioxide is used as fire extinguisher.

Yes because the fire extinguisher they use dry powder. water sand and also carbondioxide because of

(b) A Form Two student dipped a clean iron rod into a cold distilled water in a test tube and left it for 2 days.

(i) State what will happen to the iron rod after 2 days.

The iron rod will not have the possibility to work because when you put iron in cold distilled water it will not attack any materials.

(ii) Explain the observation if the iron rod is replaced by a painted nail in the same test tube and left there for 2 days.

The iron rod and painted nail If they put in test tube in two days they will not be having have the strong force to attack with any materials.

(iii) Explain the observation if cold distilled water will be replaced by a mixture of hot water and oil.

If the cold distilled water will be replaced by mixture of hot water and oil the oil and hot water you will see particles upward the water.

Extract 6.1: A sample of incorrect responses to question 6

In Extract 6.1, the student wrote incorrect responses in parts (a) and (b). He/she failed to identify contents present in sea water and its effect in rusting in part (a) (i). Additionally, in part (b), the student wrote incorrect explanations about rusting.

On the contrary, students who scored high marks (5.13%) had adequate knowledge on conditions necessary for rusting to occur. In part (a), they responded to items (i), (ii) and (iii) with the aid of correct reasons. In part (b) (i), they predicted formation of rust on the iron rod. In item (b) (ii) they explained the technique of preventing rusting through painting, while in item (b)(iii) they correctly explained that rusting would not occur in hot

water which dissolves oxygen. Extract 6.2 shows a sample of correct responses from one of the students.

6. (a) Briefly explain each of the following phenomena.

(i) A ship in sea water rust very fast compared to a ship in fresh water.
Due to the presence of salt in sea water which catalyses rusting process.

(ii) Rusting will not occur when anhydrous copper(II) sulphate is placed on top of a dry cotton wool in the test tube containing nails and left for 4 days.
Because anhydrous copper(II) sulphate is a moisture absober.

(iii) Carbon dioxide is used as fire extinguisher.
Because it does not support burning.

(b) A Form Two student dipped a clean iron rod into a cold distilled water in a test tube and left it for 2 days.

(i) State what will happen to the iron rod after 2 days.
It will rust

(ii) Explain the observation if the iron rod is replaced by a painted nail in the same test tube and left there for 2 days.
It will not rust

(iii) Explain the observation if cold distilled water will be replaced by a mixture of hot water and oil.
The iron and nail will not rust. Due to the absence of dissolved oxygen.

Extract 6.2: A sample of correct responses to question 6

In Extract 6.2, the student correctly wrote the factors affecting rusting in part (a) (i). In part (a) (ii); part (b) (i), (ii) and (iii) he/she gave correct explanations based on the necessary conditions for rusting to occur. Moreover, in part (a) (iii) the student gave correct physical properties of carbon dioxide which enable it to act as a fire extinguisher.

2.2.5 Question 7: Hydrogen

In this question, students were given information that *"The laboratory technician planned to conduct an experiment for the preparation of gas **Y**. The following set of apparatuses was used: Flat-bottomed flask, thistle funnel, delivery tube, beehive and gas jar. Also, pieces of zinc metal and dilute hydrochloric acid were used. (a) Identify gas **Y** (b) What apparatus is missing in the set provided? (c) Draw a well labeled diagram for the preparation of gas **Y** in the laboratory (d) Write a word equation for the laboratory preparation of gas **Y**.*

This question was attempted by 634,429 (100%) students. Statistics show that 45.14 per cent of the students scored from 0 to 2 marks, 38.86 per cent scored from 3 to 6 marks and 16.00 per cent scored from 7 to 10 marks. Generally, students' performance in this question was average as 54.86 per cent of the students scored 3 marks or above. The students' performance in this question is summarized in Figure 7.

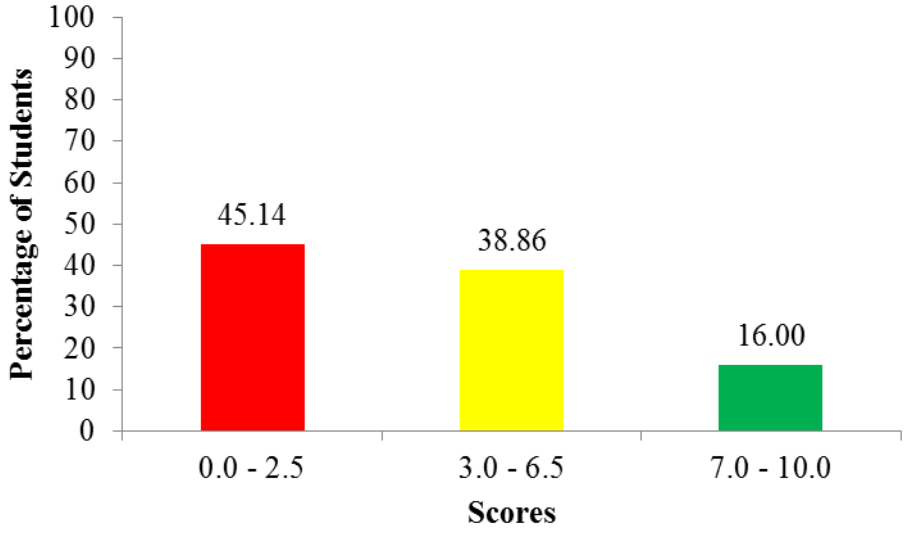


Figure 7: *Students' Performance in Question 7*

Students who scored high marks (16.00%) correctly identified gas **Y** as hydrogen. They also gave appropriate apparatuses which were missing from the set provided. Those apparatuses included retort stand, filter funnel, cork water trough, spatula and beaker. Additionally, the students demonstrated fairly good drawing skills in part (c) and gave the correct word equation in part (d). This indicates that the students had adequate knowledge on the

laboratory preparation of hydrogen gas. A sample of correct responses is provided in Extract 7.1.

7. The laboratory technician planned to conduct an experiment for the preparation of gas **Y**. The following set of apparatuses was used: Flat-bottomed flask, thistle funnel, delivery tube, beehive shelf and gas jars. Also pieces of zinc metal and dilute hydrochloric acid were used.

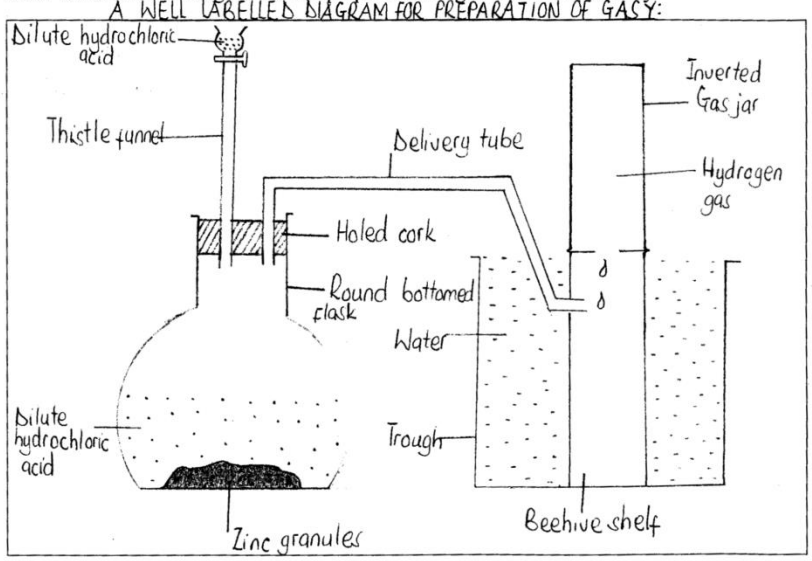
(a) Identify gas **Y**.

Hydrogen gas

(b) What apparatus is missing in the set provided?

Holed cork and trough of water

(c) Draw a well labeled diagram for the preparation of gas **Y** in the laboratory.



(d) Write the word equation for the laboratory preparation of gas **Y**.

Dilute hydrochloric acid + Zinc → Hydrogen gas + Zinc chloride

Extract 7.1: A sample of correct responses to question 7

In Extract 7.1, the student correctly identified gas **Y** in part (a). Also, he/she listed apparatuses which were missing in the set provided in part (b). Furthermore, he/she drew a well labeled diagram for the laboratory preparation of gas **Y** (hydrogen). Finally, the student wrote a word equation for the laboratory preparation of gas **Y**.

On the other hand, students who scored low marks (45.14%) failed to attempt correctly most parts of the question. In part (a), most of the students

wrote oxygen gas instead of hydrogen gas. Also, some of the students responded by writing nitrogen gas. In part (b), several incorrect apparatuses were mentioned including pipette, burette, wash bottle, retort stand and tongs. In part (c) some students drew diagrams showing simple distillation process instead of the preparation of hydrogen gas. However, most of the students skipped the diagram part. In part (d), some students indicated incorrect reactants in the equations while others showed incorrect products. There were students who wrote word equation for the laboratory preparation of oxygen gas instead of hydrogen gas. For instance, one student responded by writing "$Zinc\ metal\ +\ water \longrightarrow oxygen$" implying that he/she was referring to the preparation of oxygen gas. However, wrong reactants were used. Generally, these students had inadequate knowledge on the preparation of hydrogen gas in the laboratory. Extract 7.2 is a sample of incorrect responses.

7. The laboratory technician planned to conduct an experiment for the preparation of gas **Y**. The following set of apparatuses was used: Flat-bottomed flask, thistle funnel, delivery tube, beehive shelf and gas jars. Also pieces of zinc metal and dilute hydrochloric acid were used.

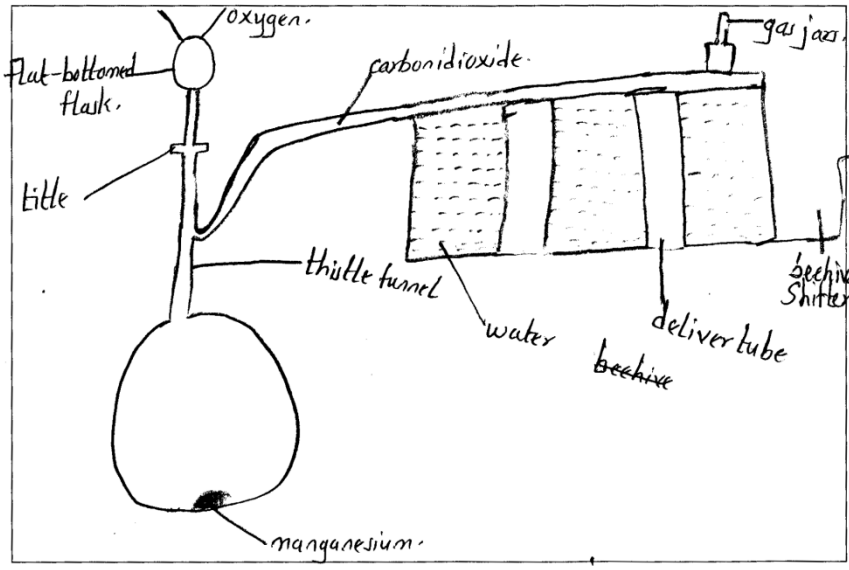
(a) Identify gas **Y**.

Is the condition or evolu evopulition number during to one place another gas exchange.

(b) What apparatus is missing in the set provided?

Is the special room or building or experment in the laboratory.

(c) Draw a well labeled diagram for the preparation of gas **Y** in the laboratory.



(d) Write the word equation for the laboratory preparation of gas **Y**.

Oxygen.

Nitrogen.

Extract 7.2: A sample of incorrect responses to question 7

In Extract 7.2, the student wrote incorrect responses in all parts of the question. In parts (a) and (b), he/she wrote incorrect sentences instead of giving name of gas Y and missing apparatus. In part (c), the student drew incorrect diagram, while in part (d) he/she mentioned elements instead of writing word equation showing the preparation of gas Y in the laboratory.

2.2.6 Question 8: Fuels and Energy

In this question students were required to explain the classification of fuels {based on efficiency} by using the following concepts*: (a) Pyrometric effect of burning (b) Heat value (c) Ignition point (d) Velocity of burning (e) Affordability.*

This question was attempted by 634,429 (100%) out of which 91.13 per cent scored from 0 to 2 marks, 6.13 per cent scored from 3 to 6 marks and 2.74 per cent scored from 7 to 10 marks. Students who scored 3 marks or above were 8.87 per cent, indicating an overall weak performance. The performance of students in this question is summarized in Figure 8.

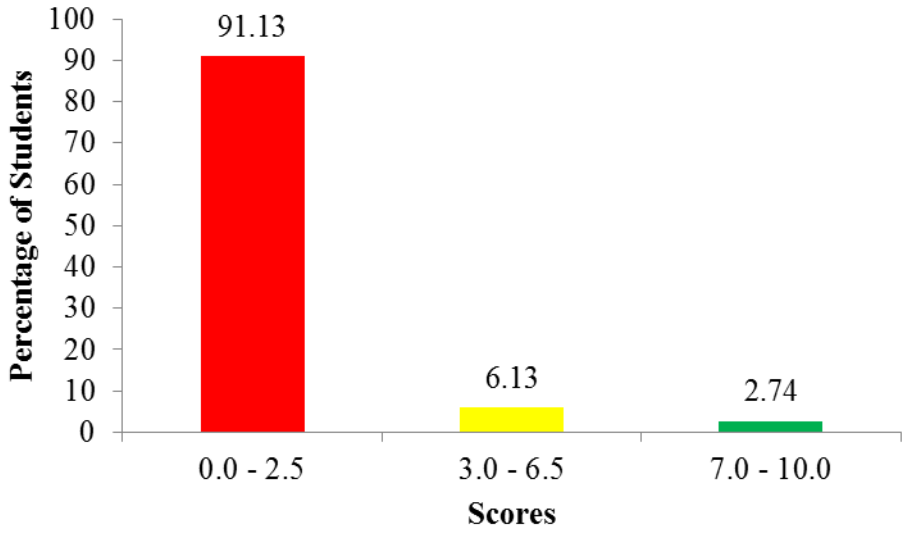


Figure 8: *Students' Performance in Question 8*

Students who scored low marks (91.13%) failed to attempts some or all the parts of the question. For instance, in part (a), some of students explained *pyrometric effect of burning* as the burning of materials in presence of air. Others associated the concept of *pyrometric effect of burning* with harmful effect on the environment as a result of burning fuels. In part (b) there were students who considered heat value as the price or cost of the fuels. Part (c) "Ignition point" was skipped by many students. However, those few who attempted gave incorrect responses. For instance, one student responded that "Ignition point is the place where fuels are kept in the laboratory". Others explained ignition point as the place where fuels are burnt. In part (d), some students regarded velocity of burning as the point at which substance burn completely, while others explained that velocity of burning is the speed of

heat. Generally, students lacked sufficient knowledge about the concept of fuel and the criteria used to classify fuels based on their efficiency. Extract 8.1 shows an example of incorrect responses from one of the students in question 8.

8. Suppose that you have been appointed by the Chemistry teacher to prepare a morning speech titled "Classification of fuels based on their efficiency." Elaborate how you would prepare your presentation basing on the following concepts:

(a) Pyrometric effect of burning
Class A of fuel Artificial Fuel

(b) Heat Value
~~Artificial fuel~~ Natural Fuel

(c) Ignition Point
Artificial fuel

(d) Velocity of burning
~~Natural~~ Artificial fuel

(e) Affordability
Natural Fuel

Extract 8.1: A sample of incorrect responses to question 8

In Extract 8.1, the student responded by writing either artificial or natural fuel to each of the concepts (a – e). This implies that the student did not understand the concepts.

On the other hand, students who scored high marks (2.74%) in this question classified fuels based on efficiency by using the concepts given. This means that they had adequate skills about both the quality of good fuels and their classification based on efficiency. Extract 8.2 is a sample of correct responses from one of the students in question 8.

8. Suppose that you have been appointed by the Chemistry teacher to prepare a morning speech titled "Classification of fuels based on their efficiency." Elaborate how you would prepare your presentation basing on the following concepts:

(a) Pyrometric effect of burning

This is the highest temperature reached when burning a certain fuel. The good fuel must have a high pyrometric effect of burning so as to enable proper heating of the desired material or substance.

(b) Heat Value

Heat value is the amount of heat energy produced per unit mass of a fuel. This means that, by burning a certain mass of fuel, a certain amount of energy is obtained. It is also called calorific value and a good fuel must have high heat value

(c) Ignition Point

This is the temperature at which the fuel has to be heated so as to start burning. This is the temperature or amount of heat that is required for a certain fuel to burn. A good fuel must have a medium ignition point because a low ignition point makes it flammable and a high ignition point makes it difficult to start burning.

(d) Velocity of burning

This is the rate at which the fuel burns. This is the time taken to burn a certain amount or mass of fuel. A good fuel must have a moderate velocity of burning, as in case it is high, it easily gets finished and a low one is not suitable.

(e) Affordability

This refers that a good fuel must be cheap, not costful and should be easily bought by all people even the low class people. The good fuel must not be too expensive as it can limit the class of people which can buy it.

Extract 8.2: A sample of correct responses to question 8

In extract 8.2, the student correctly explained each aspect of fuel and thereafter categorized fuels based on their efficiency, clearly.

2.2.7 Question 9: Atomic Structure

This question consisted two parts, namely (a) and (b). Part (a) had three sub-parts (i), (ii) and (iii). In part (a) (i), students were required to use Dalton's atomic theory to explain the fact that calcium sulphate from Tanzania and that found in Kenya has the same percentage by mass of calcium, sulphur

and oxygen. In item (a) (ii), they were required to explain the reason why isotopes of the same elements have similar chemical properties. In (a) (iii), students were required to give reasons to support or oppose the statement that "matter is made up of tiny indivisible particles called atoms". In part (b), students were given statement that, *An isotope of strontium (Sr) has mass number 87 and atomic number 38*. They were then required to answer the following questions: (i) *Write its nuclide notation* (ii) *How many neutrons does it have?* (iii) *How many protons does it have?* (iv) *How many electrons does it have?*

The question was attempted by 634,429 (100%) students out of which 53.66 per cent scored a zero mark. Students who scored from 0 to 2 marks were 75.14 per cent, from 3 to 6 marks were 20.75 per cent and those who scored from 7 to 10 marks were 4.11 per cent. These data show that the general performance in this question was weak as only 24.86 per cent of all students scored 3 marks or above. The students' performance in this question is summarized in Figure 9.

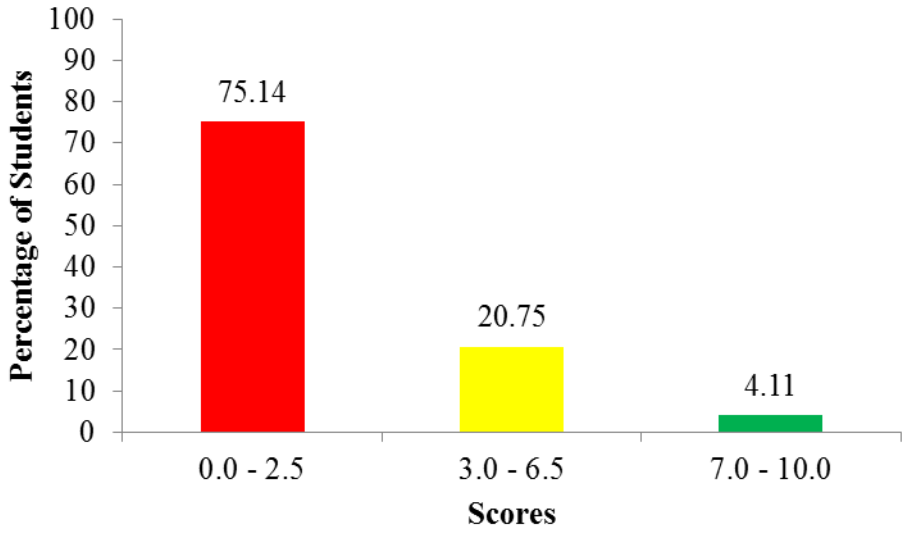


Figure 9: *Students' Performance in Question 9*

Students who scored low marks (75.14%) failed to attempt most parts of the question. Some of them gave incorrect reasons and explanations in part (a). For example, in item (a) (i) one student wrote "the percentage by mass is the same because Kenya and Tanzania have similar rocks". Another student responded "the calcium sulphate is the same because Tanzania and Kenya are neighbours". Such reasons have no scientific support. In part (a) (ii),

some of the students wrote that isotopes have the same number of neutrons instead of proton number. Others indicated isotopes to having different number of electrons which is not correct. Moreover, in part (a) (iii), most of the students failed to argue against the statement given. For example, one student wrote "the statement is true because atom is the smallest particle of matter". Other students responded to this part by writing that other substances are made up of molecules. Some went far by citing examples of molecules such as water, carbon dioxide and oxygen. The students were supposed to explain that atoms are divisible rather than indivisible since they consist of sub-atomic particles which are electrons, protons and neutrons. The incorrect responses show that the students lacked adequate knowledge of the modern concept of Dalton's atomic structure. In part (b), the students failed to write nuclide notation and calculate number of subatomic particles from the given mass number and atomic number. For instance, one student wrote the nuclide notation as 87 Sr 38 instead of writing 87, and 38 as superscript, and subscript, respectively. In calculating the subatomic particles, some students considered the number of neutrons being 87 instead of 49. Those students failed to subtract atomic number 38 from the mass number 87. Similarly, some students indicated protons to be 49 instead of 38. The students did not understand that proton number is the same as the atomic number. In item (b) (iv) some students wrote either 87 or 49 as the number of electrons, instead of 38. Generally, the students lacked adequate knowledge on the relationship between number of protons, electrons and neutrons of a particular element. Extract 9.1 shows a sample of incorrect responses to this question.

9. (a) (i) Using Dalton atomic theory, explain the fact that calcium sulphate from Tanzania and that found in Kenya has the same percentage by mass of calcium, sulphur and oxygen.

Element is made up by sub small sub atomic particles called proton, nutron and electron.
Atom can be created or destroyde by nuclear reaction
Atom of the some element adiffrur mass called Isotopes.

(ii) Why isotopes of the same element have similar chemical properties?

insoloble of water
It has less density than air

(iii) Matter is made up of tiny indivisible particle called atoms. With reason, support or oppose this statement.

Element is made up by small ~~particles~~ indivisible particles called atom

(b) An isotope of strontium (Sr) has mass number 87 and atomic number 38.

(i) Write its nuclide notation.

Elements is made up by small indivisible particles calle d atom

(ii) How many neutrons does it have?

It has no charge

(iii) How many protons does it have?

It has ~~electron~~ positive

(iv) How many electrons does it have?

It has negative

Extract 9.1: A sample of incorrect responses to question 9

In Extract 9.1, the student failed to state the reason isotopes have similar chemical properties in part (a) (ii), and to write a nuclide notation in part (b) (i). Furthermore, the student failed to calculate number of neutrons, protons and electrons from the given mass number and atomic number in part (b) (ii) (iii) and (iv).

On the other hand, students who scored high marks (4.11%) gave correct explanation and reasons with respect to modern Dalton's atomic theory in part (a). In part (b) they wrote correctly the nuclide notation of strontium

atom and gave correct number of the sub-atomic particles. A sample of correct responses from one of the students in this question is shown in Extract 9.2.

9. (a) (i) Using Dalton atomic theory, explain the fact that calcium sulphate from Tanzania and that found in Kenya has the same percentage by mass of calcium, sulphur and oxygen.

Dalton atomic theory explains that atoms of the same elements have the same mass and Number : calcium sulphate is the same as calcium sulphur and oxygen

(ii) Why isotopes of the same element have similar chemical properties?

because isotopes are only the atoms of an element with the same Atomic Number but different atomic mass

(iii) Matter is made up of tiny indivisible particle called atoms. With reason, support or oppose this statement.

No, according to Dalton matter's indivisible part is atom but atom has also sub atomic particles, Electron, Neutron and protons

(b) An isotope of strontium (Sr) has mass number 87 and atomic number 38.

(i) Write its nuclide notation.

$^{87}_{38}Sr$

(ii) How many neutrons does it have?

49 neutrons

(iii) How many protons does it have?

38 protons

(iv) How many electrons does it have?

38 electrons

Extract 9.2: A sample of correct responses to question 9

In Extract 9.2, the student correctly gave a reason for percentage composition by mass of each element in calcium sulphate in part (a) (i). He/she also gave correct explanations in both items (a) (ii) and (a) (iii). Similarly, in part (b), the student correctly wrote nuclide notation for strontium and indicated the number of each sub-atomic particle.

2.3 SECTION C: ESSAY/STRUCTURED QUESTION

This section consisted of one (1) structured question, weighing fifteen (15) marks. This question was compulsory.

2.3.1 Question 10: Formula Bonding and Nomenclature

The question consisted of three parts: (a), (b) and (c). In part (a), the students were required to construct diagram showing the arrangement of the outer electrons in each of the following molecules: (i) Chlorine (ii) Ammonia and (iii) Carbon dioxide. In part (b), students were required to indicate the type of bond which exists in each molecule stated in part (a). In part (c), they were required to identify four properties of the molecules given in part (a).

A total of 634,429 (100%) students attempted this question. Students who scored from 0 to 5.5 marks were 94.13 per cent, from 6 to 10 marks were 5.00 per cent and from 10.5 to 15 marks were 0.87 per cent. The general performance of students was weak as only 5.87 per cent of the students scored 6 marks or above. The summary of performance of the students is shown in Figure 10.

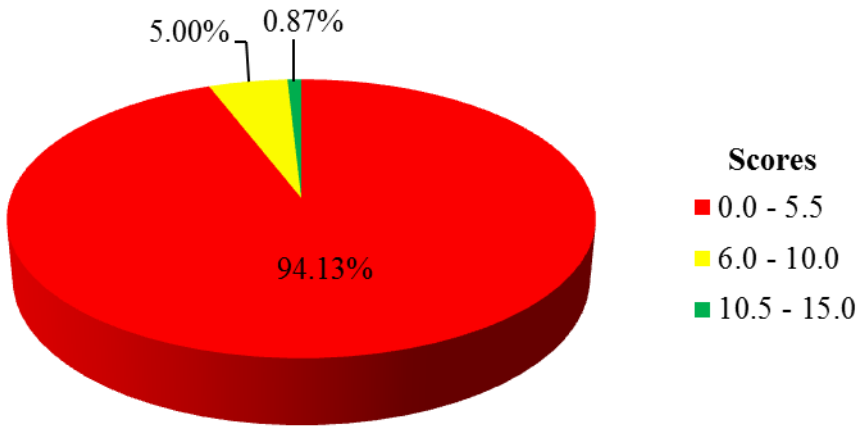


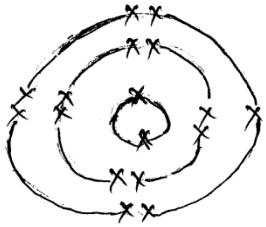
Figure 10: *Students' Performance in Question 10*

On the contrary, students who scored low marks (94.13) failed to construct diagrams of electronic structure of the molecules in part (a). Most of them drew diagrams of atoms instead of molecules especially for chlorine, carbon and nitrogen. Also, some students gave electronic configuration of chlorine

instead of electronic structures of chlorine molecule. In constructing the diagram of ammonia, many students failed to indicate the actual number of electrons around the bonded nitrogen atom. For instance, some students indicated five instead of eight electrons. In part (b), some of the students wrote ionic bond instead of covalent bond. Similarly, few students responded incorrectly by writing dative bond while others skipped the question. In part (c), some of the students responded by writing properties of group I elements. For example, one student wrote properties of metals such as high melting and boiling points. Some other students wrote properties of ionic compounds instead of those pertaining to covalent compounds. For instance, one student wrote “They are charged molecules”. Another student responded “They conduct electricity as well as heat”. However, most students confused properties of covalent with ionic compounds. The students were supposed to apply the concept of chemical bonding in order to identify properties of the molecules. Extract 10.1 shows a sample of incorrect responses from one of the students.

10. (a) Construct a diagram to show the arrangement of the outer electrons in each of the following molecules:

(i) Chlorine



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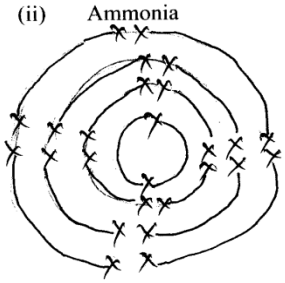
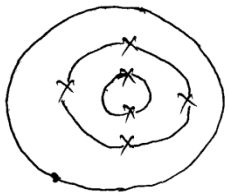
(ii) Ammonia



(iii) Carbon dioxide



(b) What type of bond exists in the molecules in part (a)?

electrovalent bond

(c) Identify four properties of the molecules in part (a).

(i) iron bond

(ii) iodin bond

(iii) electronic bond

(iv) ~~in~~ ion bond

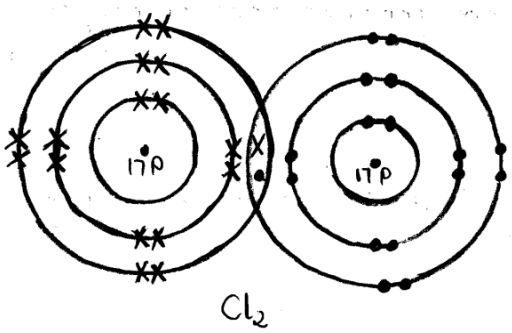
Extract 10.1: A sample of incorrect responses to question 10

In Extract 10.1, the student constructed diagram of chlorine atom and diagrams for two unknown elements instead of molecules of chlorine, ammonia and carbon dioxide in part (a). He/she wrote electrovalent bond instead of covalent bond in part (b), while in part (c), he/she wrote incorrect bonds instead of properties of covalent compounds.

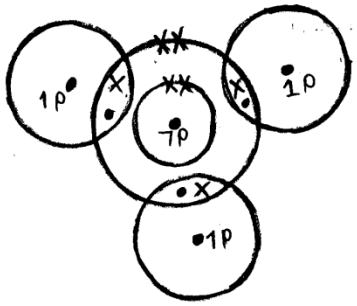
On the contrary, students who scored high marks (0.87%) constructed correct diagrams showing the electrons in the molecules of chlorine, ammonia and carbon dioxide in part (a). Likewise, in part (b), the students gave correct type of bond (covalent) associated with the three molecules. In part (c), the students responded correctly by giving four properties of the molecules (covalent compounds) given in part (a) as well. The correct responses given indicate that the students had adequate skills of combining atoms (bonding) and writing electronic configuration. Extract 10.2 shows a sample of correct responses to question 10 from one of the students.

10. (a) Construct a diagram to show the arrangement of the outer electrons in each of the following molecules:

(i) Chlorine

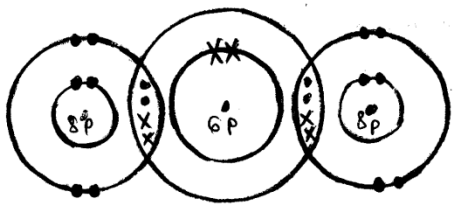


(ii) Ammonia



NH_3

(iii) Carbon dioxide



CO_2

(b) What type of bond exists in the molecules in part (a)?

Covalent bond

(c) Identify four properties of the molecules in part (a).

(i) The molecules exist in a gaseous state example Carbondioxide

(ii) The molecules have ~~big~~ low boiling and melting points

(iii) The molecules are bad conductors of heat and electricity

(iv) The molecules dissolve in ~~m~~organic substances such as hexane

Extract 10.2: A sample of correct responses to question 10

In Extract 10.2, the student drew correct structures in part (a), identified the type of bond in part (b), and gave appropriate properties of covalent compounds in part (c).

3.0 ANALYSIS OF STUDENTS' PERFORMANCE IN EACH TOPIC

In the 2022 Form Two National Assessment, a total of 10 topics were assessed. Those topics were *Introduction to Chemistry; Heat Sources and Flames; Matter; Air, Combustion, Rusting and Fire Fighting; Oxygen; Hydrogen; Fuels and Energy; Atomic Structure; Periodic Classification* and *Formula, Bonding and Nomenclature*.

The analysis shows that, question 1 which was comprised of 10 multiple choice items from different topics had good performance of 80.70 per cent. The question was set from the following topics: *Introduction to Chemistry; Oxygen; The scientific Procedures; Matter; Air Combustion, Rusting and Fire Fighting; Heat Sources and Flames; Atomic Structure; Periodic Classification* and *Formula, Bonding and Nomenclature*. Question 2 which consisted of 5 matching items from the topic of Matter had good performance of 66.57 per cent.

There were 2 topics in which the students attained average performance. Those topics were *Hydrogen (54.86%)* and *Matter (41.17%)*. The average performance of students in those topics implies that students had relatively good understanding of the concepts tested from from those topics.

Conversely, students' performance was weak in four topics. Those topics were *Fuels and Energy (*8.87%*), Air, Combustion, Rusting and Fire Fighting (13.67%), Formulae, Bonding and Nomenclature (20.81%)* and *Atomic structure (24.86%)*. The weak performance of students was caused by a number of factors including inadequate knowledge of the subject matter, failure to explain scientific facts, failure to interpret scientific results and lack of basic numerical skills in chemistry. A summary of the performance of students in different topics is presented in the Appendix.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

Generally, the performance of students who sat for Chemistry paper in Form Two National Assessment 2022 was average. The percentage of students who passed the assessment was 33.45. The performance of students in 2022 has decreased by 8.92 per cent compared to the performance in 2021. The analysis of students' performance in terms of topics showed that students achieved average performance in Hydrogen (54.86%) and Matter (41.17%). The performance of students was weak in Fuels and Energy (8.87%), Air,

Combustion, Rusting and Fire Fighting (13.67%), Formulae, Bonding and Nomenclature (20.81%) and Atomic structure (24.86%).

The weak performance of students in the topics Fuels and Energy; Air, Combustion, Rusting and Fire Fighting; Formulae, Bonding and Nomenclature; and *Atomic structure* was attributed to lack of adequate knowledge in the subject matter, lack of adequate skills to explain scientific facts, lack of basic numerical skills in chemistry and failure to interpret scientific results or principles. Basically, the candidates had limited knowledge of concepts, thus they failed to attempt the questions correctly.

4.2 Recommendations

The following recommendations are given in order to improve teaching and learning processes:

(a) Teachers are insisted to guide students to determine the calorific values of fuels experimentally. For instance, students may burn kerosene, charcoal and firewood for the purpose of comparing the calorific values of those fuels.

(b) Teachers are advised to guide students through the use of manila cards depicting atomic structures to discuss the modifications of Dalton's atomic theory.

(c) Students are encouraged to practice solving various problems which require interpreting scientific results or processes such as rusting and experiment to prove the presence of carbon dioxide in air.

(d) Students are advised to practice solving questions which require description and computation skills such as calculating empirical and molecular formulas.

APPENDIX: Analysis of Performance of Students in Each Topic

S/N	Topic	Question Number	% of Students who Scored an Average of 30% or Above	Average	Remarks
1	Introduction to Chemistry; Oxygen; The scientific Procedures; Matter; Air Combustion, Rusting and Fire Fighting; Heat Sources & Flames; Atomic Structure; Periodic Classification and Formula, Bonding & Nomenclature.	1	80.70	80.70	Good
2	Hydrogen	7	54.86	54.86	Average
3	Matter	2	66.57	41.17	Average
		3	15.76		
4	Atomic structure	9	24.86	24.86	Weak
5	Formulae, Bonding and Nomenclature	5	35.75	20.81	Weak
		10	5.87		
6	Air, Combustion, Rusting and Fire Fighting	4	6.54	13.67	Weak
		6	20.80		
7	Fuels and Energy	8	8.87	8.87	Weak