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) 2021

CHEMISTRY

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032 CHEMISTRY

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FOREWORD

The National Examinations Council of Tanzania is delighted to issue Students' Item Response Analysis Report on the Form Two National Assessment (FTNA) 2021 in Chemistry subject. The report focuses on providing feedback to teachers, students, parents and policy makers among others about the performance of students, their strengths and weaknesses in attempting the assessment questions.

The Form Two National Assessment is a two-year formative evaluation which provides feedback on the effectiveness of the education system at large and the education delivery system. Fundamentally, students' responses to the assessment questions are a strong indicator of what the education system was able or unable to offer to students in their two years of secondary education.

The analysis presented in this report is intended to contribute towards understanding some of the reasons behind the performance of the students in Chemistry subject. Students who scored high marks had adequate knowledge of concepts in Chemistry and managed to apply numerical skills effectively. On the contrary, those who scored low marks lacked adequate knowledge of the subject matter and failed to identify the demands of the questions. Furthermore, the low achievers had inadequate mathematical skills and lacked English Language proficiency, which hindered them from presenting their responses properly.

The feedback provided in this report will enable the education administrators, school managers, teachers and students to identify proper measures to be taken in order to make necessary adjustments in teaching and learning so as to improve students' performance in future assessments administered by the Council.

The National Examinations Council of Tanzania would like to thank all individuals who participated 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 students who sat for the Form Two National Assessment (FTNA) 2021 in Chemistry subject. The 2021 Chemistry assessment was set according to the FTNA format which was developed from the 2010 Chemistry syllabus for ordinary level secondary education.

The Chemistry assessment consisted of one paper which comprised two sections namely; A and B. Section A consisted of two objective questions. Question 1 comprised ten multiple choice items while question 2 consisted of five matching items and 5 filling in the blanks items. Section B consisted of 8 short answer questions.

A total of 602,347 students sat for the 2021 Chemistry assessment, out of which 42.37 percent passed the assessment, indicating an average, overall performance. Students' performance in each grade (A to F) is shown in Table 1.

Table 1: The Performance of Students in each Grade in 2021

S/N	Grade	No. of Students	% of students
1.	A	25,036	4.16
2.	B	23,984	4.00
3.	C	79,775	13.26
4.	D	126,085	20.95
5.	F	346,630	57.63

Table 1 shows that the number of students who failed the assessment amounts to 57.63 percent.

In the year 2020, 42.85 percent of the students passed the assessment. These results show that the students' performance in the year 2021 decreased by 0.48 percent compared to the performance in the year 2020. Although there is decrease in the pass percentage, there has been a notable increase in the number of students that attained grade A from 22,250 in 2020 to 25,036 in 2021.

2.0 ANALYSIS OF STUDENTS' PERFORMANCE IN EACH QUESTION

This section provides analysis of students' performance in each question. Students who attained at least 30 percent of the full mark assigned to a particular question are said to have passed the question. The students' performance analysed in this report has been categorized into the percentage intervals of 0 - 29, 30 - 64 and 65 – 100 which are classified as weak (red), average (yellow) and good (green), respectively.

2.1 SECTION A

This section consisted of two questions, each carrying 10 marks. The pass mark for each question was 3 which is equivalent to 30 percent of the full mark.

2.1.1 Question 1: Multiple Choice Items

The question consisted of 10 items set from 7 topics as follows: *Water*; *Air, Combustion, Rusting and Firefighting; Matter; Heat Sources and Flames; Formula, Bonding and Nomenclature*; *Introduction to Chemistry* and *Atomic Structure.* In each item, the students were required to choose the correct answer from among the given four alternatives (A to D) and write its letter beside the item number in the box provided against each of the items.

This question was attempted by 602,259 (99.9%) students. The analysis of the students' performance indicates that 21.2 percent scored from 0 to 2 marks, 65.4 percent scored from 3 to 6 marks while 13.4 percent scored from 7 to 10 marks. Generally, the performance on this question was good because 78.8 percent of the students scored 3 marks or above. Figure 1 gives the summary of the data.

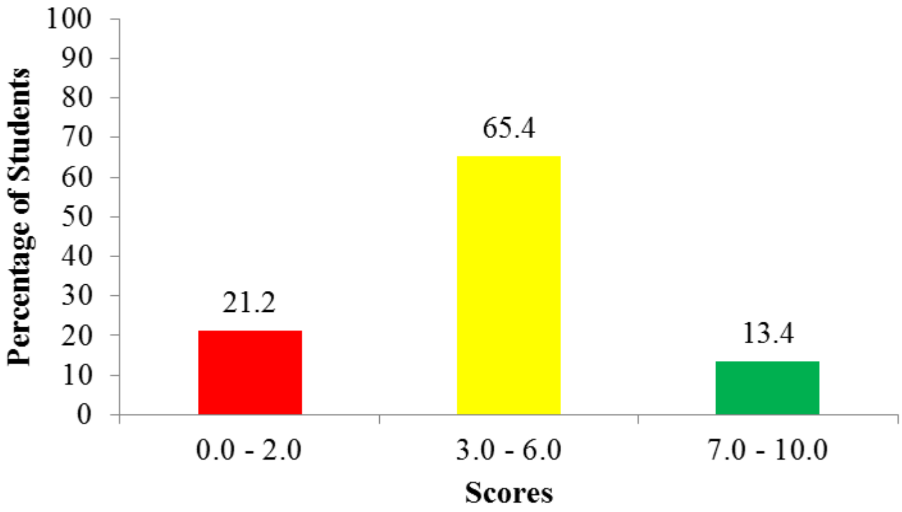


Figure 1: *Students' Performance in Question 1*

The responses of students who managed to score high marks showed that they had good mastery of concepts across different topics from which the items were composed. Also they understood the requirement of the questions, thus they responded accordingly.

On the other hand, the students who had weak performance (21.2%) failed to respond correctly to most of the items and scored low marks in this question. This is attributed to inadequate knowledge of different concepts tested in the items. The general analysis of the students' responses in each item is as follows:

In item (i), students were required to identify particles which contribute to the net charge inside the nucleus of an atom. The correct answer was *A, Protons.* Students who chose the correct answer had satisfactory knowledge that protons are positively charged and reside in the nucleus. The students who opted for *B, Neutrons,* failed to understand that neutrons have no charge although they are found in the nucleus. The students who chose *C, Electrons* were not aware that electrons carry negative charge, but are located outside the nucleus. Similarly, those who chose alternative *D, Nucleons,* failed to understand that the word nucleons is a collective term for both protons and neutrons in which the neutrons bear no charge.

In item (ii), students were asked to identify a product of applying chemistry which was not man-made from the alternatives given. The correct answer was *B, Milk*. Students who chose the correct answer understood that milk is produced naturally by mammals. Those who chose *A, Fertilizer, C, Sugar* and *D, Vaccines* were not aware that such products are man-made through applying chemistry knowledge.

In item (iii), students were required to identify the method by which the amount of air entering in the Bunsen burner is controlled. The correct answer was *B, By adjusting the opening of the collar*. Students who chose the correct answer had sufficient knowledge on how the Bunsen burner operates. Students who chose *A, By adjusting the opening of the barrel* did not comprehend that the barrel does not allow air to enter from outside. Its function is to allow mixing of the gas and air. Students who chose *C, By adjusting the opening of the jet* failed to understand that the jet is responsible for gas inlet and not outside air. Similarly, those who chose alternative *D, By adjusting the opening of the base,* failed to recognize the function of the base of the Bunsen burner which is to provide stability to the burner.

In item (iv), students were asked to give the term that chemists use to describe a mixture of milk and water. The correct answer was *A, Emulsion*. Students who opted for the answer A were conversant with the properties of mixtures whereby emulsion consists of two liquids with visible fine particles. Those who opted for *B, Suspension* had no idea that suspension is a mixture of solid and liquid in which solid particles are suspended within the liquid. Students who chose *C, Miscible solution* failed to recall that miscible solution has no visible particles. On the same way, those who chose *D, Immiscible solution* had a misconception that a mixture of milk and water forms layers. These students lacked proper competencies on identifying mixtures based on their properties.

In item (v), students were asked to account for the necessity of boiling drinking water. The correct answer was *D, To kill micro-organisms*. Students who chose the correct answer understood properly the concept of water treatment. Students who chose *A, To remove oxygen,* misinterpreted the requirement of the question since the process of water treatment does not involve the removal of oxygen. Also, those students did not comprehend that oxygen is an integral part of the water molecule. Students who chose *B, To remove impurities* were not conversant with the effect of boiling drinking water. Similarly, those who chose *C, To make it tasteless* lacked the knowledge that the act of boiling water does not alter the taste of water.

In item (vi), students were required to identify a pair of nuclides that indicate isotopes. The correct answer was *D,* $^{35}_{17}X$ *and* $^{37}_{17}X$. Students who got the correct answer had sufficient knowledge that isotopes of the same element have the same atomic number but different in mass number. Students who chose alternative, *A,* $^{40}_{20}X$ *and* $^{40}_{18}X$, had a misconception between isotopes and isobars. Those who opted for *B* $^{39}_{19}X$ *and* $^{40}_{20}X$, incorrectly regarded isotopes to having both different mass number and atomic number. Similarly, students who opted for *C,* $^{12}_{6}X$ *and* $^{12}_{6}X$, had a misconception that isotopes of the same element should have both the same atomic number and mass number.

In item (vii), students were asked to identify the products of the reaction between sodium metal and water. The correct answer was *D, Sodium hydroxide and hydrogen gas.* Students who got the correct answer had sufficient knowledge that due to its high reactivity, sodium metal reacts with water to form sodium hydroxide and hydrogen gas. Contrarily, students who chose the other alternatives, *A Sodium oxide and hydrogen gas, B Sodium hydroxide and water* and *C Sodium oxide and water vapour* lacked adequate knowledge on the chemical properties of water.

In item (viii), students were tasked to indicate the way a covalent bond forms. The correct answer was *C, By sharing of valence electrons.* Those who chose the correct answer had sufficient knowledge that covalent bonds are formed by sharing of electrons. *Those who chose alternative A, By combining opposite charged atom,* confused the concept of formation of electrovalent bond with the formation of covalent bond. Those who chose *B, By loss of electrons between ions* did not comprehend that when there is loss of electrons, the bond formed is electrovalent and not covalent bond. Students who picked alternative *D, By force of attraction of atoms* did not realize that the force of attraction of atoms is not a determinant feature for the formation of covalent compound/bond.

In item (ix), students were asked on how they could prevent rusting in fragile instruments like cameras. The correct answers were A, *By using* *silica gel* and *C, By galvanization*. Students who gave the correct answer (A or C) had sufficient knowledge on the relevant methods of preventing rusting especially on specific equipment. Those who chose *B, By using ethanol*, confused the concept of rust prevention with sterilization for which ethanol is normally used. Students who chose *D, By using oil*, failed to associate materials and their specific methods of rust prevention. Oil can be applied to prevent rusting especially in moving parts of machines but not recommended for fragile instruments like cameras.

In item (x), students were required to give the maximum number of electrons in the innermost shell of an atom. The correct answer was *C, 2*. Students who chose the correct answer had adequate knowledge that the first (innermost) shell can hold not more than 2 electrons. Students who chose alternative *A, 3* did not understand the capacity of the innermost shell to hold electrons. Students who wrote *B, 8*, confused the octet rule with the doublet rule. They did not realize that the innermost shell obeys the doublet rule while the outer shells obey the octet rule. Students who opted for distractor *D, 1* confused the number of electrons in hydrogen atom in which the only shell present has 1 electron. They did not realize that the innermost shell of an atom can hold up to two electrons.

2.1.2 Question 2: Matching Items and Filling in the Blanks

The question was comprised of two parts namely; (a) and (b). In part (a) students were required to match the premises in **List A** with the responses in **List B** by writing the letter of the correct response besides the corresponding item number in the table provided.

List A	List B
(i) Ammonium chloride crystals in sand	A Decantation
(ii) Muddy water	B Chromatography
(iii) Oil in sunflower	C Evaporation
(iv) Sodium chloride in water	D Fractional distillation
(v) Spirit in water	E Layer separation
	F Sublimation
	G Solvent extraction

In part (b), students were required to fill in the blank spaces provided. They were asked as follows:

(i) *Apart from air and fuel, what are the other components required for a flame to be produced?* ___________________

(ii) *How do we refer to the factors which can be adjusted in any experiment to get the desired results?* _________________

(iii) *In what system through which water is continually moving above and below the earth?* _______________

(iv) *What process is involved in order to obtain coke and coal gas from bituminous coal in absence of air?* _______________

(v) *Which element in period 2 can share four electrons in order to acquire stability?* _______________

The question was attempted by 601,808 (99.9%) students. The percentage of students who scored from 0 to 2.0, 3.0 to 6.0 and 7.0 to 10.0 marks were 70.9, 24.4 and 4.7 respectively. Generally, the performance of students in this question was weak as only 29.1 percent of those who attempted the question scored 3.0 marks or above. Summary of the students' performance on this question is shown in Figure 2.

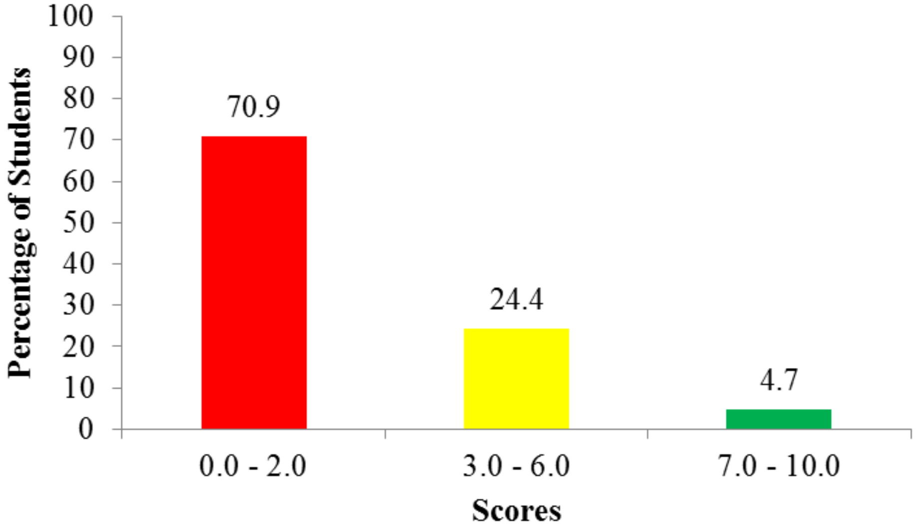


Figure 2: *Students' Performance in Question 2*

Students who scored low marks (70.9%) failed to attempt most of the items in this question. In part (a), they associated the mixtures with inappropriate methods of separation. Some of them incorrectly identified *A, Decantation*, as the suitable method of separating a mixture of spirit and water in (v). Others cited *D, Fractional distillation*, as a method of separating oil from sunflower. Similarly, some of the students wrongly identified *E, Layer separation*, as the appropriate method to separate water from muddy water. Failure of the students to match the items appropriately implies that they had inadequate knowledge on the methods of mixture separation.

In part (b)(ii), students wrote dependent variable instead of independent variable. In the same way, some of the students responded to item (b)(v) by mentioning other elements apart from the required element which was carbon. Yet, other students left some of the items in part (a) and (b), unanswered. Extract 2.1 indicates a sample of incorrect responses from one of the students.

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

List A	List B
(i) Ammonium chloride crystals in sand	A Decantation
(ii) Muddy water	B Chromatography
(iii) Oil in sunflower	C Evaporation
(iv) Sodium chloride in water	D Fractional distillation
(v) Spirit in water	E Layer separation
	F Sublimation
	G Solvent extraction

Answers

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

(b) Answer the following items by filling in the blank spaces provided.

(i) Apart from air and fuel, what is the other component required for a flame to be produced? What is the other component required

(ii) How do we refer to the factors which can be adjusted in an experiment to get the desired results? the factors which ca be

(iii) In what system through which water is continually moving above and below the Earth? is continuatly moving above.

(iv) What process is involved in order to obtain coke and coal gas from bituminous coal in absence of air? in order to obtain coke

(v) Which element in period 2 can share four electrons in order to acquire stability? four electrons to order to

Extract 2.1: 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 in part (a). In part (b), he/she copied some parts of the question items, indicating lack of adequate knowledge on the subject matter tested.

On the other hand, students who scored high marks (4.7%) correctly matched the mixtures stated with their corresponding methods of separation in part (a). This implies that they had sufficient knowledge of the different methods of separation of mixtures. In attempting part (b) of the question, the students showed good mastery of knowledge across the subject matter tested hence, managed to supply correct answers for the items provided. Extract 2.2 shows a sample of correct responses given by one of the students in question 2.

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

List A	**List B**
(i) Ammonium chloride crystals in sand	A Decantation
(ii) Muddy water	B Chromatography
(iii) Oil in sunflower	C Evaporation
(iv) Sodium chloride in water	D Fractional distillation
(v) Spirit in water	E Layer separation
	F Sublimation
	G Solvent extraction

Answers

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

(b) Answer the following items by filling in the blank spaces provided.

(i) Apart from air and fuel, what is the other component required for a flame to be produced? Heat

(ii) How do we refer to the factors which can be adjusted in an experiment to get the desired results? Independent variables

(iii) In what system through which water is continually moving above and below the Earth? water cycle

(iv) What process is involved in order to obtain coke and coal gas from bituminous coal in absence of air? Destructive distillation of coal

(v) Which element in period 2 can share four electrons in order to acquire stability? Carbon (C)

Extract 2.2: A sample of correct responses to question 2

In Extract 2.2, the student matched correctly each mixture in part (a), with its appropriate method of separation. In addition, he/she managed to fill in the blanks by using correct terms/phrases.

2.2 SECTION B

This section consisted of eight (8) short answer questions weighing ten (10) marks each. Students were required to answer all questions. The pass score for each question was 3.0 marks.

2.2.1 Question 3: Periodic Classification

The question consisted of two parts namely; (a) and (b). In part (a), students were required to make reference to the Periodic Table and give the chemical symbol of the element having the smallest and the element having the largest atomic size. In part (b), they were asked "*Identify the elements which are; (i) Metals having 3 shells of electrons each (ii) Metals having 1 electron in the valence shell (iii) Noble gases.*"

The question was attempted by 565,780 (93.9%) students out of which 72.1 percent scored from 0 to 2.5 marks, 20.3 percent scored from 3.0 to 6.0 marks and 7.6 percent scored from 6.5 to 10.0 marks. The general performance in this question was weak as only 27.9 percent of the students scored 3.0 marks or above. The distribution of students' scores in this question is shown in Figure 3.

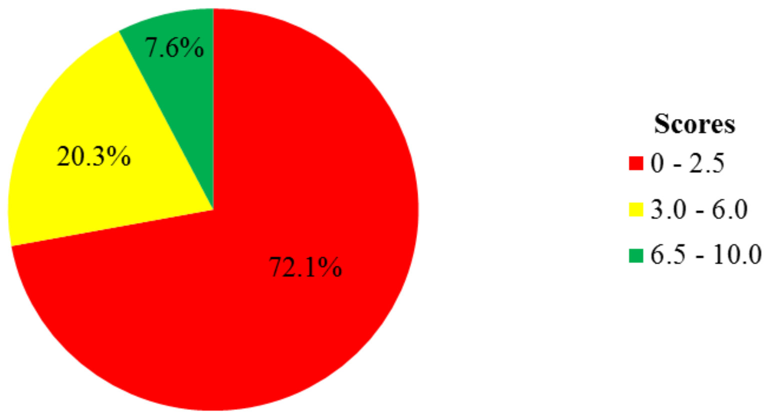


Figure 3: *Students' Performance in Question 3*

Figure 3 shows that 72.1 percent of the students had weak performance in this question. Students who scored low marks including 47.7 percent who scored a zero mark failed to give the correct chemical symbols in part (a) of the question. For instance, some of them gave symbols of other elements which do not qualify as elements having either the smallest atomic size or the largest atomic size. Most of the students with low scores identified potassium as the smallest element instead of hydrogen. Other students responded to item (a)(ii) by writing the symbol for aluminium (Al) or calcium (Ca) instead of potassium (K) for the element with the largest atomic size. Students who wrote the chemical symbol for calcium failed to understand the requirement of the question as they gave the 20th element in the Periodic Table instead of giving the element having the largest atomic size.

In attempting part (b), some of the students responded to item (b)(i) by giving metals such as iron, potassium and calcium which are not members of period 3. Similarly, other students cited calcium and magnesium in item (b)(ii) which have got two electrons in the valence shell. In item (b)(iii), the students gave gases such as carbon dioxide, oxygen and nitrogen which are constituents of air instead of giving the noble gases which are neon, argon and helium. A sample of incorrect responses in question 3 is shown in Extract 3.1.

3. Answer the following questions with reference to the first 20 elements of the Periodic Table.

(a) Give the chemical symbol of the element having:

(i) the smallest atomic size.

Calcium, Phosphorus, Sulphur, magnesiumu, Ar gon, Chloride and Silver

(ii) the largest atomic size.

Hydrogen, Lithium, Berone, Oxygen, Sodium and

(b) Identify the elements which are:

(i) metals having 3 shells of electrons each.

metal having 3 shells of electrons is 1

(ii) metals having 1 electron in the valence shell.

Metals having 1 electron in the valence She ll is 1

(iii) noble gases.

is the gases which disvode persentage combosition is by oxygen gas

Extract 3.1: A sample of incorrect responses in question 3

In Extract 3.1, the student wrote names of incorrect elements in part (a) instead of writing chemical symbols of hydrogen and potassium in items (i) and (ii) respectively. In part (b), the student wrote sentences instead of giving respective metals and noble gases as per demand of the question.

On the other hand, the few students amounting to 7.6 percent who scored high marks in this question managed to give correct chemical symbols for the required elements in part (a). They also identified the required metals and noble gases in part (b) correctly. Such responses provided by the students imply that they had adequate knowledge on the periodic trends of elements in the Periodic Table. In addition, students who performed well were conversant with the concept of electronic configuration. Extract 3.2 shows a sample of correct responses from one of the students.

3. Answer the following questions with reference to the first 20 elements of the Periodic Table.

(a) Give the chemical symbol of the element having:

(i) the smallest atomic size.

H

(ii) the largest atomic size.

K

(b) Identify the elements which are:

(i) metals having 3 shells of electrons each.

Sodium, Magnesium, and Aluminium

(ii) metals having 1 electron in the valence shell.

Lithium, Sodium and Potassium

(iii) noble gases.

Helium, Neon, and Argon

Extract 3.2: A sample of correct responses in question 3

In Extract 3.2, the student wrote correctly the atomic symbols in part (a) of the question. He/she identified the required elements in part (b) by giving their correct names.

2.2.2 Question 4: Formula, Bonding and Nomenclature

This question comprised parts (a) and (b). In part (a), the students were required to give the IUPAC names of two radicals: (i) ClO_3^- (ii) PO_4^{3-}. However, in the question paper, the negative charges were incorrectly positioned. In part (b), the students were required to calculate the oxidation state of the underlined element in each of the following compounds:

(i) $NH_4\underline{Cl}$ (ii) $Al_2\underline{O}_3$ (iii) $Na_2\underline{S}O_4$ (iv) $H_2\underline{O_2}$

This question was attempted by 569,559 (94.6%) students of which 77.1 percent scored from 0 to 2.5 marks, 9.4 percent scored from 3.0 to 6.0 marks and 13.5 percent scored from 6.5 to 10.0 marks. Generally, the performance in this question was weak as only 22.9 percent of the students scored 3.0 marks or above. The students' performance is summarized in Figure 4.

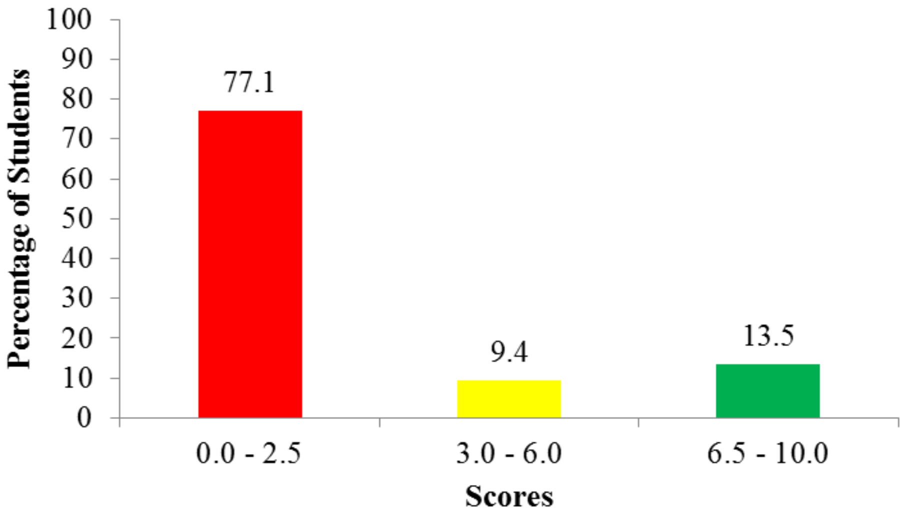


Figure 4: *Students' Performance in Question 4*

Students who scored low marks (77.1%) failed to attempt most parts of the question. For instance, in part (a), some of the students identified names of the constituent elements forming the radicals instead of naming the two radicals. Others wrote names of elements such as carbon and iodine which were not even among the constituents of the radicals. Those students had misconception that the underlined element (Cl) in item (i) represented

Carbon and Iodine instead of Chlorine. Most of the students in this category hardly attempted part (b). Some of them just copied the formulae of the given compounds without carrying on the calculations. Others tried the calculations by using atomic masses of the elements instead of using valencies. Furthermore, some of the students carried the calculations without considering the subscripts of the elements thus they ended up getting incorrect answers. Similarly, there were students who did not consider the oxidation state of the neutral compounds being zero. There were also students who gave the number of atoms of the underlined elements instead of calculating their oxidation states. In some cases, some of the students calculated molar masses of the compounds which imply that they did not understand the requirement of the question. Extract 4.1 shows a sample of incorrect responses from one of the students.

4. (a) Give the IUPAC names of the following radicals:

(i) ClO_3^- .... carbon iron oxygen. ....

(ii) PO_4^{3-} .... pottassium oxygen ....

(b) Calculate the oxidation state of the underlined element in each of the following compounds:

(i) $NH_4\underline{Cl}$

4(2: 4)

4x6

= 24

C = 24

C = 24

(ii) $Al_2\underline{O}_3$

O= Oxygen (2:6)

2x3(2:6)

6 (2:6)

6(2+6)

6x8

O= 48

(iii) $Na_2\underline{S}O_4$

S = Sodium (2:8:4)

2x4 (2:8:4)

8(2+8+4)

8x 14

114

S = 114

(iv) $H_2\underline{O}_2$.

O = Oxygen (2:6)

2x2 = (2+6)

4 x 8

Extract 4.1: A sample of incorrect responses in question 4

In Extract 4.1, the student wrote elements instead of naming the radicals in part (a). In part (b), the student carried unclear calculations by taking the product of the subscripts and electronic configurations. Such a procedure in the calculation is not valid, and misled the student from getting the correct answers.

On the other hand, students who scored high marks (28.2%) managed to name the two radicals in part (a) which were (i) chlorate (v) and (ii) phosphate (v). Similarly, in part (b), the students correctly calculated the oxidation state for each underlined element in the four compounds provided. In addition, they managed to indicate the correct oxidation state for the rest of the elements present in the given compounds as represented in Extract 4.2.

4. (a) Give the IUPAC names of the following radicals:

(i) ClO_3^- .... Chlorate (V)

(ii) PO_4^{3-} .... Phosphate (V)

(b) Calculate the oxidation state of the underlined element in each of the following compounds:

(i) $NH_4\underline{Cl}$

The oxidation state of NH_4Cl is 0, N = ⁻3, H = ⁺1, Cl = ?

⁻3 + (⁺1 × 4) + Cl = 0

⁻3 + ⁺4 + Cl = 0

⁺1 + Cl = 0

Cl = 0 − ⁺1, Cl = ⁻1

∴ The oxidation state of Cl is ⁻1

(ii) Al_2O_3

The oxidation state of $Al_2O_3 = 0$, $Al = {}^{+}3$, $O = ?$

$({}^{+}3 \times 2) + O_3 = 0$

${}^{+}6 + 3O = 0$

$3O = 0 - {}^{+}6$

$\frac{3O}{3} = \frac{{}^{-}6}{3}$ 2 $\therefore O = {}^{-}2$

$\therefore$ The oxidation state of O is $^{-}2$.

(iii) Na_2SO_4

The oxidation state of $Na_2SO_4 = 0$, $Na = {}^{+}1$, $S = ?$ and $O = {}^{-}2$

$({}^{+}1 \times 2) + S + (^{-}2 \times 4) = 0$

${}^{+}2 + S + {}^{-}8 = 0$

$S + {}^{-}6 = 0$

$S = {}^{+}6$

$\therefore$ The oxidation state of S is $^{+}6$.

(iv) H_2O_2.

The oxidation state of $H_2O_2 = 0$, $H = {}^{+}1$, $O = ?$

$({}^{+}1 \times 2) + O_2 = 0$

${}^{+}2 + 2O = 0$

$2O = 0 - {}^{+}2$

$\frac{2O}{2} = \frac{{}^{-}2}{2}$ 1 $\therefore O = {}^{-}1$

$\therefore$ The oxidation state of O is $^{-}1$.

Extract 4.2: A sample of correct responses in question 4

In Extract 4.2, the student named the radicals in part (a) according to the IUPAC rules. He/she followed all the steps in calculation of oxidation states by writing the correct formula and corresponding substitutions hence, getting the correct responses in all parts of the question.

2.2.3 Question 5: Heat Sources and Flames

The question comprised three parts, namely (a), (b) and (c). Students were asked as follows:

"(a) Assign each of the properties given, to either luminous or non-luminous flames by putting a tick on the respective column in the following table.

Property of Flame	***Luminous Flame***	***Non-luminous Flame***
(i) Give plenty of smoke and soot.		
(ii) Blue in colour and almost invisible.		
(iii) Yellow zone is larger than blue zone.		
(iv) Formed when the air holes are completely lost.		
(v) Blue zone larger than the yellow zone.		
(vi) Produces the hottest flame.		

(b) *Assume that you are doing an experiment in the laboratory at 07:30 pm and suddenly the lights go off. Give two reasons to justify the fact that you would consider luminous flame rather than non-luminous flame as an alternative source for lighting.*

(c) *Identify two properties of the flame produced by the Bunsen burner (air holes full opened) that cannot be found in the flame produced by the spirit burner."*

A total of 595,510 (98.9%) students attempted the question, out of which 32.2 percent scored from 0 to 2.5 marks, 49.2 percent scored from 3.0 to 6.0 marks and 18.6 percent scored from 6.5 to 10.0 marks. The general performance of the students in this question was good since 67.8 percent of the students who attempted this question scored 3.0 marks or above. These data are summarized in Figure 5.

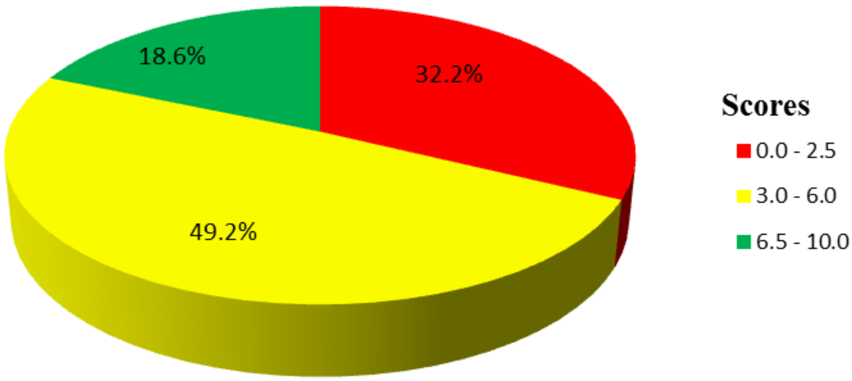


Figure 5: *Students' Performance in Question 5*

Students who scored high marks correctly assigned the properties of luminous and non-luminous flame in part (a). This is an indication that they had adequate knowledge on describing luminous and non-luminous flames. In part (b), the students gave appropriate reasons for preferring luminous flame to non-luminous flame. The bright light of luminous flame and its tendency to produce much less heating effect as compared to non-luminous flame makes it suitable for lighting. In part (c), the students managed to point out two properties of the flame produced by the Bunsen burner when the air holes were fully opened. This implies that students had adequate knowledge on the use of Bunsen burner to produce different flames by adjusting the amount of air entering it. Extract 5.1 shows a sample of correct responses from one of the students.

5. (a) Assign each of the properties to either luminous or non-luminous flame by putting a tick (✓) on the respective column in the following table.

Property of Flame	Luminous Flame	Non-luminous Flame
(i) Gives plenty of smoke and soot.	✓	
(ii) Blue in colour and almost invisible.		✓
(iii) Yellow zone is larger than blue zone.	✓	
(iv) Formed when the air holes are completely closed.	✓	
(v) Blue zone is larger than yellow zone.		✓
(vi) Produces the hottest flame.		✓

(b) Assume that you are doing an experiment in the laboratory at 07.30 pm and suddenly the lights go off. Give two reasons to justify the fact that you would consider luminous flame rather than non-luminous flame as an alternative source for lighting.

(i) I will consider luminous Flame because It does not produce hottest flame

(ii) I will consider luminous Flame because It has bright light.

(c) Identify two properties of the flame produced by the Bunsen burner (air holes full opened) that can not be found in the flame produced by the spirit burner.

(i) It has a triangular shape.

(ii) It has three zones.

Extract 5.1: A sample of correct answers in question 5

In Extract 5.1, the student assigned the properties of luminous and non-luminous flames correctly in part (a). In part (b), he/she justified the need to use luminous flame over non-luminous flame by giving two reasons. Similarly, in part (c), the student gave two properties that are associated with the flame produced when the air holes of the Bunsen burner are fully opened as compared to the flame produced by a spirit burner.

On the other hand, students who scored low marks failed to assign the properties of the flames as per question demand in part (a). Some of them interchanged the properties of luminous flame with those of non-luminous flame. Yet, other students left the portion of the question unanswered which implies lack of adequate knowledge on distinguishing luminous flame from non-luminous flame. In part (b), the students gave incorrect reasons as to why luminous flame is more preferred than non-luminous flame as a source of light. For instance, one of the students argued that "*the luminous flame has many zones*". This statement is too general and the student did not elaborate the relationship between the flame zones and lighting. Another student pointed out that "*luminous flame last long time than non-luminous*". Moreover, some students gave the properties of luminous flame which have no connection with the suitability in lighting. For example, a certain student stated that "*luminous flame produces soot hence suitable*". This again was incorrect because the property of being sooty does not favour luminous flames to be suitable for illumination. In part (c), some of the students gave properties associated with the flame when the air holes of the Bunsen burner are closed. Similarly, some of the students drew diagrams of the Bunsen burner, an indication that they did not understand the requirement of the question. Failure of the students to answer the question appropriately signifies that they had inadequate knowledge on the concept of heat sources and flames. Extract 5.2 shows a sample of incorrect responses from one of the students.

5. (a) Assign each of the properties to either luminous or non-luminous flame by putting a tick (✓) on the respective column in the following table.

Property of Flame	Luminous Flame	Non-luminous Flame
(i) Gives plenty of smoke and soot.	✓	✓
(ii) Blue in colour and almost invisible.	✓	✓
(iii) Yellow zone is larger than blue zone.	✓	✓
(iv) Formed when the air holes are completely closed.	✓	✓
(v) Blue zone is larger than yellow zone.	✓	✓
(vi) Produces the hottest flame.	✓	✓

(b) Assume that you are doing an experiment in the laboratory at 07.30 pm and suddenly the lights go off. Give two reasons to justify the fact that you would consider luminous flame rather than non-luminous flame as an alternative source for lighting.

(i) Source of oxygen

(ii) Source of carbon dioxide.

(c) Identify two properties of the flame produced by the Bunsen burner (air holes full opened) that can not be found in the flame produced by the spirit burner.

(i) luminous flame

(ii) Non-luminous flame.

Extract 5.2: A sample of incorrect responses in question 5

In Extract 5.2, the student filled the table by assigning each of the properties to both luminous and non-luminous flame in part (a). He/she referred to oxygen and carbon dioxide instead of giving reasons in part (b). Similarly, in part (c), the student gave two types of flames instead of identifying two properties of the flame as per question demand.

2.2.4 Question 6: Laboratory Technique and Safety

In this question, students were required to draw a diagram for each of the given apparatuses and give one use for each apparatus. Those apparatuses were as follows:

(i) Volumetric flask (ii) Simple funnel (iii) Liebig condenser (iv) Thermometer and a (v) Retort Stand.

The question was attempted by 594,119 (98.6%) students out of which 55.3 percent scored from 0 to 2.5 marks, 39.8 percent scored from 3.0 to 6.0 marks while 4.9 percent scored from 7.0 to 10.0 marks. The general performance of students in this question was average in which 44.7 percent of the students scored 3.0 marks or above. The performance of the students is summarized in Figure 6.

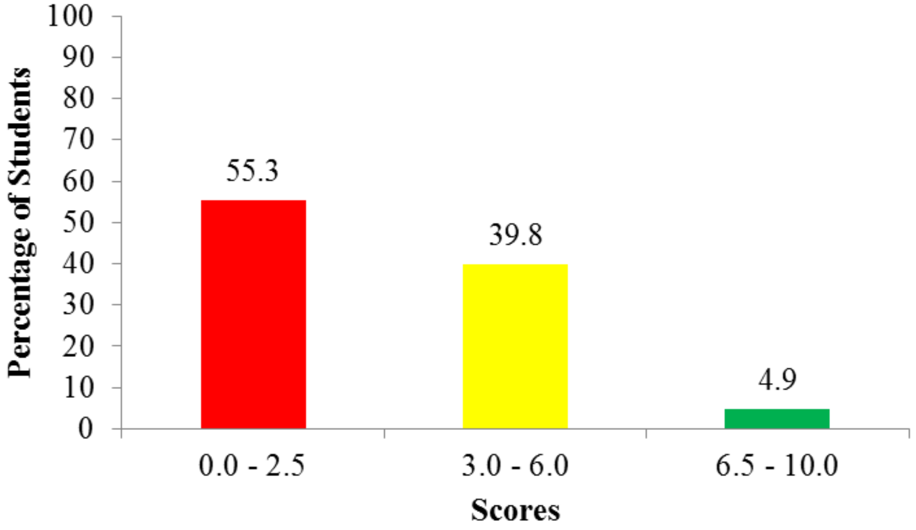
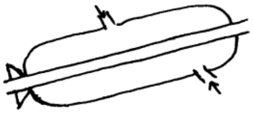
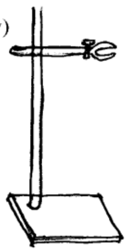


Figure 6: *Students' Performance in Question 6*

The analysis of the students' responses shows that, those who scored high marks managed to draw appropriate diagrams of the required laboratory apparatuses. This is an indication that they were familiar with the laboratory apparatuses. They also gave one correct use of each of the apparatuses. Extract 6.1 shows a sample of correct responses from one of the students in this question.

6. (a) Draw a diagram and give one use for each of the following apparatuses:

Diagram	Name and Use
(i) 	Name: Volumetric flask Use: Used to measure accurate fixed volume of chemicals
(ii) 	Name: Simple funnel Use: Used with a filter paper to separate pure water from muddy water.
(iii) 	Name: Liebig condenser Use: Used for cooling substances after heating
(iv) 	Name: Thermometer Use: It is used to measure temperature of substances
(v) 	Name: Retort stand Use: Used to hold apparatus when heating or during heating

Extract 6.1: A sample of correct responses in question 6

In Extract 6.1, the student correctly drew diagrams of the laboratory apparatuses and specified one use for each of the apparatuses.

Students who scored low marks in this question failed to draw the required diagrams of apparatuses. For instance, some of them sketched diagrams of other laboratory apparatuses which were not asked in the question. Yet other students drew tripod stand instead of retort stand. It was also noted that some students drew filter paper instead of the required funnel. Some students did not follow assessment instructions as they used blue pen to draw the apparatuses instead of using pencil. They also failed to give specific uses of the laboratory apparatuses asked. For example, one of the students responded to item (i) "*the volumetric flask is used for measurement*". This response was incorrect in the sense that it is too general and does not give the specific use of volumetric flask. Other students, though understood that the apparatuses are found in the laboratory, did not identify how each of the apparatuses is used. Some students skipped some parts of the question while others skipped the whole question. Generally, students with low scores in this question showed to have weak drawing skills and inadequate knowledge on the laboratory apparatuses as depicted in Extract 6.2.

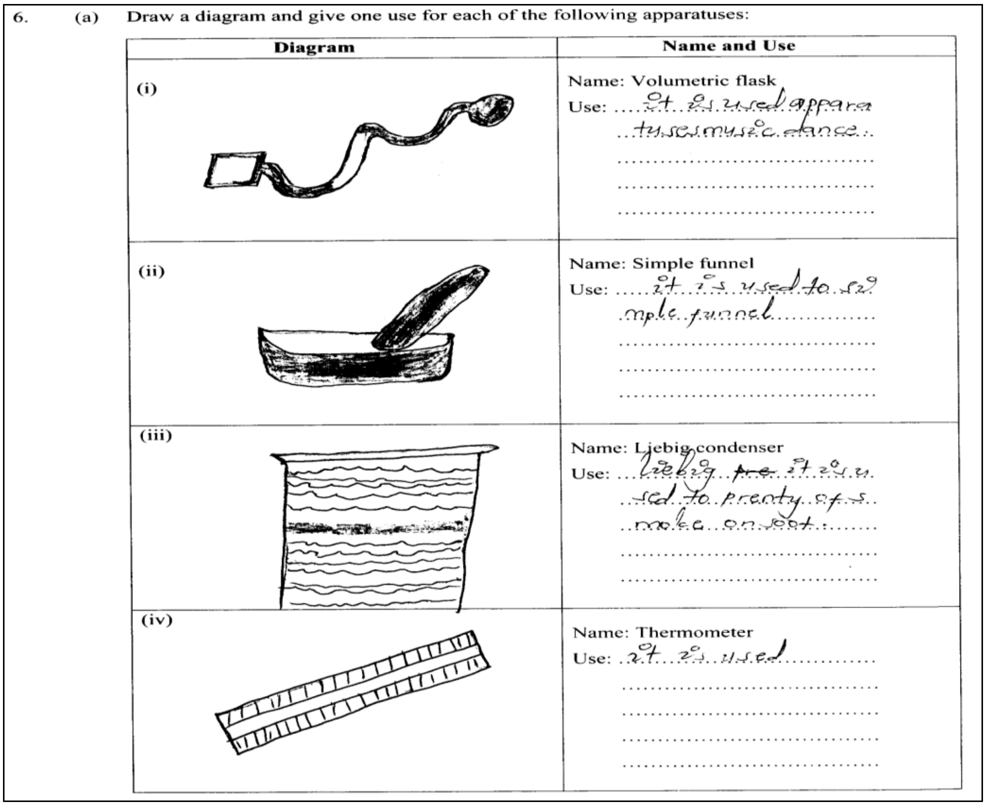

6. (a) Draw a diagram and give one use for each of the following apparatuses:

Diagram	Name and Use
(i)	Name: Volumetric flask Use: it is used apparatuses music dance
(ii)	Name: Simple funnel Use: it is used to simple funnel
(iii)	Name: Liebig condenser Use: liebig pre it is used to prenty of smoke on pot
(iv)	Name: Thermometer Use: it is used

Extract 6.2: A sample of incorrect responses in question 6

In Extract 6.2, the students drew incorrect diagrams of apparatuses contrary to the requirement of the question. He/she sketched what looks like a mortar and pestle instead of a funnel in item (i). The student gave wrong answers in subsequent parts of the question and scored zero.

2.2.5 Question 7: Matter

The question consisted of two parts namely, (a) and (b). In part (a), students were required to distinguish between the following substances. "*(i) Saturated from unsaturated solution (ii) Miscible from immiscible liquids (iii) Homogenous mixture from heterogeneous mixture.*" In part (b), they were asked to explain the means of separating each of the following mixtures *(i) Pure water and muddy water (ii) Kerosene and water.*

This question was attempted by 547,661 (90.9%) students. Statistics show that 84.5 percent of the students scored from 0 to 2.5 marks out of which 68.0 percent scored a zero mark. Those who scored from 3.0 to 6.0 marks and 6.5 to 10.0 marks were 11.7 percent and 3.8 percent respectively. Statistical data further indicate that only 0.3 percent of the students who attempted the question scored full marks. Generally, students' performance in this question was weak as only 15.5 percent of the students scored 3.0 marks or above. Summary of the performance of students in this question is shown in Figure 7.

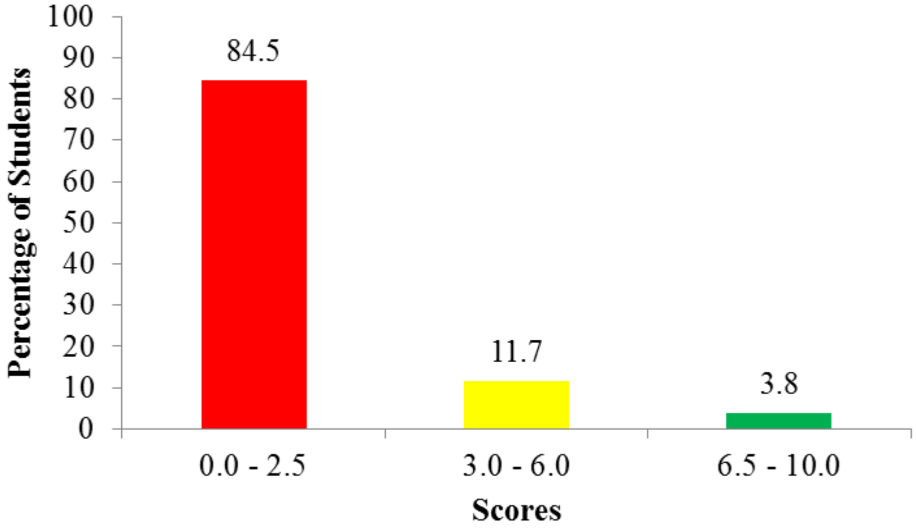


Figure 7: *Students' Performance in Question 7*

Students who scored low marks failed to distinguish the substances provided in part (a). Some of the students gave incorrect meanings of saturated solution, unsaturated solutions, miscible liquids, immiscible liquids, homogenous mixture and heterogenous mixture. For instance, one of the students responded to part (a)(i) as follows: "*Saturated solution can dissolve more solute but unsaturated solution cannot dissolve more salt*." This response was incorrect because the student exchanged the meaning of saturated solution and unsaturated solution. Other students gave incorrect examples of the substances in an attempt to differentiate them. For example, one of the students gave water and kerosene as examples of miscible liquids. This response was not correct because water and kerosene do not mix up, hence they are immiscible liquids. On the same way, some of the students gave methods of mixture separation instead of differentiating the terms given. This implies that they failed to understand the demand of the question in part (a). In part (b), students with low scores gave incorrect methods of separating the mixtures given. For example in item (b)(i), some of the students wrote layer separation instead of simple distillation. They also confused the concept of mixture separation with that of water treatment and purification. This was noted following some of the students giving boiling and chlorination as the methods of separating mixtures contrary to the fact that those are methods of water treatment. Extract 7.1 is a sample of weak responses in this question.

7. (a) Distinguish the following substances:

(i) Saturated from unsaturated solution.

Saturade solution are the solution ~~combined~~ which are mixed with solid mattirials and the a ~~d~~ being disolved in them eg. Sugar and water while unsaturated solution they are ~~bier~~ being mixed ~~with~~ ~~s~~ Liquid and liquid eg. milk and water.

(ii) Miscible from immiscible liquids.

Miscible liquids are those Liquids when combined or mixed together theycan't be separated eg water and alchole ~~whethe~~ while immiscible

(iii) Homogenous from heterogeneous mixture.

Homogenous is the where by the mixtures can combine together while in heterogeneous mixtures combine but not direct because of different in temperature.

(b) How can you separate each of the following mixtures?

(i) Pure water and muddy water

You can separat pure water and muddy water by Fractional destillation method.

(ii) Kerosene and water

You can separate kerosene and water by layer distillation method.

Extract 7.1: A sample of incorrect responses in question 7

In Extract 7.1, the student wrote incorrect responses in part (a) of the question. He/she failed to distinguish the given pairs of substances and gave incorrect differences between the asked pairs of substances.

On the other hand, 15.5 percent of the students managed to distinguish between the liquid substances in part (a). In doing so, some managed to provide vivid examples of the liquid mixtures. For instance, some of them mentioned water and oil as examples of immiscible liquids. Similarly, in part (b), students managed to explain the appropriate methods of separating each of the given mixtures. This implies that students had mastered the skill of applying the methods of mixture separation. A sample of correct responses is depicted in Extract 7.2.

7. (a) Distinguish the following substances:

(i) Saturated from unsaturated solution.

Saturated solution is the type of solution which can not dissolve more solute at a given temperature WHILE Unsaturated solution is the solution which can dissolve more solute at a given temperature.

(ii) Miscible from immiscible liquids.

Miscible liquids is the homogeneou mixiture of two or more liquids which mix completely without forming any distict layer Example the mixture of Alcohol and water WHILE Immiscible liquids is the heterogeneous mixture of two or more liquid which do not mix they form separate layer between them. Example the mixture of Oil and water.

(iii) Homogenous from heterogeneous mixture.

Homogenous mixture is the type of mixture which Mixes uniformly for example solution and Miscible liquids WHILE Heterogeneous mixture is type of mixture which do not mix uniformlly.

(b) How can you separate each of the following mixtures?

(i) Pure water and muddy water

The mixture of Pure water and muddy water can be separated through the process called Simple Distillation. Where Pure water will be called a distillate which sand will be called Residue.

(ii) Kerosene and water

The mixture of Kerosene and water can be separated through the method of Layer Separation by using an Instrument called Separating funnel!

Extract 7.2: A sample of correct responses in question 7

In Extract 7.2, the student correctly distinguished the mixtures in part (a) and gave appropriate methods of separating each of the given mixtures in part (b).

2.2.6 Question 8: Oxygen

The question had three parts, namely (a), (b) and (c). In part (a), students were required to identify two reagents which can be used to prepare oxygen gas in the laboratory apart from hydrogen peroxide. In part (b), the students were required to name the product formed in each reaction by reacting oxygen gas with each of the following: *(i) Carbon (ii) Phosphorus* and *(iii) Sulphur*. In part (c), the students were required to give five uses of oxygen gas.

A total of 582,241 (96.7%) students attempted this question. A total of 58.9 percent scored from 0 to 2.5 marks, 34.2 percent scored from 3.0 to 6.0 marks and the 6.9 percent scored from 6.5 to 10.0 marks. Students who scored 3.0 marks or above were 41.1 percent, indicating an overall average performance. Summary of data showing students' performance is shown in Figure 8.

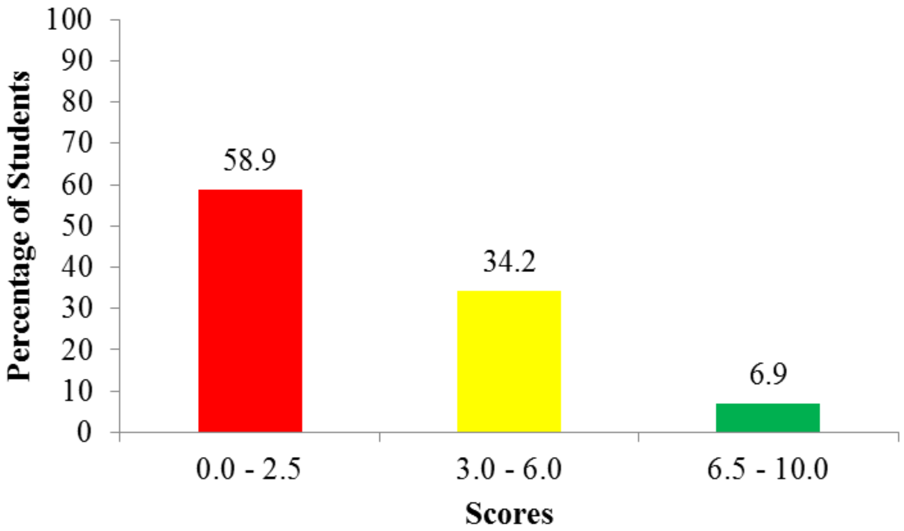


Figure 8: *Students' Performance in Question 8*

Students who scored high marks managed in this question to identify reagents which are used to prepare oxygen gas in the laboratory. Those reagents included potassium chlorate ($KClO_3$), potassium permanganate ($KMnO_4$) and mercury oxide (HgO). This indicates that students had adequate knowledge on different ways of preparing oxygen gas in the laboratory. In part (b), the students managed to give the products from the reactions of oxygen with carbon, phosphorus and sulphur as carbon dioxide, phosphorus (V) oxide and sulphur dioxide respectively. This indicates that the students were competent on the chemical properties of oxygen. In part (c), students gave correct uses of oxygen gas. This again indicates that they were conversant with the application of oxygen gas in daily life situations. Extract 8.1 displays a sample of correct responses from one of the students in question 8.

8. Oxygen gas is one of the important gases in the atmosphere. It combines with different elements to form oxides. It can be made in the laboratory and industries.

(a) Which reagents can be used to prepare oxygen gas in the laboratory apart from hydrogen peroxide?

(i) Heating mercuric oxide

(ii) Heating potassium permanganate.

(b) Give the name of the product formed by reacting oxygen gas with each of the following:

(i) Carbon Carbon dioxide.

(ii) Phosphorus phosphorus oxide.

(iii) Suphur Sulphur dioxide.

(c) Give five uses of oxygen gas.

(i) Oxygen is used during breathing and respiration, due the Oxygen it is important for the life process to take place.

(ii) It used during welding, the oxygen it support Combustion So that is Suitable for this task

(iii) It used by higher mountain climbers because at higher altitude there low accumulation of oxygen hence causing difficult In the process of breathing.

(iv) Oxygen it is used by the Ocean divers, through Oxygen oce an divers get breathing In the ocean due In the ocean there is most oxygen this cause difficult of divers to get breathing.

(v) Oxygen it is used In the hospitals, In the hospitals the victims require Oxygen Soas to get breathing due to their problems of breathing.

Extract 8.1: A sample of correct responses in question 8

In extract 8.1, the student correctly gave reagents for preparing oxygen in part (a). In part (b) and (c), the student gave the correct products and uses of oxygen gas respectively.

On the other hand, students who scored low marks in this question gave correct chemical reagents in part (a). Some of them wrote compounds such as zinc oxide, copper sulphate, water and sodium oxide. Those students gave compounds which contain oxygen atoms rather than the specified reagents. Other students attempted this part of the question by giving the reagents which are used to prepare hydrogen gas such as dilute hydrochloric acid. Consequently, some students gave incorrect products such as oxygen and water in part (b). Other students gave word equations without indicating the products for each reaction. This was attributed to failure of the students to understand the requirement of the question.

In part (c), some of the students gave uses of hydrogen gas instead of oxygen gas. Yet, others wrote partial answers which specified the fields where oxygen gas is of importance, contrary to the requirement of the question. Further analysis of the students' responses revealed that some of them wrote sentences with no proper meaning due to insufficient English language proficiency. To be specific, the students had inadequate knowledge on the preparation, properties and uses of oxygen gas hence missed most parts of the question. Extract 8.2 shows an example of incorrect responses from one of the students in question 8.

8. Oxygen gas is one of the important gases in the atmosphere. It combines with different elements to form oxides. It can be made in the laboratory and industries.

(a) Which reagents can be used to prepare oxygen gas in the laboratory apart from hydrogen peroxide?

(i) Heating compound chloride

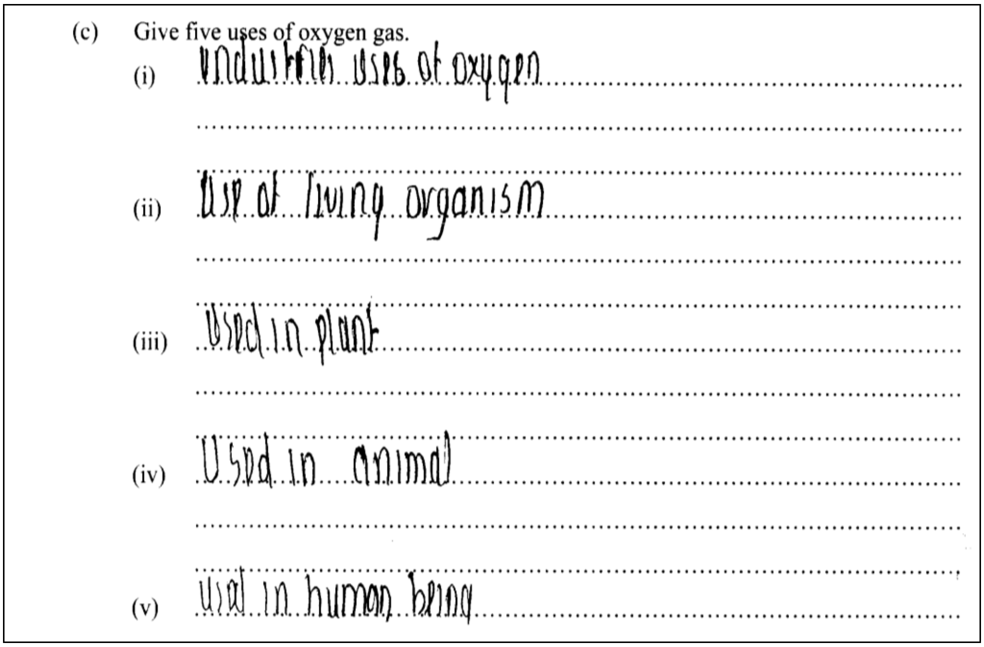
(ii) potassium chloride

(b) Give the name of the product formed by reacting oxygen gas with each of the following:

(i) Carbon carbon hydroxide and gas

(ii) Phosphorus phosphorus and water vapour

(iii) Suphur suphur oxygen gas



(c) Give five uses of oxygen gas.

(i) industrial uses of oxygen

(ii) use of living organism

(iii) used in plant

(iv) Used in animal

(v) used in human being

Extract 8.2: A sample of incorrect responses in question 8

Extract 8.2 shows responses of a student who wrote incorrect compounds in part (a) and (b). In part (c), the responses of the student were too general, contrary to the demand of the question.

2.2.7 Question 9: Formula, Bonding and Nomenclature

This question consisted of two parts namely, (a) and (b). In part (a), students were required to differentiate molecular formula from empirical formula. In part (b)(i), they were required to calculate the empirical formula of a compound which is a pure oxide of lead (Pb) containing 13.4% of oxygen. In item (b)(ii), they were required to show the way a compound can be formed between magnesium ion and chloride ions.

The question was attempted by 539,304 (89.5%) students out of which 59.0 percent scored a zero mark. Students who scored from 0 to 2.5 marks were 73.1 percent, 3.0 to 6.0 marks were 22.0 percent and from 6.5 to 10.0 marks were 4.9 percent. These data show that the general performance on this question was weak because 26.9 percent of all students scored 3.0 marks or above. The statistics of students' performance in this question is shown in Figure 9.

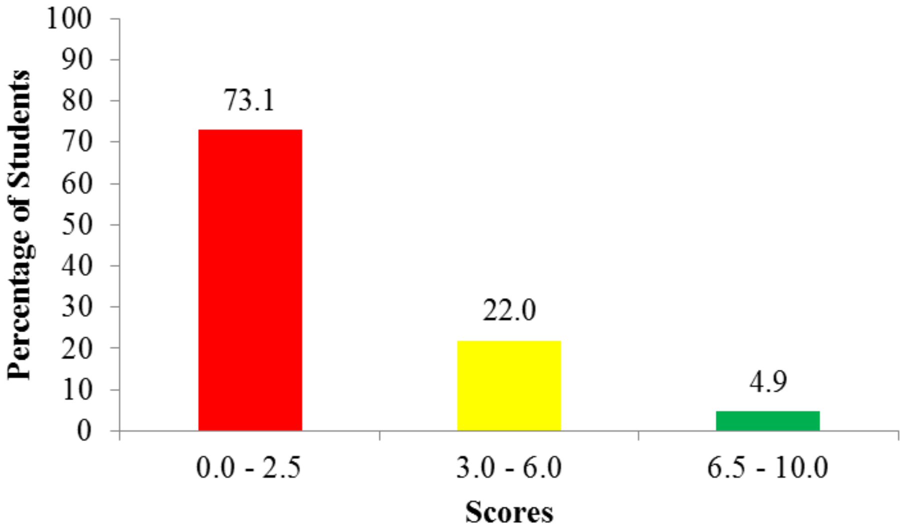
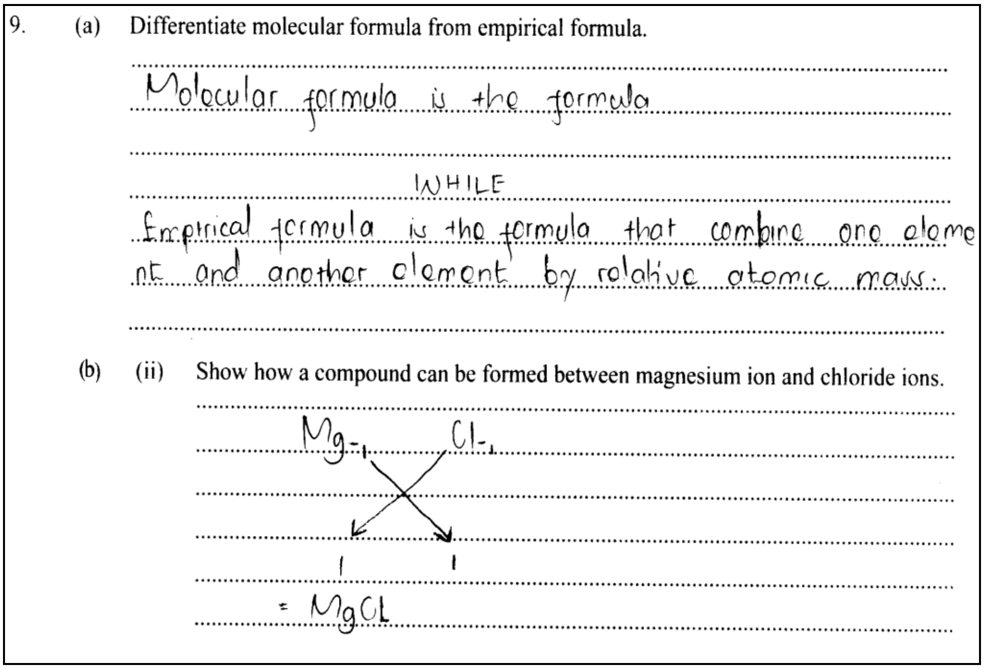


Figure 9: *Students' Performance in Question 9*

Students who scored low marks in this question could not identify the difference between molecular formula and empirical formula in part (a). Some of them interchanged the meaning of molecular formula and empirical formula. For instance, one of the students responded "*Molecular formula show the simplest ratio of atoms in a compound while empirical formula show the actual number of atoms in a molecule".* Another student responded to item (a)(i) as follows: that "*empirical formula is more important than the molecular formula."* This response was again not correct as the student gave his/her opinion on the terms asked contrary to the requirement/demand of the question. In part (b)(ii), the students failed to show the formation of magnesium chloride from its ions. This was attributed to failure of students to manipulate the valencies of magnesium and chlorine hence, gave incorrect product. For example, some of the students wrongly assigned magnesium ion an oxidation of 1+ which led to formation of a compound MgCl that do not exist. Other students used a molecule of chlorine gas (Cl_2) instead of chlorine ion (Cl^-) in the mechanism. To arrive at the correct compound, the students were supposed to assign magnesium and chlorine oxidation state of 2+ and -1 respectively hence, they would get $MgCl_2$. However, in part (b)(i), the atomic mass of lead was not provided in the question paper. Extract 9.1 shows a sample of incorrect responses in this question.



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

Molocular formula is the formula

WHILE

Empirical formula is the formula that combine one eleme nt and another element by relative atomic mass.

(b) (ii) Show how a compound can be formed between magnesium ion and chloride ions.

Mg-1 Cl-1

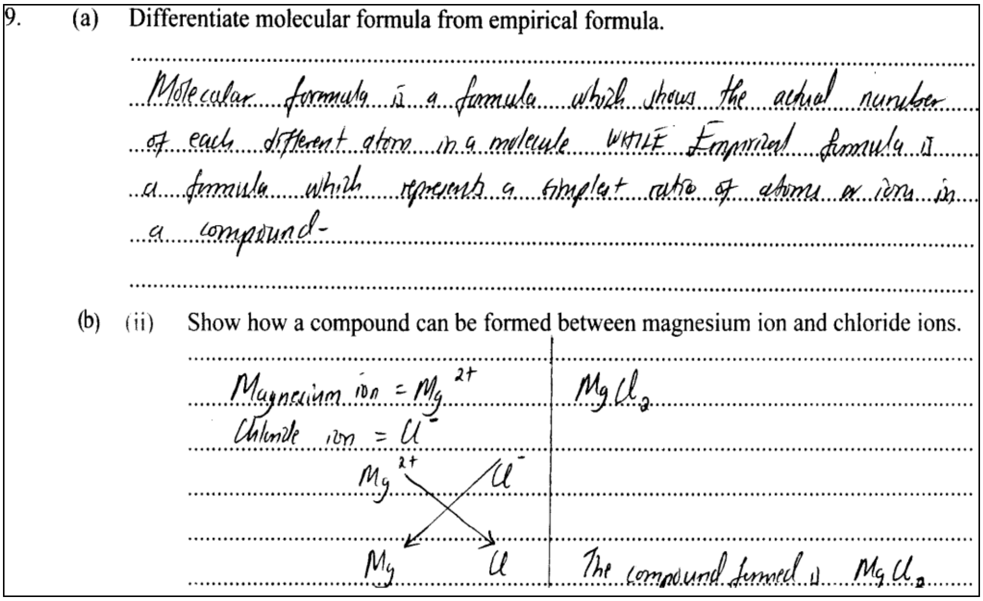
1 1

= MgCl

Extract 9.1: A sample of incorrect responses in question 9

In Extract 9.1, the student gave partial difference between molecular formula and empirical formula in part (a). In part (b)(ii), he/she showed the formation of magnesium chloride as MgCl instead of $MgCl_2$. The student used incorrect value of valency for magnesium hence got the incorrect formula.

On the other hand, students who scored high marks in this question managed to differentiate molecular formula from empirical formula in part (a). This indicates that they had extensive knowledge on the concept of formulae. In part (b), the students managed to show the formation of magnesium chloride from its ions. Some of them used the approach of cross arrows while others applied the concept of drawing orbitals of the respective ions. In addition, the students had adequate knowledge on the concept oxidation state and bonding. A sample of correct responses from one of the students in this question is shown in Extract 9.2.



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

Molecular formula is a formula which shows the actual number of each different atom in a molecule WHILE Empirical formula is a formula which represents a simplest ratio of atoms or ions in a compound.

(b) (ii) Show how a compound can be formed between magnesium ion and chloride ions.

Magnesium ion = Mg^{2+}

Chloride ion = Cl^-

Mg^{2+} Cl^-

Mg Cl

$MgCl_2$

The compound formed is $MgCl_2$

Extract 9.2: A sample of correct responses in question 9

In Extract 9.2, the student correctly gave the distinction between molecular formula and empirical formula in part (a). In part (b)(ii), he/she showed appropriately the formation of $MgCl_2$ from magnesium and chloride ions.

2.2.8 Question 10: The Scientific Procedure

The question required students to describe the main five approaches which chemists carry out during scientific research.

A total of 481,642 (80.0%) students attempted this question. Students who scored from 0 to 2.5 marks were 62.6 percent, from 3.0 to 6.0 marks were 26.2 percent and 6.5 to 10.0 marks were 11.2 percent. The general performance of students in this question was average as 37.4 percent of the students scored 3.0 marks or above. The summary of these data is shown in Figure 10.

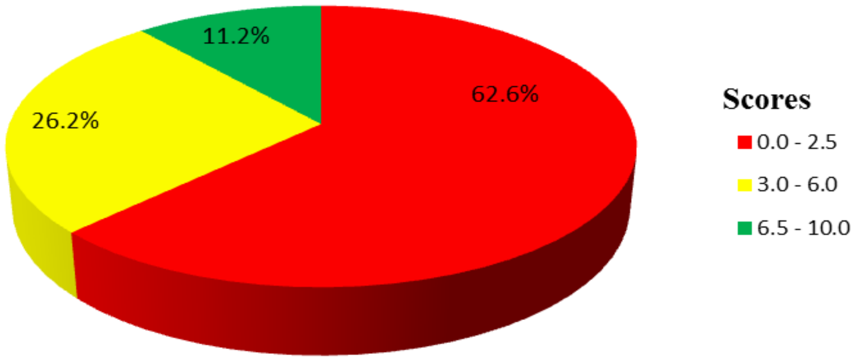


Figure 10: *Students' Performance in Question 10*

The analysis of students' responses shows that those who scored high marks (37.4%) described approximately the main five approaches to be followed in scientific research. In addition, those students included examples in their explanations, an indication that they had acquired appropriate competences on the concept of scientific procedures. Extract 10.1 shows a sample of correct responses from one of the students in question 10.

10. Describe the main five approaches which chemists carry out during scientific research.

1. Identifying the problem.
Before starting any scientific research, the chemist should first identify the problem. In this stage, the chemist observes and finds out the problems to work upon. For example, It has been observed that, there is low bean yield in a given place. And the chemist wants to know why. By understanding there is low bean yield in a place, he/she must have identified the problem.

2. Identifying the problem brings us to second approach which is Hypothesis formulation. This stage involves inquiry of the chemist himself to guess the reason for the problem. Hypothesis is an intelligent guess made by the chemist to achive the main cause of the problem. Here, the hypothesis may be due to poor soil fertility.

3. Experimentation and data collection:
This process is done to test the hypothesis. It can lead to rejection, acception or modification of the hypothesis, since the experiment is done to prove the hypothesis. Data collection is done together with experimentation. Data can be anything observed during experiment. Here, two plots X and Y may be prepared where, plot X will be applied fetilizer while plot Y will not be applied fertilizer to prove if it soil fertility is the reason.

4. Data analysis and interpretation:
This process involves analyzing and interpreting data which means, arranging the data collected in a good order so as to be understood by every one. If there are symbols used, they should be interpreted, so as to make order out of chaos.

5. Drawing conclusion:
This involveds making a theory if the hypothesis is accepted. If the hypothesis is not accepted, formulate or think of another idea and repeat the experiments and if the hypothesis is accepted, modify the results and develop the theory.

Extract 10.1: A sample of correct responses in question 10

In Extract 10.1, the student gave appropriate description of the main five approaches that chemists use during scientific research. This implies that the student had good mastery of the concept of scientific procedures.

On the contrary, students who scored low marks in this question failed to describe the approaches of a scientific research. Some of them mentioned laboratory apparatuses such as beaker, gas jar test tube and thermometer. Some students gave the uses of laboratory apparatuses. Others gave the common fittings of a chemistry laboratory such as good supply of water, gas supply, presence of fire extinguishers and chemicals. Yet, others skipped the question. Failure of the students to answer this question appropriately implies that they had inadequate knowledge on the scientific procedure. Extract 10.2 shows a sample of incorrect responses from one of the students.

10. **Describe the main five approaches which chemists carry out during scientific research.**

Chemistry Is the brach of science which dede with the study of
composition and decomposition of matter. Therecare scientific research
Don't make noise In the laboratory, This is the very sentific
because student and people It make nose In the laboratory In the
special room laboratory people to school saint In the laboratory in
experment In the special room or builing where santie method
Don't eat In the laboratory, people or student In eat in the labora
-tory In the school forexample student In the clase or builing of
the cals In the rabaratory rules people It make the roo In the school
to microscope or experment in the laboratory from special room.

Extract 10.2: A sample of incorrect responses in question 10

In Extract 10.2, the student gave definition of Chemistry and elaborated some of the laboratory rules contrary to the requirement of the question.

3.0 ANALYSIS OF STUDENTS' PERFORMANCE IN EACH TOPIC

In the 2021 Form Two National Assessment, a total of 12 topics were assessed. Those topics were *Introduction to Chemistry; Laboratory Techniques and Safety; Heat Sources and Flames; The Scientific Procedure; Matter; Air, Combustion, Rusting and Firefighting; Oxygen; Water; Fuels and Energy; Atomic Structure; Periodic Classification;* and *Formula, Bonding and Nomenclature*.

The analysis shows that, question 1 which was comprised of multiple choice items from different topics had good performance of 78.8 percent. The question was set from the following topics: *Water; Air, Combustion, Rusting and Firefighting; Matter; Heat Sources and Flames; Formula, Bonding and Nomenclature; Introduction to Chemistry* and *Atomic Structure.* The topic of *Heat Sources and Flames* which was assessed in question 5 had a good performance in which 67.8 percent of the students who sat for the assessment passed.

A total of three topics attained average performance. Those topics were: *Laboratory Techniques and Safety* (44.7%), *Oxygen* (41.1%) and *The Scientific Procedure* (37.4%). The average performance implies that students had reasonable understanding of the concepts tested across the topics.

On the other hand, the performance of the students was weak in three topics, namely, *Periodic Classification* (27.9%)*; Formula, Bonding and Nomenclature (24.9%)* and *Matter* (22.3%). The weak performance of students was caused by a number of factors including inadequate knowledge of the subject matter, failure to identify the requirement of the questions, poor English Language proficiency and lack of the basic numerical skills. A summary of the performance of students in different topics is presented in the appendix.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

In general, the performance of students who sat for Chemistry paper in Form Two National Assessment 2021 was average, in which the percentage of students who passed the assessment was 42.37. The number of students who attained grade A increased from 22,250 (3.7%) in 2020 to 25,036 (4.2%) in 2021. The analysis of students' performance on specific questions showed that, the students achieved good performance in question 1 and 5. Question 6, 8, and 10 had average performance of 44.7, 41.1 and 37.4 percent respectively. The performance of students was weak in questions 2, 3, 4, 7 and 9 which were set from the topics of *Periodic Classification* (27.9%); *Formulae, Bonding and Nomenclature* (24.9%) and *Matter* (22.3%).

The weak performance of students on the stated topics was attributed to:

(a) Lack of knowledge on various concepts in Chemistry for instance, 84.5 percent of the students failed to explain appropriate means of mixture separation in question 7.

(b) Lack of sufficient mathematical skills: This was evident in the responses to question 4 part (b) which involved calculations based on determining oxidation state of elements.

(c) Failure of the students to identify the requirements of the questions. For example, some of the students gave uses instead of properties of flames in question 5 part (c).

(d) Poor English language proficiency: This was obvious in several questions especially those in which students were required to give explanations. For example, in attempting question 10, some of the students wrote sentences with major grammatical errors.

4.2 Recommendations

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

(a) Students should be guided to demonstrate separation of mixtures by using various methods of mixture separation. This will improve students' understanding in the topic of *Matter*.

(b) Teachers are insisted to use wall charts and manila cards showing the modern Periodic Table when teaching periodic trends of elements, so as to improve performance in the topic of Periodic Table.

(c) When teaching, the topic of *Formula, Bonding and Nomenclature,* teachers are encouraged to use valence cards and wall charts showing the common radicals so as to sharpen students' understanding of the concepts related to bonding.

(d) Students are advised to thoroughly read the instructions of each question before attempting it. Additionally, they are advised to revise on their responses before submitting the scripts. This will help them to discover some errors and make necessary corrections.

(e) Students are insisted to consider speaking English Language regularly, which is the medium of instruction in Secondary schools so as to improve their ability to communicate in English.

APPENDIX

ANALYSIS OF STUDENTS' PERFORMANCE PER TOPIC

S/N	Topic	The Percentage of Students Who Scored 30% or Above		Average	Remarks
		Question No.	%		
1	Water; Air, Combustion, Rusting and Firefighting; Matter; Heat sources and Flames; Formula, Bonding and Nomenclature; Introduction to Chemistry and Atomic Structure	1	78.8	78.8	Good
2	Heat Sources and Flames	5	67.8	67.8	Good
3	Laboratory Techniques and Safety	6	44.7	44.7	Average
4	Oxygen	8	41.1	41.1	Average
5	The Scientific Procedure	10	37.4	37.4	Average
6	Periodic Classification	3	27.9	27.9	Weak
7	Formulae, Bonding and Nomenclature	4	22.9	24.9	Weak
		9	26.9		
8	Matter	2	29.1	22.3	Weak
		7	15.5		