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

CANDIDATES' ITEMS RESPONSE ANALYSIS REPORT FOR THE ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION(ACSEE) 2020

132 CHEMISTRY

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

CANDIDATES' ITEMS RESPONSE ANALYSIS REPORT FOR THE ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION (ACSEE) 2020

132 CHEMISTRY

Published by:

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

TABLE OF CONTENTS

FOREWORD

This Candidates' Items Response Analysis (CIRA) report for the Advanced Certificate of Secondary Education Examinations (ACSEE) 2020 has been prepared for the purpose of providing feedback to students, teachers, parents, policy makers and the public in general, on the performance of the candidates who sat for Chemistry examination.

The ACSEE marks the end of two years of the advanced level in secondary education. It is therefore, a summative evaluation which among other things shows the effectiveness of the educational system in general and the education delivery mechanism in our country. Essentially, the candidates' responses to the examination questions is a strong indicator on what the education system was able or unable to offer to students in their two years of pursuing the advanced level of secondary education.

This analysis report intends to contribute towards clear understanding of the reasons that have in most cases played a key role on the observed candidates' performance in Chemistry subject. The report further highlights some factors that contributed to the candidates' scoring of high marks. It has included the factors that made some of the candidates to score low marks in each question, including but not limited to inadequate ability to apply principles in interpreting scientific observations and improper approaches in carrying out calculations. The feedback provided in this report will enable the educational stakeholders to identify proper measures to be taken to improve the candidates' performance in future examinations administered by the Council.

Lastly, the Council would like to express sincere appreciation to examination officers, examiners and all other staffs who participated in the preparation of this report.

Dr. Charles E. Msonde
EXECUTIVE SECRETARY

1.0 INTRODUCTION

This report analyses the performance of the candidates who sat for the Advanced Certificate of Secondary Education Examinations (ACSEE) 2020 for Chemistry Paper 1 and Paper 2. The ACSEE 2020 Chemistry examination was the first examination set in accordance with the new ACSEE Chemistry format put in action in 2019. The ACSEE new format is based on the 2010 ACSEE Chemistry syllabus.

Paper 1 consisted of two sections namely; A and B. Section A consisted of seven (7) short-answer questions and the candidates were required to answer all the questions. Section B had three (3) structured questions and the candidates were required to answer two (2) questions.

Paper 2 had a total of six (6) short answer questions. The candidates were required to answer a total of five (5) questions.

A total of 29,279 candidates sat for the chemistry examination in 2020. The analysis of the examination results showed that the overall performance was good, as the candidates' scores in most of the questions were above 35 percent of the allocated marks. The results show that the candidates' performance in 2020 has increased by 1.56 percent as 94.38 percent of the candidates passed the examination compared to 92.82 percent of the candidates who passed the examination in 2019.

This report is presented in four sections, namely; introduction, analysis of the candidates' performance in each question, analysis of performance in each topic and finally, the conclusions and recommendations.

2.0 ANALYSIS OF THE CANDIDATES' PERFORMANCE IN EACH QUESTION

For each of the analyzed question, an overview of what the candidates were required to do, the general performance and the possible reasons for the observed performance, have been provided. Samples of extracts showing the candidates' responses have been used in appropriate sections to illustrate the cases presented.

The performance of the candidates has been classified into three categories. It is termed as poor/weak if the percentage of the candidates who passed the question or a particular topic ranges from 0 to 34; average if ranges from 35 to 59 percent and good if ranges from 60 to 100. The colours green; yellow and red have been used throughout the report to denote different categories of performance attained by candidates in a particular question or topic. Green colour denotes good, yellow shows average and the red colour, denotes weak or poor performance.

2.1 132/1-CHEMISTRY 1

This paper consisted of two sections, A and B. Section A had a total of 7 questions which weighed 10 marks each. Section B consisted of 3 structured questions which carried 15 marks each. Candidates were required to answer all the questions from section A and two questions from section B. The pass mark in each question in section A was 3.5, and 5.5 marks in section B.

2.1.1 Question 1: Selected Compounds of Metals

The question consisted of three parts namely; (a), (b), and (c). Part (a) required the candidates to use chemical equations to describe amphoteric and basic oxides.

Part (b) required the candidates to explain briefly the preparation of soluble chlorides while supporting their answers with the chemical equations. In part (c), the candidates were provided with the information that "A student suggested a methodology to prepare aluminium trichloride ($AlCl_3$) by following the steps (i) - (iv) as follows:

(i) Add sodium hydroxide solution to aluminium sulphate solution.

(ii) Filter off the precipitate.

(iii) Convert the hydroxide into a chloride by adding hydrochloric acid.

(iv) Evaporate the solution to leave the crystals of $AlCl_3$".

The candidates were then required to justify if the process could work.

The question was attempted by 24,018 (82%) candidates out of which 2101 (8.7%) scored from 6.0 – 10 marks, indicating a good performance, 7831 (32.6%) scored from 3.5 - 5.5 marks, indicating an average performance and 14,086 (58.7%) of the candidates who attempted this question scored poorly (from 0 - 3.0 marks). Figure 1 shows distribution of the candidates' scores.

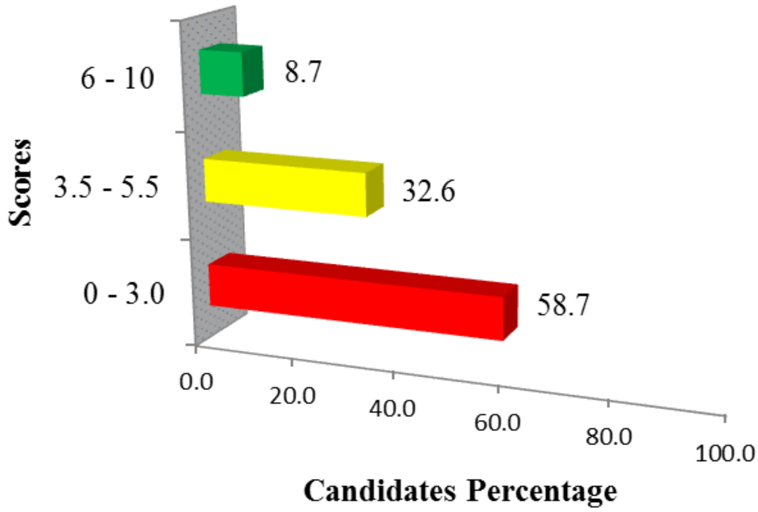
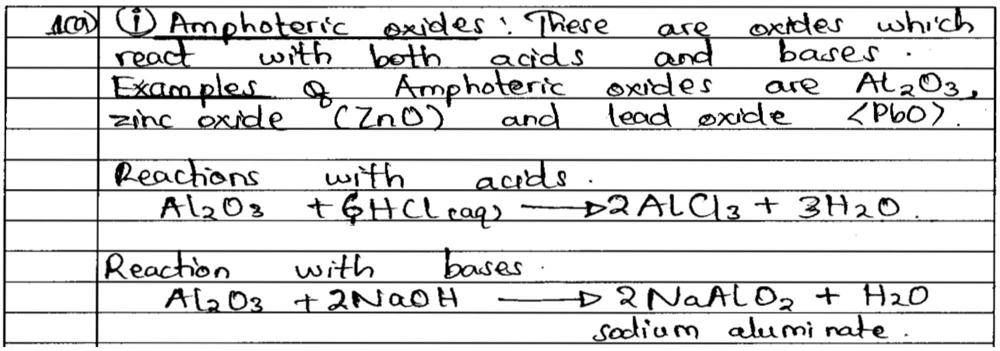


Figure 1: *Performance of the candidates in question 1*

Figure 1 shows that 41.3 percent of the candidates scored from 3.5 to 10 marks. This indicates that the overall performance in this question was average.

The candidates who scored all the 10 marks in this question described properly the dual properties of amphoteric oxides to behave as acids as well as bases. They were able to write appropriate chemical equations to support their responses. This justified their richness in concepts about the subject matter in question. In part (c) of the question, the candidates proved to have mastered properly the concept pertaining to the preparation of aluminium trichloride ($AlCl_3$). This could only be possible if the candidates understood in detail the chemical properties of aluminium chloride ($AlCl_3$), specifically hydrolysis. Extract 1.1 shows a sample of good responses from a candidate who performed well in this question.



1(a) (i) Amphoteric oxides: These are oxides which react with both acids and bases.
Examples of Amphoteric oxides are Al_2O_3, zinc oxide (ZnO) and lead oxide (PbO).

Reactions with acids.
$Al_2O_3 + 6HCl_{(aq)} \longrightarrow 2AlCl_3 + 3H_2O$.

Reaction with bases.
$Al_2O_3 + 2NaOH \longrightarrow 2NaAlO_2 + H_2O$
sodium aluminate.

(ii) Basic oxides : These are metallic oxides that react with acids to form salt and water only and when dissolved in water form alkaline solution.
For example ; sodium oxide (Na_2O).

Reaction with acid.

$Na_2O + 2HCl_{(aq)} \longrightarrow 2NaCl + H_2O$.

Reaction with water.

$Na_2O_{(s)} + H_2O_{(l)} \longrightarrow 2NaOH$.
alkaline solution of sodium hydroxide.

1(b) Soluble chlorides include sodium and potassium chloride.
* Reaction of a metal with HCl acid.
$2Na_{(s)} + 2HCl_{(aq)} \longrightarrow 2NaCl + H_2$.

1(b) * Reaction of metal oxide with HCl acid.

$Na_2O + 2HCl_{(aq)} \longrightarrow 2NaCl + H_2O$.

* Reaction of metal hydroxide with HCl acid.

$NaOH + HCl \longrightarrow NaCl + H_2O$.

* Reaction of carbonates with HCl acid.

$Na_2CO_3 + 2HCl_{(aq)} \longrightarrow 2NaCl_{(s)} + CO_{2(g)} + H_2O_{(l)}$

Extract 1.1: A sample of good responses in question 1

Extract 1.1 displays the responses of a candidate who described properly the terms asked and supplied appropriate chemical equations. The candidate gave proper explanations regarding the preparation of soluble chlorides.

However, some of the candidates scored unsatisfactorily in this question despite the fact that the concept is taught in the lower classes of ordinary level of secondary education. These candidates described wrongly the concept asked. For example, in part (a) (i), one of the candidates responded that "*amphoteric oxide is a compound that has acid and base for neutralization reaction to give salt and water.*" This indicated poor understanding on the topic of acids and bases. Moreover, these candidates did not understand the difference between soluble and insoluble chlorides. For example, in part 1(b) of the question, one of the candidates wrongly wrote "*silver chloride (AgCl) and lead chloride ($PbCl_2$)*" as soluble chlorides while they are not soluble. The candidates' responses in part 1 (c) revealed that they did not understand how to prepare aluminium trichloride ($AlCl_3$) through precipitation, evaporation and crystallization processes. Extract 1.2 shows a sample of poor responses from one of the candidates.

01a	i: Amphoteric oxides
	These are oxide which do not form compounds
	ii: Basic oxides
	These are the oxides which form compound whe
	n reacted.
b	Soln.
	a: Sodium Chloride (NaCl2)
	Na2 + Cl⁻ ⟶ NaCl2.
	b: Pottasium Chloride (KCl2)
	K2 + Cl⁻ ⟶ KCl2
	c: Calcium Chloride (CaCl2)
	Ca2 + Cl⁻ ⟶ CaCl2
	d: Hydrochloric acid (HCl)
	H⁺ + Cl⁻ ⟶ HCl

Extract 1.2: A sample of incorrect responses in question 1

In Extract 1.2, the candidate responded wrongly that amphoteric oxides do not form compounds and added ions to get chlorides while supplying wrong chemical formulae contrary to the requirement of the question.

2.1.2 Question 2: Soil Chemistry

This question had three parts namely; (a), (b) and (c). In part (a), the candidates were required to explain two detrimental effects of excessive salts in the soil. Part (b) required the candidates to give four advantages of adding organic manures in the soil. Part (c) required the candidates to calculate the Percentage Base Saturation (P.B.S.) of the soil sample from the following information: "20 g of soil sample was shaken with 40 cm^3 of 0.1 M HCl solution. After filtering and washing the soil, the filtrate required 27 cm^3 of 0.1 M NaOH solution for complete neutralization. The total Cation Exchange Capacity (C.E.C.) of the soil is 29 milli.eq per 100 g of the soil sample."

This question was attempted by a total of 28,308 (96.7%) candidates, out of which 12,851 (45.4%) candidates scored between 6.0 - 10 marks, 10,500 (37.1%) scored from 3.5 - 5.5 marks while 4957 (17.5%) candidates scored marks ranging from 0 - 3.0. Figure 2 summarizes the performance of the candidates in question 2.

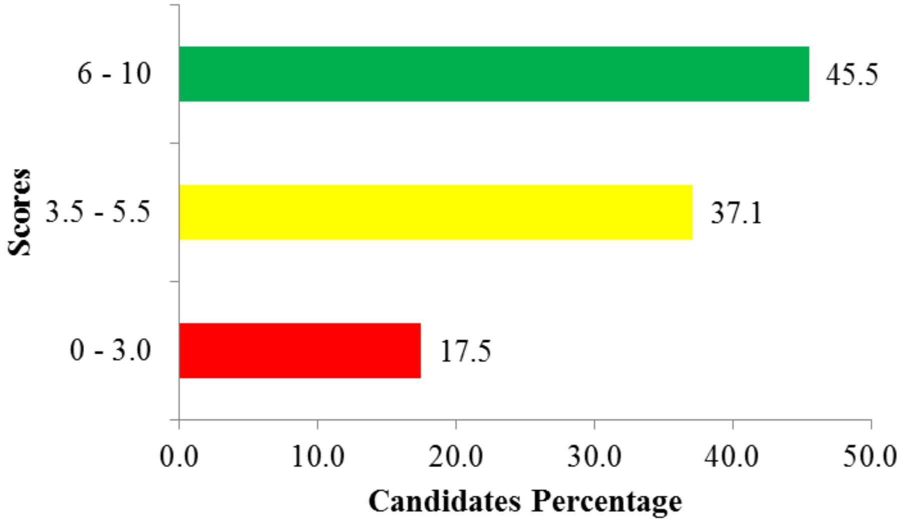


Figure 2: *Performance of the candidates in question 2*

The statistics shows that the general performance in this question was good, as a total of 23,351 (82.5%) of the candidates scored 3.5 marks or above.

The candidates with good performance gave appropriate explanation on the detrimental effects of excessive salts in the soil while responding to part 2 (a). Some of them supported their explanation by giving different examples of salts and their possible effects when they will be used excessively in the soil. Similarly, in part (b), the candidates gave correct explanation on the advantages of adding organic manures in the soil. This was an indication that these candidates were familiar with the importance of organic manures in the soil as well as their bioavailability.

In part (c), the candidates presented good mathematical manipulation skills on calculating the PBS of the soil sample. They were able to plug in the data correctly into the formula, proper unit conversions and arrived at the correct answer. Extract 2.1: is a set of correct responses from one of the candidates.

Extract 2.1

2. a) - Make the salt to be acidic if acidic salts such as $AlCl_3$ are in excess or more basic if basic salts are excess such as $CaCO_3$, hence become not conducive for some plants to grow on them.

- Affects microbodial activities by changing the pH of the soil whether by decreasing due to excess acidic salts ~~ane~~ or increasing due to the ~~preges~~ presence of basic salts.

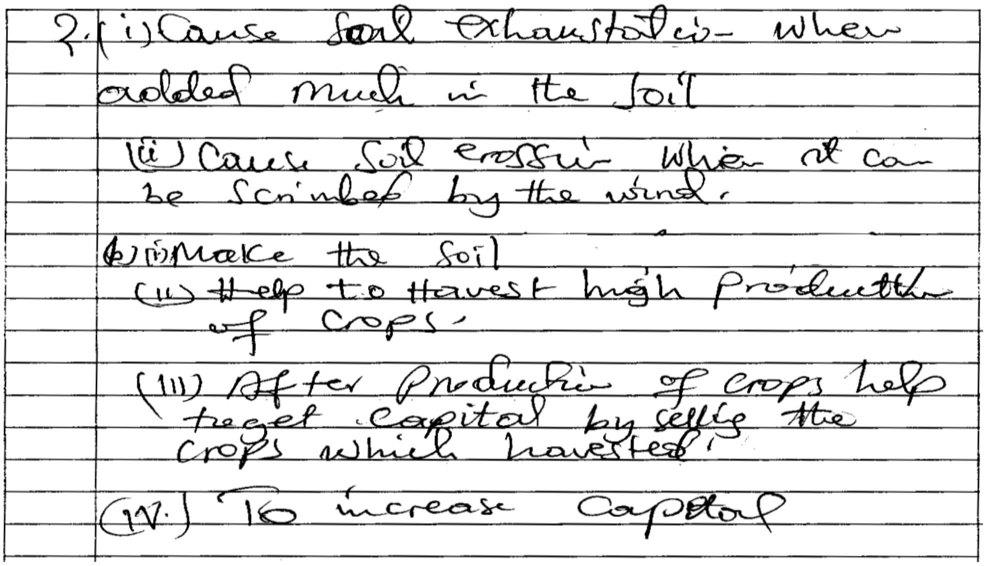
2.	b) - Improves soil structure.
	- Increasing water holding capacity of the soil.
	- Increase soil nutrients such as humus.
	- Increase microbodial activities such as decomposing of organic matters.
	c) $HCl + NaOH \longrightarrow NaCl + H_2O$.
	mole ratio 1 : 1.
	Excess volume of HCl = $40cm^3 - 27cm^3$
	$= 13cm^3$
	number of moles of $H^+ = \frac{13dm^3 \times 0.1M}{1000}$
	$= 1.3 \times 10^{-3}$ moles.
	number of moles of $H^+ \equiv$ number of moles of OH^- since the reaction involved ratio of 1 to 1.
	1.3×10^{-3} moles $= 1.3 \times 10^{-3}$ eq.
	1eq $\longrightarrow$ 1000meq.
	1.3×10^{-3}eq $\longrightarrow$?
	= 1.3meq.
	Then.
	1.3meq $\longrightarrow$ 20g of a soil sample.
	? $\longrightarrow$ 100g of a soil sample.
	$= \frac{1.3meq \times 100g}{20g}$
	= 6.5meq per 100g of soil
	$P.B.S = \frac{\Sigma \text{Base exchange capacity}}{C.E.C} \times 100\%$

2.	c) $P.B.S = \frac{6.5meq}{29meq} \times 100\%$
	$= 22.41\%$.
	∴ Percentage Base saturation of soil sample was 22.41%.

Extract 2.1: A sample of correct responses in question 2

In Extract 2.1, the candidate correctly explained the detrimental effects of excessive salts in the soil, stated the advantages of organic manures in the soil and used appropriate formula to correctly calculate the P.B.S.

On the contrary, some of the candidates with poor performance in this question wrote the common uses of the table salt (NaCl) interchangeably with the concept of excessive salt in the soil. For example, in part 2(a), one of the candidates wrote that; *salt is used for drying, so excess salt in the soil will dry the soil.* It was also noted that some candidates did not know the meaning of the term "*detrimental*" which was the root of the question hence, in part 2(b), some of the candidates used interchangeably the terms "*organic manure*" and "*liming material*". As a result of this, some provided advantages of liming materials instead of those for organic manures which indicates that they did not understand the requirement of the question. Also, few candidates failed to change moles into millmoles and relate it to gram unit hence, scored low marks in part 2 (c). Extract 2.2 shows a sample of poor responses.


2. (i) Cause soil exhaustation- when added much in the soil
(ii) Cause soil erossin when it can be scrinbef by the wind.
(b) (i) Make the soil
(ii) Help to havest high productthe of crops.
(iii) After production of crops help to get capital by selling the crops which havested.
(iv) To increase capital

Extract 2.2: A sample of poor responses in question 2

Extract 2.2 shows responses of a candidate who wrote the incorrect detrimental effects of excessive salts in the soil. The candidate also wrote grammatically incorrect sentences. Moreover, he/she gave incomplete advantages on the importance of adding organic manures to the soil.

2.1.3 Question 3: Aliphatic Hydrocarbons

This question comprised of parts (a), (b) and (c). In part (a) (i), the candidates were required to name two major natural sources of organic compounds and in (a) (ii), they were required to explain briefly three properties of carbon element that makes it to form a large number of compounds. Part (b) of the question read: "A form six student gave the following names for various substituted aliphatic hydrocarbons:

(i) 2-methyl-3-bromobutane
(ii) 3,3-dimethyl-2-chlorobutane
(iii) 4-chloro-3-bromo-2-pentene
(iv) 2-methyl-4-butyne.

The names indicate the formulae of the substituted aliphatic hydrocarbons but do not strictly obey IUPAC rules. Draw the structure suggested by the incorrect names and assign the correct name for each compound."

In part (c), the candidates were required to explain the observation that (i) Methyl propane has a lower boiling point than butane although both of them have the same molecular mass and (ii) Ignition sources such as smoking are not allowed at petrol stations.

The question was attempted by 28,519 (97.4%) candidates of whom 15,386 (54%) scored from 6.0 to 10, 9337 (32.7%)) scored 3.5 – 5.5, and the rest 3796 (13.3%) candidates scored 0 – 3.0 marks. Figure 3 summarizes the candidates' performance in this question.

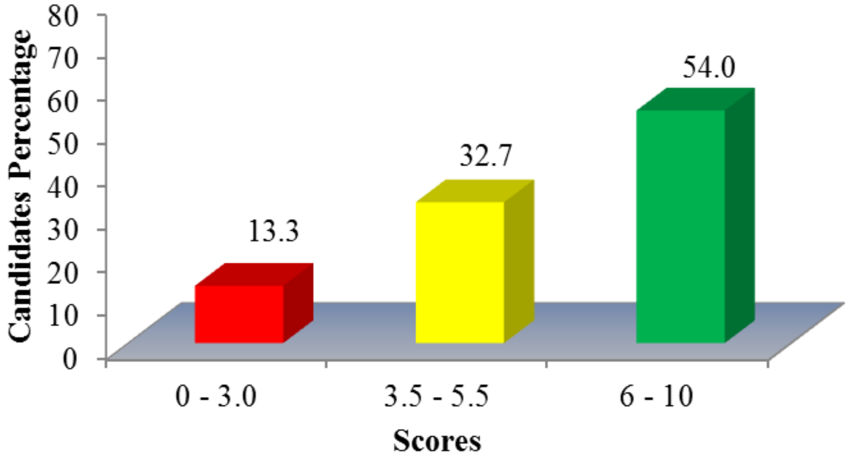
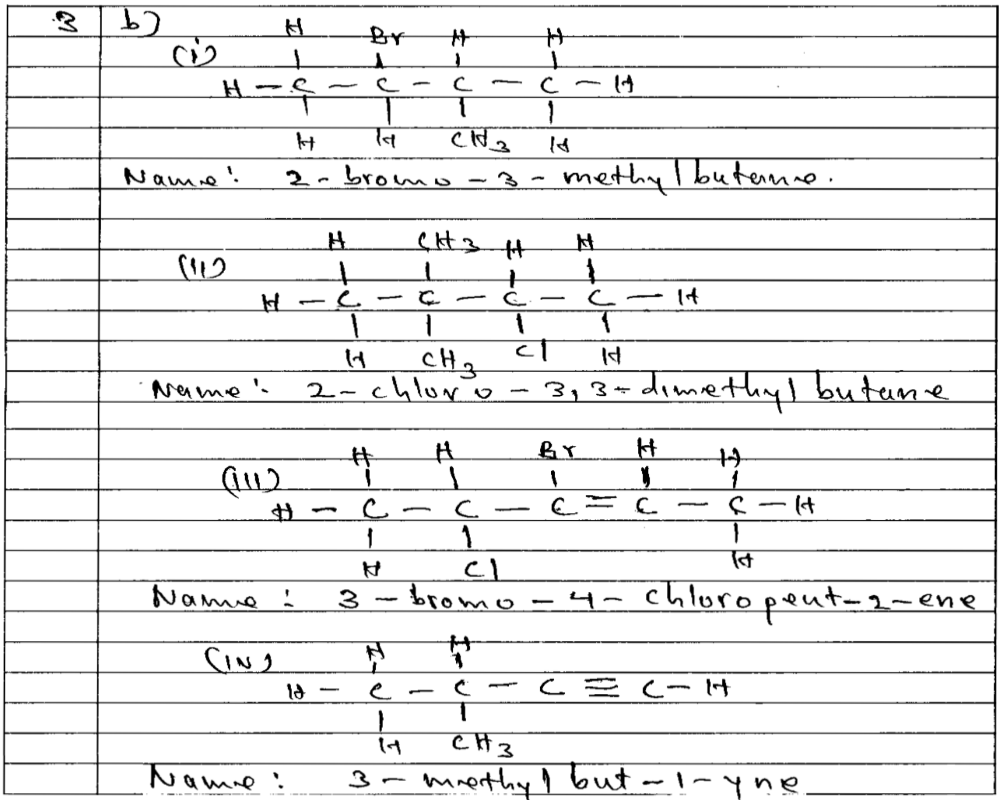


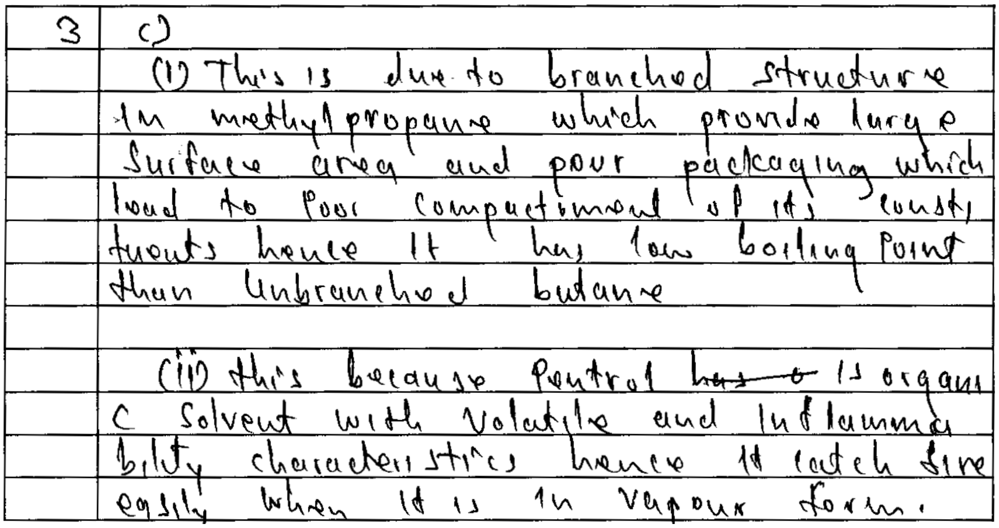
Figure 3: *Performance of the candidates in question 3*

The statistical analysis (Figure 3) shows that the overall performance in this question was good, as 24,723 (86.7%) of all the candidates who attempted this question scored 3.5 marks or above. Only 3796 (13.3%) candidates scored below pass mark. This was one of the best performed questions by the candidates.

The candidates who managed to score good marks were able to give correct responses to most parts of the question. These candidates had adequate basic knowledge on hydrocarbons and their derivatives, especially their properties as well as their major natural sources. The candidates also managed to apply the IUPAC rules to draw the correct structures from incorrect ones. Extract 3.1 is an example of responses from one of the candidates with good performance.

3	(a) (i) Coal
	(ii) Petrolleum.
	(b) (i) Catenation
	- Carbon as ability to form long linked
	Chain of carbon - carbon bonds hence
	it form large number of compounds
	(ii) Ability to undergo different types
	of hybridization
	- Carbon can undergo SP^3, SP^2 and SP
	types of hybridization hence large
	number of compounds are formed
	(iii) Ability to form multiple bonds
	between its atom
	- Carbon - carbon bonds can be single, double
	or triple hence alot of variety of compounds





Extract 3.1: A sample of correct responses in question 3

Extract 3.1 shows responses of a candidate who gave correct names of the two major natural sources of organic compounds and explained the properties of carbon that enable it to form large number of compounds. Furthermore, the candidate named the aliphatic compounds asked, explained the concept of branching in relation to lower boiling point and clearly, managed to give a correct reason on why smoking is strictly prohibited at petrol stations.

The analysis of the responses from the few candidates who scored unsatisfactorily revealed that, some of the candidates gave wrong answers regarding the natural sources of hydrocarbons in part (a) of the question. They also gave wrong natural sources of hydrocarbons. For instance, one of the candidates responded that: "*source of hydrocarbon is pentane*" instead of mentioning the major natural sources such as coal, petroleum or natural gas. This failure was attributed to lack of knowledge and competencies on hydrocarbons.

The analysis further reveals that few of the candidates copied the incorrect names in part (b), into their booklets as their responses. This indicated that these candidates were lacking the basic concepts on how to apply the IUPAC rules to name different compounds. Similarly, on explaining the observation that "Ignition sources such as smoking are not allowed at petrol stations", one of the candidates wrote *"Smoking can react with petrol in petrol stations and cause explosions and therefore it is not advised to smoking in petrol station."* This again revealed poor mastery of the content, particularly on the properties of hydrocarbons. Extract 3.2 illustrates a sample of incorrect responses given by one of the candidates in this question.

3! (a) (i) The two natural sources of organic compounds.

(a) Carbon.

(b) Hydrogen.

(ii) The following are the properties of Carbon compounds.

(a) Carbon has large number of lone pair.

(b) Carbon is the mostly abundant element for both metals and not metals.

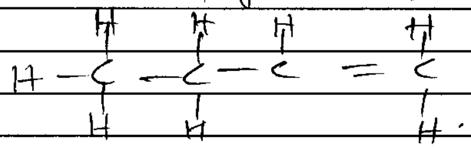
(c) Carbon has large number of electron affinity.

(b) The IUPAC rules at a correct names of aliphatic hydrocarbons.

(i) 2-methyl ~~bromobut~~ -3-ene.

$CH_3CH_2CH = CH_2$

The structural formular will be as

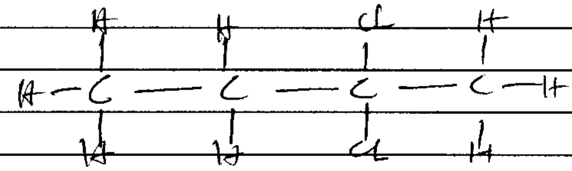


(ii) 3, 3 - dimethyl - 2 Chlorobutane. wrong!

3, 3 - dimethyl - 2 - chlorobutane. Correctness

$CH_3CH_2CCl_2CH_3$,

The structural formular.



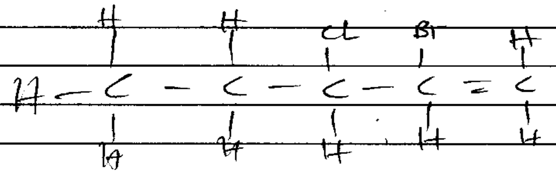
(iii) 4-chloro-3-bromo-2-pentene. wrong.

4, 3 -chloro bromo -2 pentene. Correctness.

$CH_3CH_2CHCL\ CBr{=}CH_2$

$CH_3CH_2CHCl\ CBr{=}CH_2$

The structure formular.



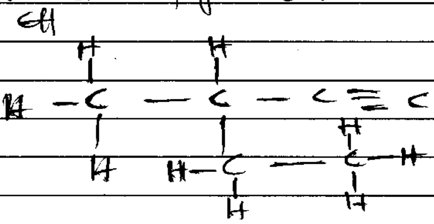
(iv) 2-methyl-4-butyne.

$CH_3CH - C \equiv C$

$\quad\quad |$

$\quad CH_2CH_3$

The structural formular.



(c)(i) The methyl propane has a lower boiling point than butane although both has the same molecular mass because the methyl propane has a triple complex bond ($C{\equiv}CH_3$) compared to Butane has simple single bond ($CH_3CH_2CH_2CH_3$) so that this may lead to methyl propane to have a lower boiling point compared to Butane but both has the same molecular mass.

(ii) Therefore Ignition sources such as smoking are not allowed at petrol stations because the smoking mainly made by a component of fire which has strong enough to cause the explosion out of petrol stations because the petrol pumps yield the organic compound which is the fluid has higher mains of gas at passes the occurrence of explosion throughout the petrol pump.

Extract 3.2: A sample of incorrect responses in question 3

Extract 3.2 shows the candidates' responses to part (a) of the question. The candidate gave incorrect names of the two major natural sources of organic compounds and gave wrong reasons regarding the uniqueness of carbon. Moreover, the candidate named incorrectly the compounds asked. He/she failed to explain the concept of branching in relation to lower boiling point and he/she was unable to explain why smoking is not allowed at petrol stations.

2.1.4 Question 4: Energetics

The question was as follows:

(a) Diborane (B_2H_6) is very reactive such that it was once considered as a possible rocket fuel for U.S space programs. The overall equation for the synthesis of diborane is:

$2B(s) + 3H_2\,(g) \rightarrow B_2H_6(g)$

Use the following data to calculate the enthalpy change of formation of B_2H_6 from its elements:

$B_2H_6\,(g) + \frac{3}{2}O_2\,(g) \rightarrow B_2O_3(s)$ $\Delta H = -1273$ kJ

$B_2H_6(s) + 3O_2\,(g) \rightarrow B_2O_3(s) + 3H_2O\,(g)$ $\Delta H = -2035$ kJ

$H_2\,(g) + \frac{1}{2}O_2\,(g) \rightarrow H_2O\,(l)$ $\Delta H = -286$ kJ

$H_2O\,(l) \rightarrow H_2O\,(g)$ $\Delta H = 44$ kJ

(b) When 100 cm^3 of 0.1 M KOH and 100 cm^3 of 0.1 M HCl were mixed in a calorimeter, temperature rose by 6.25 K. Given that the heat capacity of the calorimeter was 95 J/K and specific heat capacity of the solution mixture was 4.2 J/g K, calculate the standard enthalpy of neutralization. Assume that the density of the solution is equal to the density of water.

The question was attempted by 28,122 candidates corresponding to 96 percent, out of which 8545 (30.4%) candidates scored good marks (6 - 10), 6872 (24.4%) scored average marks (3.5 - 5.5) and 12,705 (45.2%) scored 0 – 3.0 marks. The summary of the performance in this question is shown in Figure 4.

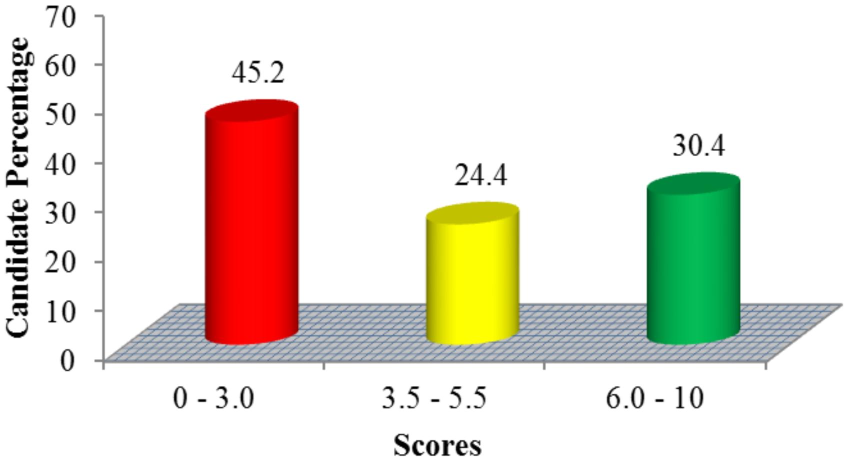
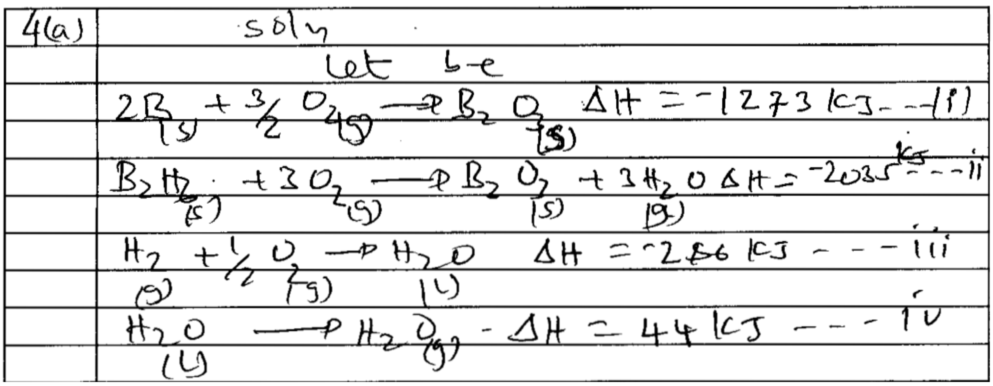


Figure 4: *Performance of the candidates in question 4*

The overall performance in this question was average as 15,417 (54.8%) candidates scored 3.5 marks and above. The candidates who scored high marks were able to use the given combustion data to calculate the change in enthalpy of formation of B_2H_6 from its elements. They also managed to use the given calorimetric information to calculate the standard enthalpy of neutralization between potassium hydroxide (KOH) and hydrochloric acid (HCl). The candidates' responses revealed that they had enough knowledge on the topic of energetics, specifically on calculations based on combustion and those based on calorimetry. Moreover, they correctly calculated the quantities of heat energy by using heat capacity and specific heat capacity. This signified that they had acquired sufficient knowledge regarding the application of the Hess's law of constant heat summation. Extract 4.1 represents a sample of good responses from one of the candidates.


4(a) soln

Let be

$2B_{(s)} + \frac{3}{2}O_{2(g)} \rightarrow B_2O_{3(s)}$ $\Delta H = -1273$ kJ ---(i)

$B_2H_{6(s)} + 3O_{2(g)} \rightarrow B_2O_{3(s)} + 3H_2O_{(g)}$ $\Delta H = -2035$ kJ ---ii

$H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)}$ $\Delta H = -286$ kJ ---iii

$H_2O_{(l)} \rightarrow H_2O_{(g)}$ $\Delta H = 44$ kJ ---iv then

∴ reverse equation (ii)

$B_2O_{3(s)} + 3H_2O_{(g)} \rightarrow B_2H_{6(s)} + 3O_2$ ΔH = 2035 KJ ---- a

$2B_{(s)} + \frac{3}{2}O_2 \rightarrow B_2O_{3(s)}$ ΔH = −1273 KJ ---- (b)

$3H_{2(g)} + \frac{1}{2}O_2 \rightarrow 3H_2O_{(l)}$ ΔH = 3 × −286 KJ ---- (c)

$3H_2O_{(l)} \rightarrow 3H_2O_{(g)}$ ΔH = 3 × 44 KJ ---- d

add equation a + b + c + d

$2B_{(s)} + 3H_2 \rightarrow B_2H_{6(s)}$

ΔH_f = 36 KJ

∴ Heat formation is 36 KJ

4b given ΔT = 6.25 K

volume of base, V_b = 100 cm³

Molarity of base M_b = 1 M KOH

Volume of acid, V_a = 100 cm³

Molarity of acid, M_a = 1 M

from reaction

$KOH_{(aq)} + HCl_{(aq)} \rightarrow KCl_{(aq)} + H_2O_{(l)}$

mole ratio KOH : HCl : H_2O is 1 : 1 : 1

now

n_b = Molarity × volume of base

n_b = 1 M × 100 × 10^{-3} dm³

n_b = 0.1 mol

and

n_a = 1 M × 100 × 10^{-3} dm³

n_a = 0.1 mol

so since

$n_b : n_a : n_{H_2O}$ = 0.1 mol

n_{H_2O} = 0.1 mol

from

H = (Heat capacity of calorimeter × ΔT + $M_c C_c$ ΔT of content)

= ((95 J/K × 6.5 K) + ρ_{water} × V_{total} × C_c ΔT)

= ((95 K/K × 6.5) + 1g/cm³ × 200 cm³ × 4.2 J/gK × 6.25

H = −5867.5 J

ΔH_{neut} = ΔH evolved / n_{H_2O}

then

4b ΔH_{neutr} = −5867.5 J / 0.1 mol

= −58675 J/mol

$\Delta H_{neutralization}$ = −58.675 KJ/mol.

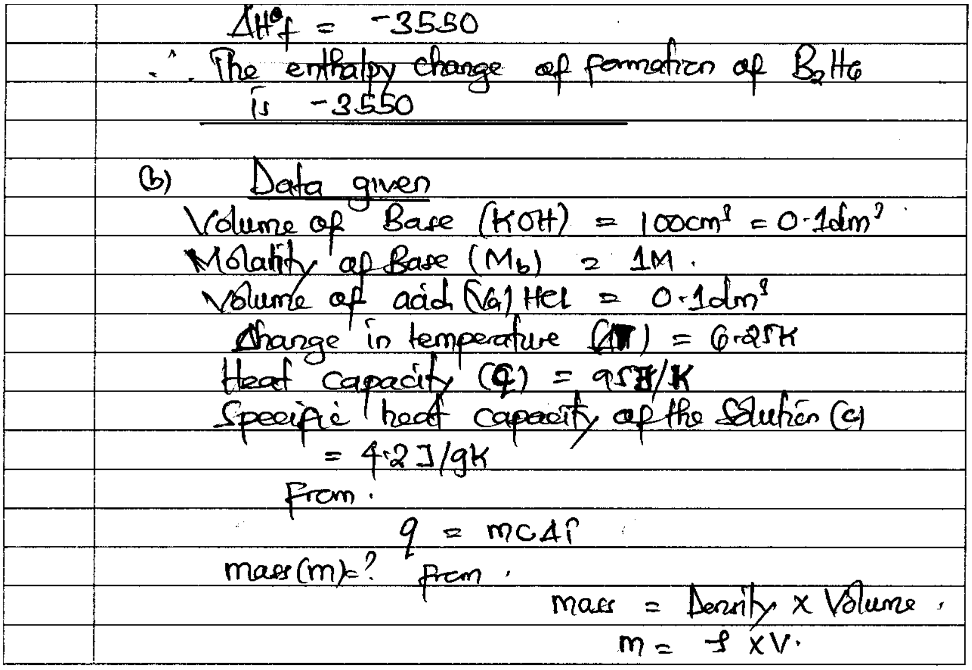
Extract 4.1: A sample of good responses in question 4

In Extract 4.1, the candidate explained properly the phrases asked and calculated correctly the enthalpy of formation of B_2H_6. Finally, the candidate performed calculation step by step to arrive at the correct value of the standard enthalpy of neutralization.

On the other hand, the analysis of the responses given by the candidates who scored poorly in this question showed that they faced the following challenges: In part (a), they derived wrongly the overall equation for the synthesis of diborane (B_2H_6) which was required to calculate the enthalpy of formation of diborane. It was noted that, some of the candidates treated gaseous water and liquid water molecules interchangeably while they have different states. Hence, they calculated wrongly the enthalpy of formation of diborane (B_2H_6).

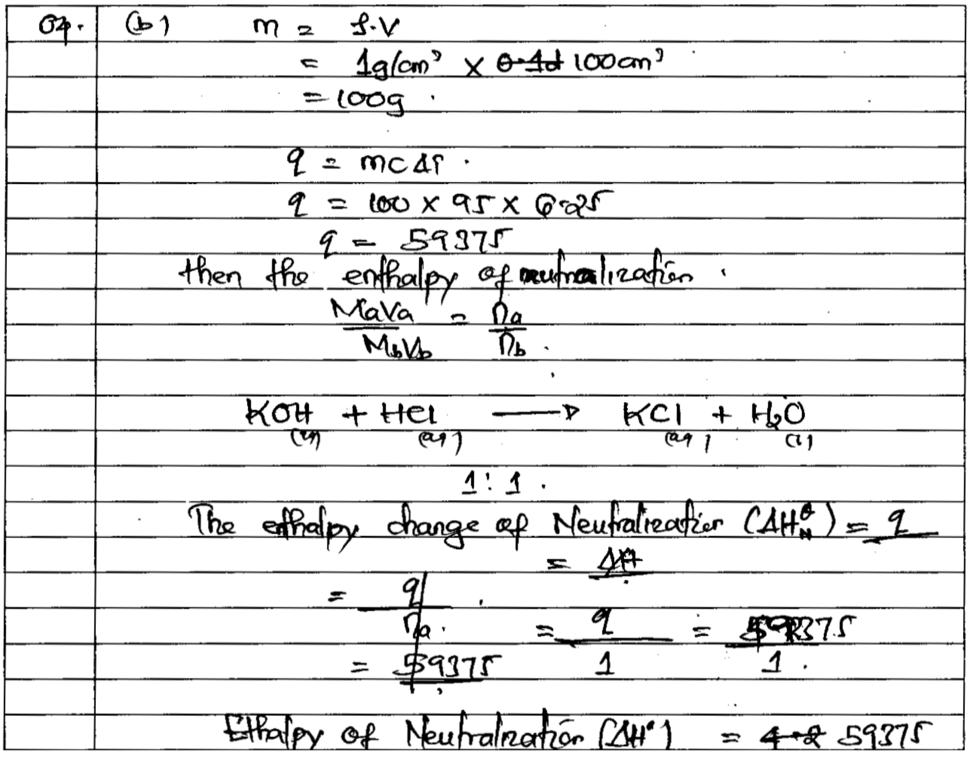
In part 4 (b) of the question, some of the candidates had common mistakes as one of them wrote; *the heat gained by calorimeter = mass x specific heat capacity x temperature. Change*; the candidate substituted *mass = 200 g, 95 J/K as heat capacity of the calorimeter and 6.25 K as change in temperature*. This signified that the candidates were not aware of the use of the heat capacity and specific heat capacity in calculating the required heat energy. As a result, they obtained a wrong value of heat to be gained by the calorimeter. It was also revealed that some of the candidates forgot to put a negative sign on the value of enthalpy obtained. This indicated the lack of knowledge of differentiating between endothermic and exothermic reactions. Extract 4.2 illustrates an example of poor responses supplied by one of the candidates.

04.	(a)	Data given:
		$2B(s) + \frac{3}{2}O_2(g) \longrightarrow B_2O_3(s)$ $\Delta H = -1273KJ$
		$B_2H_6(g) + 3O_2(g) \longrightarrow B_2O_3(s) + 3H_2O(g)$ $\Delta H = -2035KJ$
		$H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(l)$ $\Delta H = -286KJ$
		$H_2O(l) \longrightarrow H_2O(g)$ $\Delta H = 44KJ$
		Required the enthalpy change of formation of B_2H_6 =?
		Solution
		From:
		$\Delta H_f^\circ = \Delta H_1 + \Delta H_2 + \Delta H_3 + \Delta H_4$
		$\Delta H_f = -1273 - 2035 - 286 + 44$



ΔH^θ_f = −3550
∴ The enthalpy change of formation of B_2H_6 is −3550

(b) Data given
Volume of Base (KOH) = 100cm³ = 0.1dm³
Molality of Base (M_b) = 1M.
Volume of acid (Va) HCl = 0.1dm³
Change in temperature (ΔT) = 6.25K
Heat capacity (C) = 95J/K
Specific heat capacity of the solution (c) = 4.2J/gK
From.
q = mcΔT
mass(m) = ? From,
mass = Density x Volume,
m = ρ x V.



04. (b) m = ρ.V
= 1g/cm³ x ~~0.1d~~ 100cm³
= 100g.

q = mcΔT.
q = 100 x 95 x 6.25
q = 59375
then the enthalpy of neutralization.
$\frac{M_aV_a}{M_bV_b} = \frac{n_a}{n_b}$.

KOH (aq) + HCl (aq) ⟶ KCl (aq) + H_2O (l)
1 : 1.
The enthalpy change of Neutralization (ΔH^θ_N) = $\frac{q}{\Delta H}$
= $\frac{q}{n_a}$. = $\frac{q}{1}$ = $\frac{59375}{1}$.
= 59375
Enthalpy of Neutralization (ΔH°) = ~~4.2~~ 59375

Extract 4.2: A sample of incorrect responses in question 4

In Extract 4.2, the candidate did not reverse the second equation and substituted wrong data while calculating the standard enthalpy of neutralization.

2.1.5 Question 5: The Atom

The question comprised of parts (a), (b) and (c). Part (a) (i) required the candidates to state four postulates of Dalton's atomic theory. Part (a) (ii) needed the candidates to explain why different atoms have different chemical properties. In part (b), the candidates were provided with the following information:

S/n	Number of Neutrons	Number of Electrons
(i)	13	11
(ii)	7	8
(iii)	17	18
(iv)	16	16

Then, they were required to write the chemical symbol ($^{Z}_{A}X$) and orbital electronic configuration for the atoms in the table. In part (c), the candidates were required to calculate the minimum energy required to remove an electron from the hydrogen atom in its ground state.

A total of 29,099 candidates equivalent to 99.4 percent attempted the question, out of which 47.9 percent scored from 6 – 10 marks, 31.9 percent scored from 3.5 – 5.5 marks and 20.2 percent scored from 0 – 3.0 marks. Figure 5 shows a pictorial distribution of the candidates' scores in question 5.

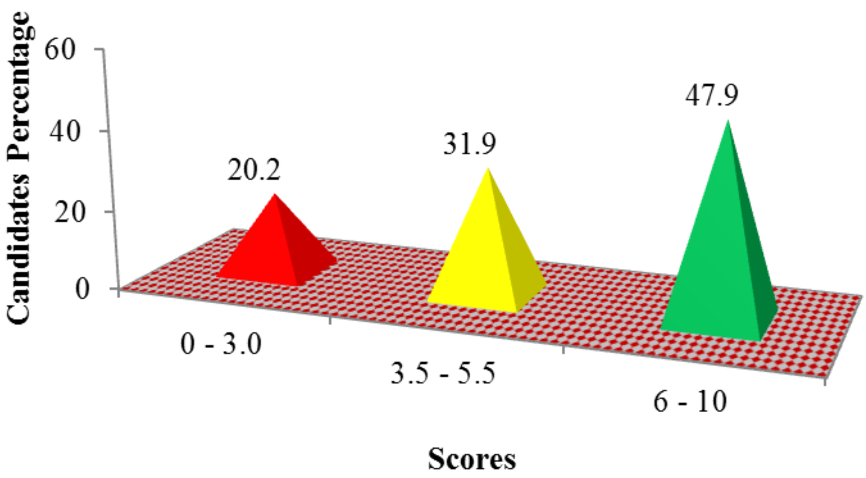


Figure 5: *Performance of the candidates in question 5*

The overall performance in this question was good as 23,215 (79.8%) candidates scored 3.5 marks or above (Figure 5). The analysis of the responses revealed that majority of the candidates, who scored high marks, were able to state four postulates of Dalton's atomic theory and clearly explained the concept of different atoms to have different chemical properties in part (a). Furthermore, they managed to write correctly the chemical symbols ($^{Z}_{A}X$) and the orbital electronic configurations for the atoms asked.

In part (c), the candidates gave a step by step manipulation on calculating the minimum energy required to remove an electron from the hydrogen atom in its ground state. Extract 5.1 displays an example of good responses from a candidate who scored high marks in this question.

5ai	i/ Matter are made up of smallest indivisible
	particle called atom
	ii/ Atom can not be created nor destroyed
	iii/ Atoms of the same element are the same
	iv/ Atoms of different elements are different
aii	Different atoms have different chemical
	properties due to difference in their atomic
	number which is responsible for chemical
	properties of a substance. Since different
	occupy different atomic number hence
	can not have the same chemical
	properties.

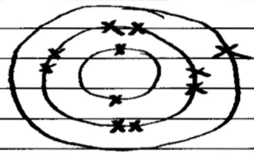
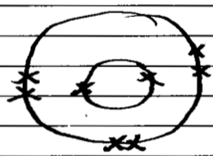
5 b	i) $^{24}_{11}X$
	ii) $^{15}_{8}X$
	iii) $^{35}_{18}X$
	iv) $^{32}_{16}X$
	The orbital configuration are
	i) [He] 2s [↑↓] 2p [↑↓][↑↓][↑↓] 3s [↑]
	ii) [He] 2s [↑↓] 2p [↑↓][↑][↑]
	iii) [Ne] 3s [↑↓] 3p [↑↓][↑↓][↑↓]
	iv) [Ne] 3s [↑↓] 3p [↑↓][↑][↑]
5 c.	$n_1 = 1$ $n_2 = \infty$
	From $E = \frac{hc}{\lambda}$.
	$E = hc \cdot \frac{1}{\lambda}$.
	$\frac{1}{\lambda} = R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$.
	$\frac{1}{\lambda} = 1.09678 \times 10^7 \left(\frac{1}{1^2} - \frac{1}{\infty^2} \right)$.
	$\frac{1}{\lambda} = 1.09678 \times 10^7 \left(\frac{1}{1^2} - 0 \right)$
	since $\frac{1}{\infty} = 0$
5c	$\frac{1}{\lambda} = 1.09678 \times 10^7$
	$\lambda = 9.11267 \times 10^{-8}$
	$E = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{9.11267 \times 10^{-8}}$
	$E = 2.181 \times 10^{-18}$ J
	∴ The minimum energy required is
	2.181×10^{-18} J

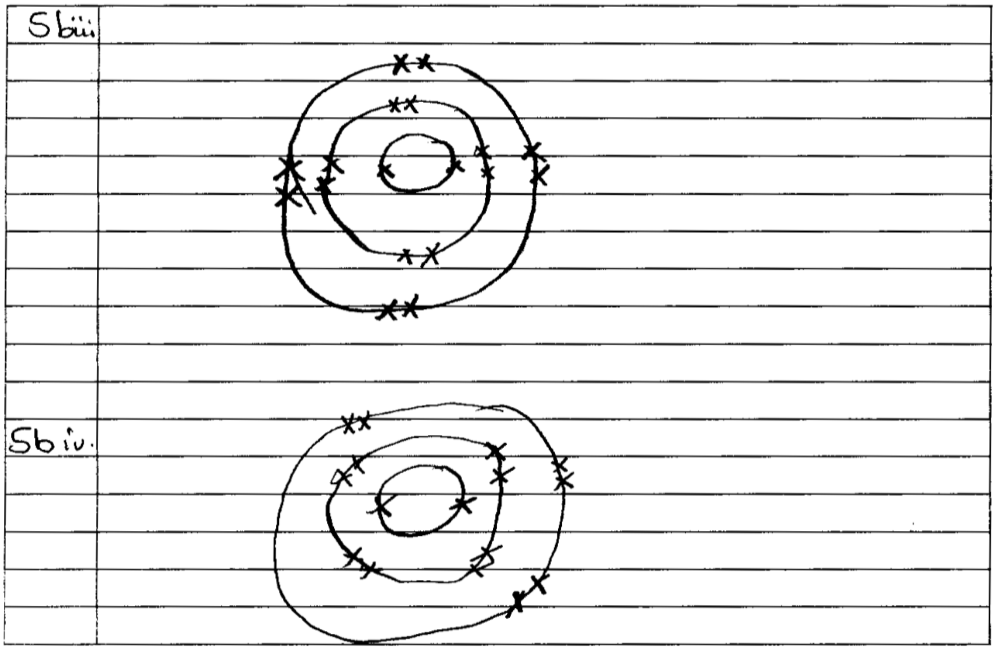
Extract 5.1: A sample of correct responses in question 5

Extract 5.1 shows responses of a candidate who stated well the four postulates of Dalton's atomic theory, gave good explanation as to why different atoms have different chemical properties and presented the correct chemical symbols and orbital electronic configuration for each atom. The candidate calculated correctly the minimum energy asked.

On the other hand, some candidates scored low marks in this question. The analysis shows that, in part 5 (a) (i), some of the candidates gave wrong postulates for Dalton's atomic theory. For example, one of the candidates wrote: "*Atom is anything that occupy space, atom has mass, atom has chemical properties*". Unfortunately, these statements were not correct as they have not been stipulated by John Dalton. The candidates were expected to write postulates such as (i) *Matter is made up of tiny indivisible particles called atoms* (ii) *The atoms of a given element are identical in all aspects* (iii) *Atoms can combine to form a compound, and when they do so they do in small whole numbers* and (iv) *Atoms of different elements vary in size and mass*.

In part 5 (a) (ii) of the question, some candidates gave also wrong reason as to why different atoms differs in their chemical properties. In responding to part 5 (b), some of the candidates interchanged A and Z while writing chemical symbols using the notation ($^{Z}_{A}X$). Moreover, some of them wrote wrong formulae while calculating the minimum energy required to remove an electron from Hydrogen atom at ground state hence, ended up with incorrect value. Extract 5.2 illustrates a sample of incorrect responses given by one of the candidates in this question.

5a·i·	Four postulates of Dalton's atomic theory i) Atom is anything that occupy space. ii) Atom has mass iii) Atom has chemical propartíes iv) Atoms may form bond with other atom.
5a ii·	Different atoms has different chemical propatíes since they differ number of atomic vacancy and amount of proton gain or loose.
5bi·	
5bii	



Extract 5.2: A sample of inappropriate responses in question 5

Extract 5.2 portrays a response of a candidate who stated the properties of matter instead of Dalton's atomic theory. He/she wrote incorrect statements in both parts 5 (a) (i) and 5 (a) (ii). The candidate drew elementary atomic structure diagrams, instead of writing chemical symbols using the notation $^{Z}_{A}X$.

2.1.6 Question 6: Chemical Bonding

This question had four parts, namely; (a), (b), (c) and (d). In part (a), the candidates were asked to differentiate (i) electrovalent bond from octet rule and (ii) lone pair from bonding pair of electrons. Part (b) required the candidates to use sketches to explain briefly the three possible overlaps that could occur during a sigma bond formation.

In Part (c), the candidates were asked to give two reasons for the observed difference in bond strength between the sigma and pi bonds in compounds. In part (d), the candidates were required to predict the geometry of ammonia basing on the Valence Shell Electron Pair Repulsion (VSEPR) theory.

The question was attempted by a total of 26,705 (91.2%) candidates. Statistical data shows that 2161 (8.1%) candidates scored 6.0 - 10 marks, 7281 (27.3%) scored 3.5 - 5.5, marks and 17,263 (64.6%) scored 0 - 3.0

marks. Figure 6 shows the distribution of the candidate's scores in question 6.

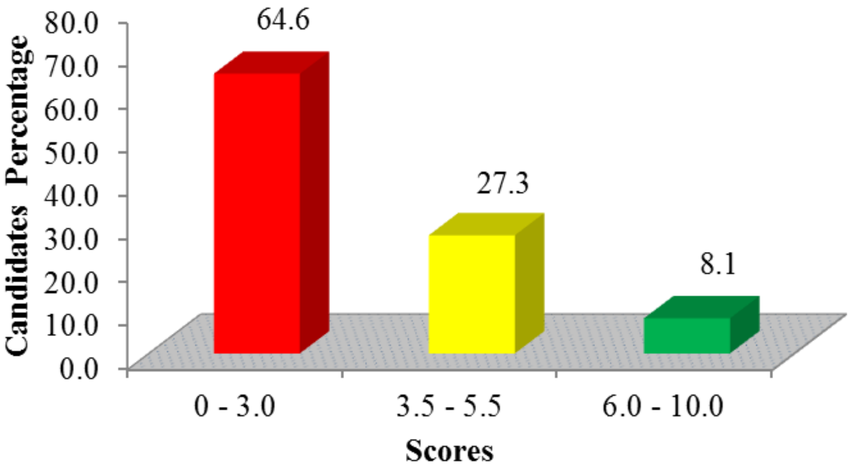


Figure 6: *Performance of the candidates in question 6*

The general performance in this question was average as 9442 (35.4%) of the total candidates who attempted this question scored 3.5 marks or above. The candidates who scored high marks responded correctly to most parts of the question. They managed to differentiate electrovalent bond from octet rule and lone pair from bonding pair of electrons. These candidates showed to have understood properly the electron arrangement in an atom as well as the hybridization of atomic orbitals which in turn enabled them to arrive at a correct answer. Moreover, they were able to use sketches to explain the possible overlaps that could occur during the sigma bond formation.

They gave appropriate reasons for the observed difference in bond strength between sigma and pie bonds in compounds. This showed that they were competent in relating the relative strength of the molecular bonds with the type of overlapping involved.

In the last part of the question, they predicted correctly the geometry of ammonia basing on the Valence Shell Electron Pair Repulsion (VSEPR) theory. This was possible because they had proper knowledge regarding the effect of lone pair on the geometry of molecules. Extract 6.1 shows an example of good responses from one of the candidates' work sheet.

6 (a) (i) Electrovalent bond - Is the chemical bond that is formed by transfer of electrons from metal to non-metal example in NaCl

while

Octet rule state that " An atom can gain, lose or share electron(s) and acquire the duplet or octet configuration (state)".

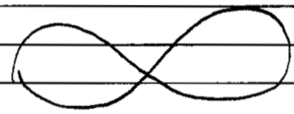
(ii) lone pair, are valence electrons which do not take part in a chemical bond formation

WHILE

Bonding pair electrons are valence electrons which takes part in chemical bond formation

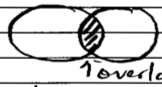
6 (b) Sigma bond is formed by end to end overlapping of atomic orbital

Sketch



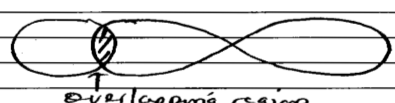
6 (b) Sigma bond is formed by end to end overlapping of atomic orbitals

(i) by overlapping of s and s orbital
Example in formation of H_2, formation of H



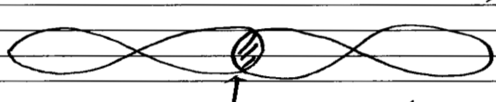
overlapping region

(ii) by overlapping of s and p orbital
Example formation of HF



overlapping region

(ii) by overlapping of p - p orbitals
Example formation of F_2



Overlapping region

6 (c) The reasons for the observed differences are

(i) Sigma bonds is relatively stronger than Pi bond (pi bonds are weaker than sigma bond).

(ii) The free rotation about sigma bond is not possible while the free rotation about Pi bond is possible

6 (d)

Molecule NH_3

from VSEPR

Number of hybrid orbitals = Number of lonepair(s) + number of sigma bond

Number of lone pair = $\frac{\text{Number of outermost valence electron of central atom} - \text{Total number of bonds}}{2}$

$= \frac{5 - 3}{2}$

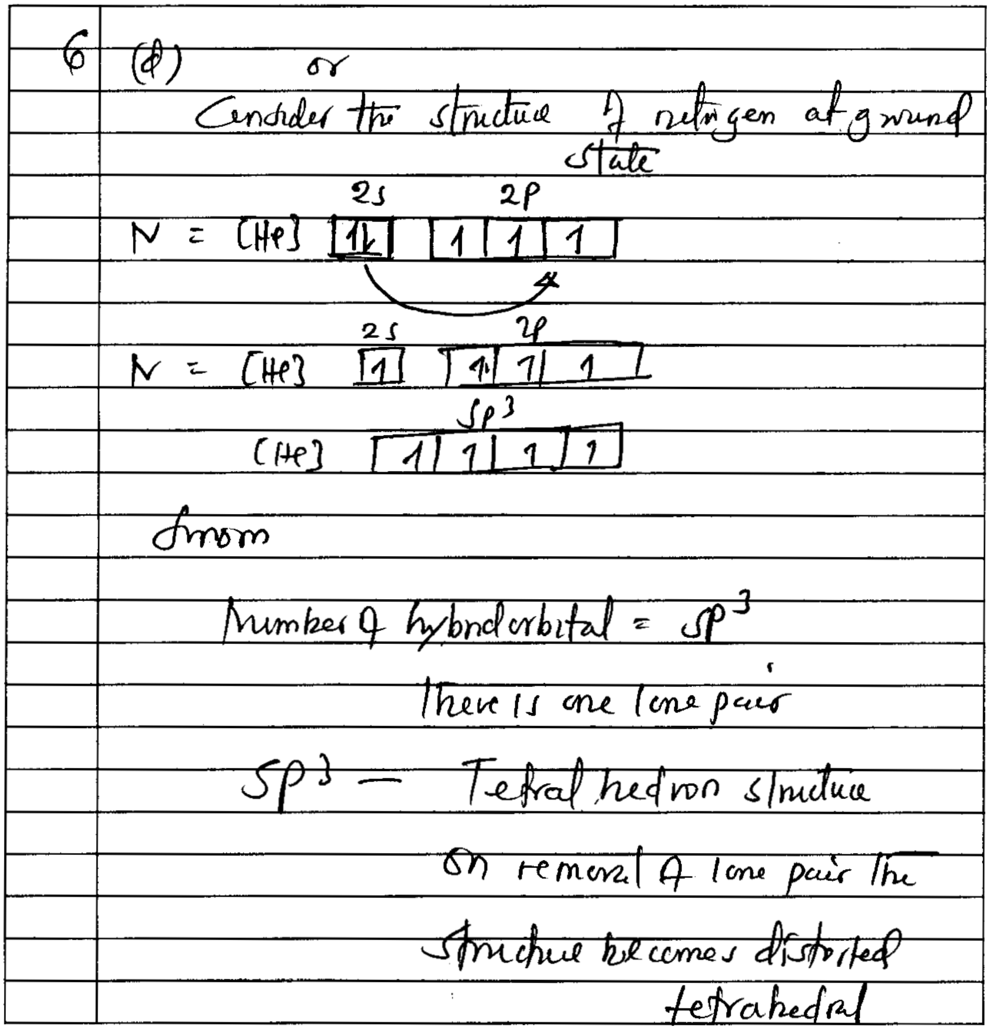
$= 1$ lone pair

Sigma bond = 3

Then

Number of hybrid orbitals = 3 + 1

= 4 = sp^3


6 (d) or

Consider the structure of nitrogen at ground state

2s 2p

N = [He] [1↓] [1 | 1 | 1]

2s 2p

N = [He] [1] [1 | 1 | 1]

sp3

[He] [1 | 1 | 1 | 1]

from

Number of hybrid orbital = sp3

There is one lone pair

sp3 — Tetrahedron structure

On removal of lone pair the structure becomes distorted tetrahedral

Extract 6.1: A sample of appropriate responses in question 6

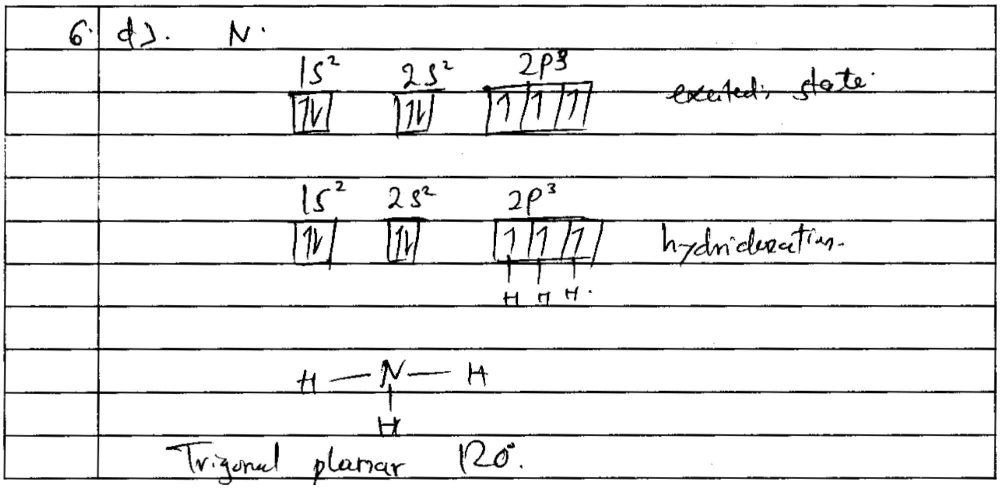
Extract 6.1 represents the responses from a candidate who differentiated properly the electrovalent bond from an octet rule and lone pair from bonding pair of electrons. The candidate managed to explain the possible overlaps that could occur during the sigma bond formation with the help of sketches. Finally, the candidate managed to predict the geometry of ammonia basing on the Valence Shell Electron Pair Repulsion (VSEPR) theory. However, the candidate gave incorrect reason in 6 (c) (ii).

On the other hand, some of the candidates who scored low marks in this question differentiated incorrectly the electrovalent bond from octet rule and lone pair from bonding pair of electrons. This indicated that they had inadequate knowledge on electron arrangement in an atom and hybridization of atomic orbitals. Eventually, this made them fail to arrive at the expected answer. It was revealed that some of the candidates used wrong sketches to explain the possible overlaps that could occur during the sigma bond formation. Some of them even used the diagrams of atomic structure. Moreover, they differentiated incorrectly the relative strength of the molecular bonds. For example, one of the candidates wrote "*sigma bond is weaker than pi bond because have few electrons*" instead of differentiating the sigma and pie bond in terms of the extent of overlapping as well as the orientation of atomic orbitals. In the last part of the question, the candidates predicted incorrectly the geometry of ammonia. This indicated that they were not conversant with the Valence Shell Electron Pair Repulsion (VSEPR) theory. Extract 6.2 illustrates a sample of incorrect responses given by one of the candidates in this question.

6. a.

i. Electrovalent bond
Is bond formed due to shairing of electron between two atom to acquire noble gas state.
while;
Octet rule.
Is role which state for the stable atom which is full fill in valency obitals such as noble gases.

ii). Lone pair.
Is obital which do not participent on bonding formation.
whiles
Bonding pair of electrons.
Is process of combine the pair of electrons which do not participent on bonding to form the new bond.



6. d). N·

$1s^2$ $2s^2$ $2p^3$ ~~excited; state~~

$1s^2$ $2s^2$ $2p^3$ hybridization.

H H H·

H — N — H
H

Trigonal planar 120°.

Extract 6.2: A sample of incorrect responses in question 6

In Extract 6.2, a candidate differentiated incorrectly an electrovalent bond from octet rule by defining covalent bond instead of electrovalent bond. Moreover, the candidate gave a wrong explanation for the octet rule. He/she misspelled the word participate into "*partizipent*" hence, could not convey properly the intended message. Furthermore, He/she wrote inappropriate reasons regarding the difference in bond length between sigma and pie bond. Finally, the candidate predicted the geometry of ammonia as trigonal planar instead of distorted tetrahedral.

2.1.7 Question 7: Gases

This question had two parts, namely; (a) and (b). In part (a) (i), the candidates were asked to calculate the volume occupied by 0.25 moles of air entered in a diesel engine at a pressure of 1.05×10^5 Pa and a temperature of 27 °C assuming that the air is ideal. In part (a) (ii), the candidates were asked to calculate the temperature of 0.25 moles of air entered in a diesel engine at a pressure of 1.05×10^5 Pa and a temperature of 27°C immediately after compression to one twentieth of its original volume where the pressure rises to 7.0×10^6 Pa, assuming that the air is ideal.

In part (b), the candidates were required to calculate the partial pressure of nitrogen gas and hydrogen gas and the total pressure of the gas mixture when 42 g of nitrogen gas and 8 g of hydrogen gas are mixed in a 10 litre vessel at 20 °C.

The question was attempted by 28,586 (97.6%) candidates out of which 16,649 (58.3%) percent scored 6 - 10 marks, 7268 (25.4%) scored 3.5 - 5.5 marks while 4669 (16.3%) scored marks ranging from 0 to 3.0. Summary of the candidates' performance in this question is shown in Figure 7.

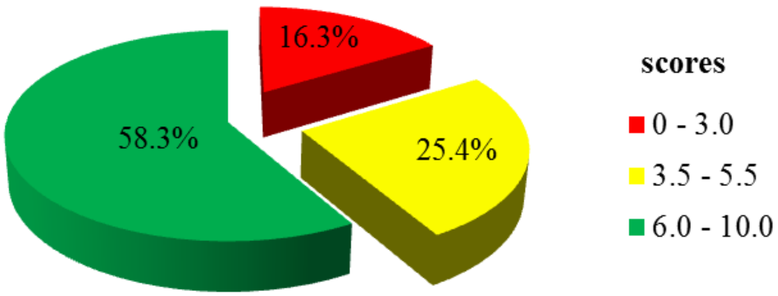


Figure 7: *Performance of the candidates in question 7*

Figure 7 shows that the general performance in this question was good as 23,917 (83.7%) candidates who attempted this question scored an average or above mark. This question was among the most highly performed by the candidates.

The candidates who scored high marks in this question correctly calculated the volume of air that entered the diesel engine using the ideal gas equation PV = nRT. This indicated that they mastered properly the concepts of gas laws. In part 7 (a) (ii), they were able to calculate the temperature of air when its volume decreased to one twentieth of its original volume due to compression. Most of the candidates showed clearly how they calculated the partial pressure of hydrogen and nitrogen as well as the total pressure of the gas mixture. In addition, these candidates managed to manipulate correctly the units for volume, temperature and pressure. Extract 7.1 is a sample of response from one of the candidates who performed well in this question.

7. (a) Number of moles, n = 0.25 moles

Pressure, P_1 = 1.05×10^5 Pa,

Temperature, T_1 = 27°C (300K).

Assumption: Air is ideal,

(i) Volume occupied V: Required

for ideal gas

$$PV = nRT.$$

$$V = \frac{nRT}{P}.$$

where, R = universal gas constant = $8.31\ J\ mol^{-1}\ K^{-1}$

$$V = \frac{0.25\ moles \times 8.31\ J\ mol^{-1}K^{-1} \times 300K}{1.05 \times 10^5\ Pa.}$$

$$= 5.9357 \times 10^{-3}\ m^3$$

(ii) Temperature T_2: Required when compression to 1/20 of original volume, when temperature rise to 7×10^6 Pa.

Data.

T_2: Required

$P_2 = 7 \times 10^6$.

$V_2 = \frac{1}{2} V_1$.

from combined equation

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}.$$

$$\frac{1.05 \times 10^5 \times V_1}{300} = \frac{7 \times 10^6 \times 1/20 \times V_1}{T_2}.$$

$$T_2 = \frac{7 \times 10^6 \times 300}{1.05 \times 10^5 \times 20}$$

$$= 1000K.$$

∴ Temperature is 1000 K

7. (b) Data.

Mass of nitrogen, M_N = 42g.

Mass of hydrogen gas, M_H = 8g

Volume of a vessel, V = 10 dm³.

Temperature of a vessel, T = 20 °C. (293K)

Solution

Part ~~mole fraction for hydrogen~~ — from, number of moles = $\frac{Mass}{Molar\ mass, Mr}$

number of moles for hydrogen n_H = $\frac{8g}{2g/mol}$ = 4mol

since Molar Mass of hydrogen = 2.

Number of moles for nitrogen, n_N = $\frac{42}{(14\times2)}$ = 1.5mol

Since molar mass for nitrogen = ~~1.5mol~~. 14x2 = 28.

Mol fraction for hydrogen, X_H = $\frac{n_H}{n_H+n_N}$

= $\frac{4}{1.5+4}$ = 0.73.

Mole fraction for nitrogen X_N = 1 − 0.73 = 0.27.

Then partial pressure for hydrogen,

$P^o_H = \frac{n_H RT}{V}$.

= $\frac{4 \times 8.31 \times 293 \times (0.0821)}{10 \quad 10}$

P^o_H = 9.622 atm

∴ Partial pressure for hydrogen is 9.622 atm.

Partial pressure for nitrogen

$P^o_N = \frac{n_N RT}{V}$

7. (b) $P^o_N = \frac{1.5 \times 0.0821 \times 293}{10}$

= 3.608 atm.

∴ Partial pressure for nitrogen is 3.608 atm

Total pressure, P_T

$P_T = P^o_H + P^o_N$.

= 9.622 + 3.608

= 13.23 atm

∴ Total pressure is 13.23 atm

Extract 7.1: A sample of correct responses in question 7

Extract 7.1 depicts the responses of a candidate who manipulated correctly the values of volume, temperature and partial pressure of nitrogen, hydrogen as well as the total vapour pressure. The candidate performed calculations correctly in the subsequent sections

On the other hand, the analysis of the candidates' responses in this question showed that some of the candidates scored marks below average. These candidates failed most parts of the question. For instance, in responding to part 7 (a) (i), some of the candidates applied the gas constant R as 0.0821 atm mol^{-1} K^{-1} dm^3 and pressure P as 1.05 x 10^5 Pa without considering the unit agreement between the two constants. This signified incompetency in manipulation of the units.

Further analysis on the responses of the candidates revealed that, in part 7 (a) (ii), they wrote the mathematical term "one twentieth" as "*20^{th} =20 dm^3*" instead of $\frac{1}{20}$ which signified incompetency in both English language and mathematical reasoning. In part 7 (b), some of the candidates calculated the mole fraction by applying masses. For example, one of the candidates wrote "$\chi_{N2} = \frac{42}{42+8} = 0.84$" instead of using the mole fractions.

Extract 7.2 illustrates a sample of incorrect responses given by one of the candidates in this question.

07 (a) (i) soln

Data given

Pressure = 1.05 x 10^5 pa

temperature 27°C + 273K = 300K

Air (O_2) = 0.25 moles

required

volume = ?

From

ideal gas equation

PV = nRT

$V = \frac{nRT}{P}$

V = 0.25 x 8.314 x 300 K

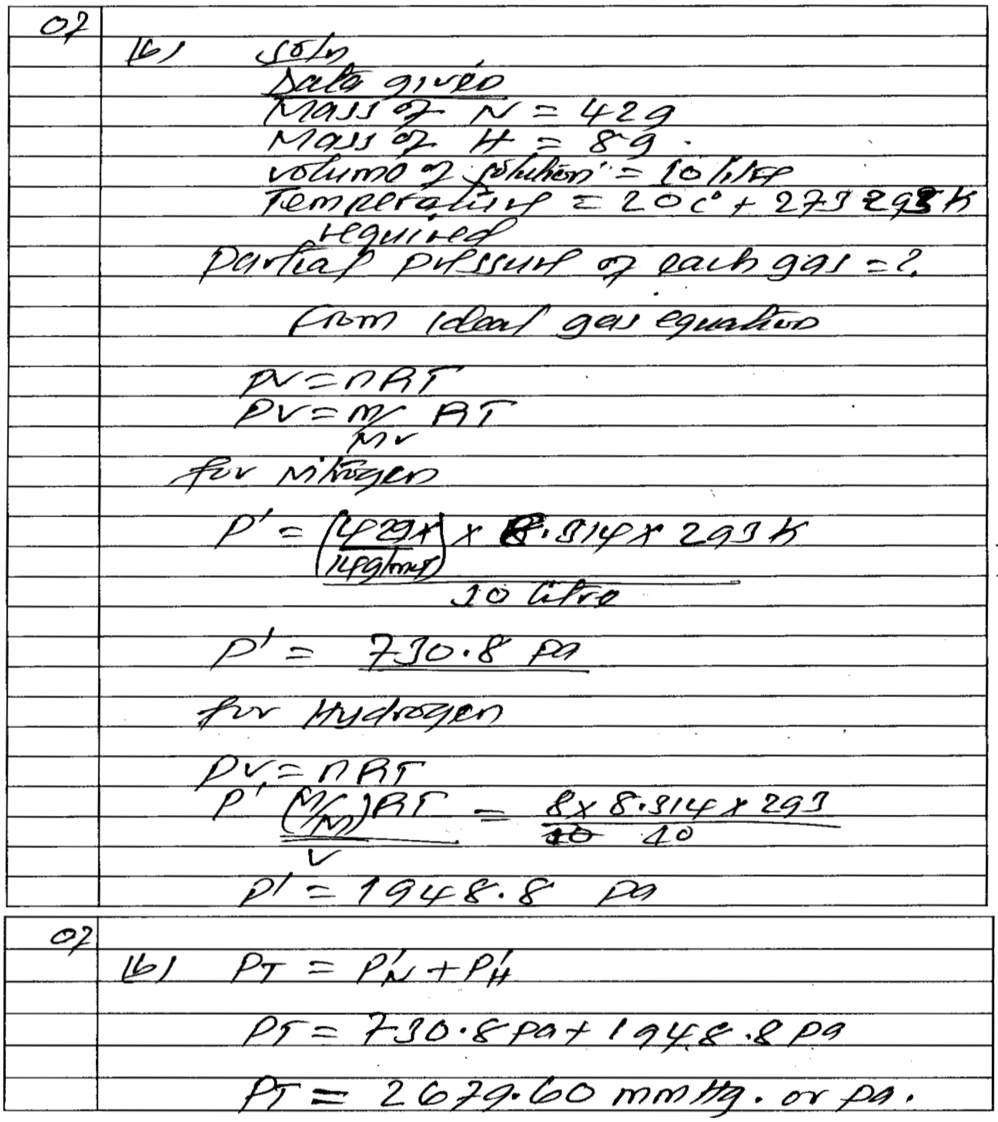
V = 623.55 ~~dm³~~

(ii) from

PV = nRT

$V = \frac{nRT}{P}$ = 0.25 x 8.314 x 294

V = 611.079 dm^3



07 (b) soln

Data given

Mass of N = 42g

Mass of H = 8g.

volume of solution = 10 litre

Temperature = 20c° + 273 293K

required

Partial pressure of each gas = ?

From ideal gas equation

PV = nRT

PV = m/Mr RT

for nitrogen

P' = (42g / 14g/mol) x 8.314 x 293K / 10 litre

P' = 730.8 pa

for hydrogen

PV = nRT

P' = (m/Mr)RT / V = 8 x 8.314 x 293 / 40

P' = 1948.8 pa

07 (b) PT = P'N + P'H

PT = 730.8 pa + 1948.8 pa

PT = 2679.60 mmHg. or pa.

Extract 7.2: A sample of incorrect responses in question 7

Extract 7.2 depicts responses of a candidate who managed to write correct formula in 7 (a) and (b), but failed to manipulate the data to get the correct answers.

2.1.8 Question 8: Relative Molecular Masses in Solution

This question had four parts namely, (a), (b), (c) and (d). In part (a), the candidates were required to (i) differentiate between cryoscopic constant and ebullioscopic constant, (ii) derive an expression relating the van't Hoff factor(i) and the degree of dissociation (α) and (iii) briefly explain the effect of degree of dissociation of a solute on the boiling point of a solution.

In part (b), the candidates were required to calculate the mass of ethylene glycol, $C_2H_6O_2$, the main component of antifreezing agent which must be added to a 10.0 L of water to produce a solution for use in a car radiator that freezes at -23.3°C assuming the density of water is exactly 1 g/ml and cryoscopic constant is 1.86°C kg/mol. Part (c) required the candidates to calculate the relative molecular mass of haemoglobin when 0.120 g of haemoglobin was dissolved in 200 cm^3 of benzene at 20 °C, if the solution exerted an osmotic pressure of 25.6 Pa.

In part (d), the candidates were required to calculate the degree of dissociation of a 1% solution of sodium chloride that freezes at -0.604°C, if the molal freezing point depression constant for water is 1.86°Ckg/mol.

This question was attempted by 16,801 (57.4%) candidates, making it the least attempted question in section B. The candidates who scored 9.0 - 15 marks were 27.3 percent while 34.0 and 34.6 percent scored 5.5 - 8.5 and 0 - 5.0, respectively. Figure 8 gives the summary of statistical analysis in this question.

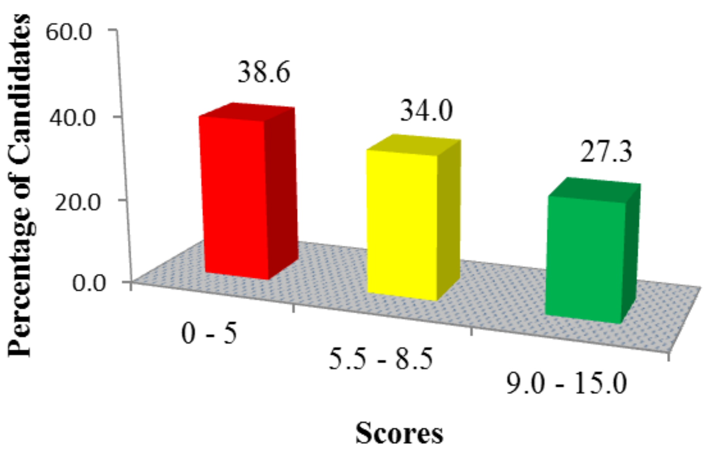


Figure 8: *Performance of the candidates in question 8*

The overall performance was good as most of the candidates (61.3%) managed to score the pass mark (5.5 marks) or above. Most of the candidates who scored high marks in this question managed to differentiate between cryoscopic constant and ebullioscopic constant, derived well an expression relating the van't Hoff factor (*i*) and the degree of dissociation (α), and managed to explain properly the effect of degree of dissociation of a solute on the boiling point of a solution. These candidates proved to have appropriate competency in the concept of colligative properties of solutions, particularly the concept of weak and strong electrolytes. The candidates were able to calculate systematically the mass of ethylene glycol and the relative molecular mass of haemoglobin. This was attributed to good skills in mathematical manipulations.

Finally, in the last part of the question, the candidates managed to calculate the degree of dissociation of a 1% solution of sodium chloride. This was achieved because they derived correctly an expression relating the van't Hoff factor (i) and the degree of dissociation (α).

Extract 8.1 is a sample of correct responses given by one of the candidates in this question.

8 a)

i) cryoscopic constant is the freezing point depression obtained when one mole of a non volatile solute is dissolved in a solvent of one kilogram (1000g) while Ebullioscopic constant is the boiling point elevation obtained when one mole of a non volatile solute is dissolved into a solution containing one kilogram (1000g) of a solvent.

ii) Expression relating vant hoffs factor (i) and degree of dissociation (α)

Consider

$$A_xB_y \longrightarrow xA + yB$$

	A_xB_y	xA	yB
Initially	1	0	0
At time = t	$1-\alpha$	αx	αy

Total number of moles initially $n_i = 1$ = Number of moles expected

Total number of moles after time t n_t = Number of moles observed

$n_t = 1-\alpha + (x+y)\alpha$ but $x+y=N$

$n_t = 1+\alpha(N-1)$

From i

Vant hoffs factor $i = \frac{\text{observed colligative property}}{\text{Expected colligative property}}$

$i = \frac{\text{Observed number of moles}}{\text{Expected number of moles}}$

$i = 1+\alpha(N-1)$

$i-1 = \alpha(N-1)$

$\alpha = \frac{i-1}{N-1}$

∴ Relationship between i and α is

$\alpha = \frac{i-1}{N-1}$

8 a)

iii) The effect of degree of dissociation of a solute on the boiling point of a solution is that, dissociation increases number of moles hence colligative property; Thus boiling point of a solution is raised (there is boiling point elevation)

b) Volume of water to dissolve = $10 \times 10^3 cm^3 = 10000 cm^3$

Density of water $\rho = 1g/ml = 1g/cm^3$

Cryoscopic constant $K_f = 1.86°C kg/mol$

From Blagden's law

$$\Delta T = K_f \times \frac{m \times 1000}{M_r \times wt}$$

$$wt = \rho V$$

$$\Delta T = \frac{K_f \times m \times 1000}{M_r \times \rho V}$$

$$m = \frac{\Delta T \times M_r \times \rho V}{K_f \times 1000}$$

M_r of $C_2H_6O_2 = (12 \times 2 + 6 + 16 \times 2) = 62 g/mol$

$\Delta T = 0°C - 23.3°C = 23.3°C$

Then $m = \frac{23.3°C \times 62g/mol \times 1g/cm^3 \times 10000cm^3}{1.86°C kg/mol \times 1000}$

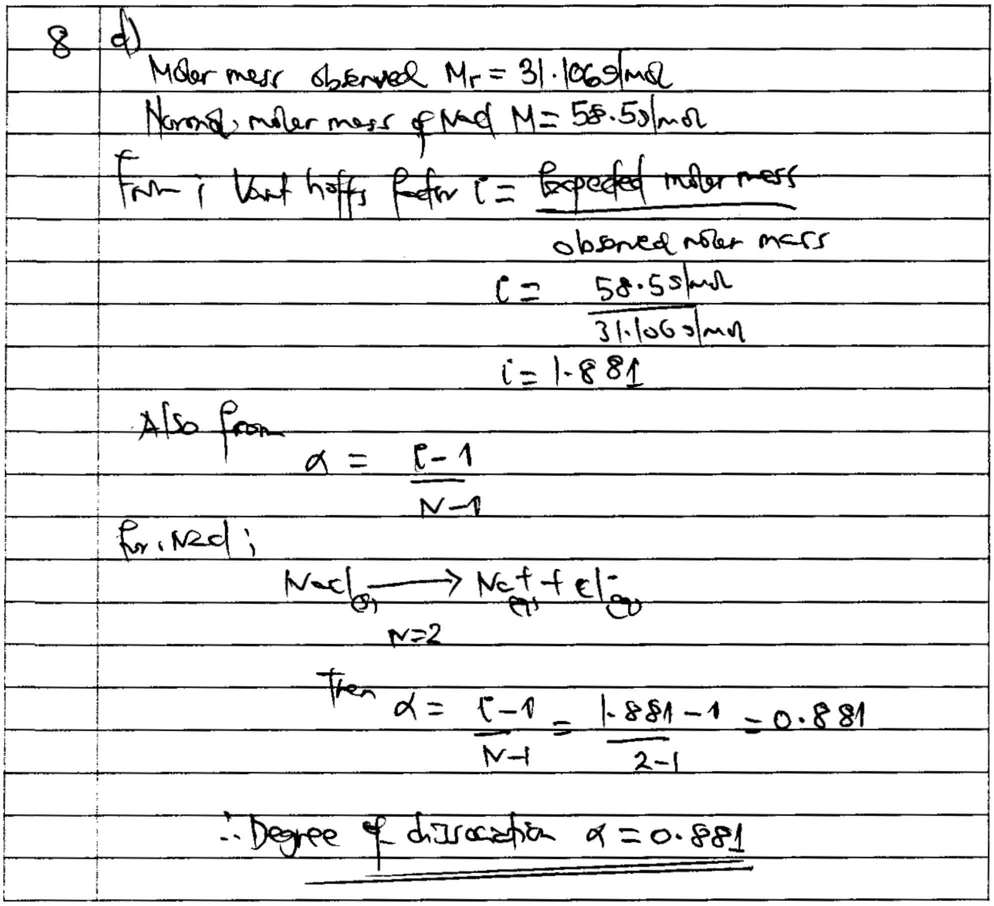
$m = 7,766.67 g$

$\therefore$ Mass required is $7,766.67g$ of $C_2H_6O_2$

c) Given $m = 0.12g$, $V = 200cm^3 = 200 \times 10^{-6} m^3$

$T = 20°C = 293K$; $P = 25.6 Pa$

8	c)
	From $PV = nRT$
	$PV = \frac{m}{M_r}RT$
	$M_r = \frac{mRT}{PV} = \left(\frac{0.12 \times 8.314 \times 293}{25.6 \times 200 \times 10^{-6}}\right) g\,mol^{-1}$
	$M_r = 57,066.32813\ g/mol$
	$\therefore$ Molar mass is $57,066.32813\ g\,mol^{-1}$
	d)
	Freezing point depression $\Delta T = 0.604$
	Freezing point depression constant $K_f = 1.86\ °C\ kg/mol$
	From Blagden's law
	$\Delta T = \frac{K_f \times m \times 1000}{M_r \times wt}$
	But $m = 1/100\ mt$
	and $wt = 99/100\ mt$
	then $\Delta T = \frac{K_f \times 1/100\,mt \times 1000}{M_r \times 99/100\,mt}$
	$\Delta T = \frac{K_f \times 1000}{99 M_r}$
	$M_r = \frac{K_f \times 1000}{99\,\Delta T} = \left(\frac{1.86 \times 1000}{99 \times 0.604}\right) g/mol$
	$M_r = 31.106$



8 d)
Molar mass observed $M_r = 31.1069/mol$
Normal molar mass of NaCl $M = 58.5g/mol$
From Van't hoffs factor $i = \frac{\text{Expected molar mass}}{\text{observed molar mass}}$
$i = \frac{58.55/mol}{31.1069/mol}$
$i = 1.881$
Also from $\alpha = \frac{i-1}{N-1}$
For NaCl;
$NaCl_{(aq)} \rightarrow Na^+_{(aq)} + Cl^-_{(aq)}$
$N=2$
Then $\alpha = \frac{i-1}{N-1} = \frac{1.881-1}{2-1} = 0.881$
∴ Degree of dissociation $\alpha = 0.881$

Extract 8.1: A sample of appropriate responses in question 8

Extract 8.1 illustrates the responses of a candidate who managed to differentiate between cryoscopic constant and ebullioscopic constant, derived the expression relating the van't Hoff factor (i) and the degree of dissociation (α). Finally, he/she manipulated the data given and substituted them into the required formulae and arrived at the correct values for the mass of ethylene glycol, relative molecular mass of haemoglobin as well as the degree of dissociation of sodium chloride.

On the other hand, some of the candidates who scored low marks (0 – 5.0), seem to have lacked basic concepts on the topic of relative molecular masses in solution, particularly the subtopic of *Colligative Properties of Solutions*. These candidates were not competent in applying the colligative properties of solutions to determine the molar masses of solutes. Hence, they missed most parts of the question. The candidates used incorrect formulae and provided incorrect responses. Most of them were unsystematic in calculating the mass of ethylene glycol and the relative molecular mass of haemoglobin. For example one of the candidates wrongly used the formula *PV=nRT* to calculate relative molecular mass of ethylene glycol. This indicated that they had inadequate knowledge on the concept of colligative properties. Extract 8.2 is a sample of poor response given by one of the candidates in this question.

8. (b) Volume (V) (H_2O) = 10.0L.

Temperature (T) = -23.3°C + 273 = 249.7°K

Density of H_2O = 1 g/ml

Cryoscopic constant = 1.86°C kg/mol

Mass (m) $C_2H_6O_2$. 2x12 + 6 + 16x2

30 + 32 = 62

Density ρ x Volume = n R T.

$\frac{1 \times 10L}{1.86 \times 249.7K}$ = = n.

$\frac{10L}{464.44n}$ = n = 0.02153mol

n = $\frac{mass}{molecular\ mass}$ = mass = n + molecular m

m = 0.0215 x 62 = 1.3349 g.

Mass of of $C_2H_6O_2$ = 1.3349 g.

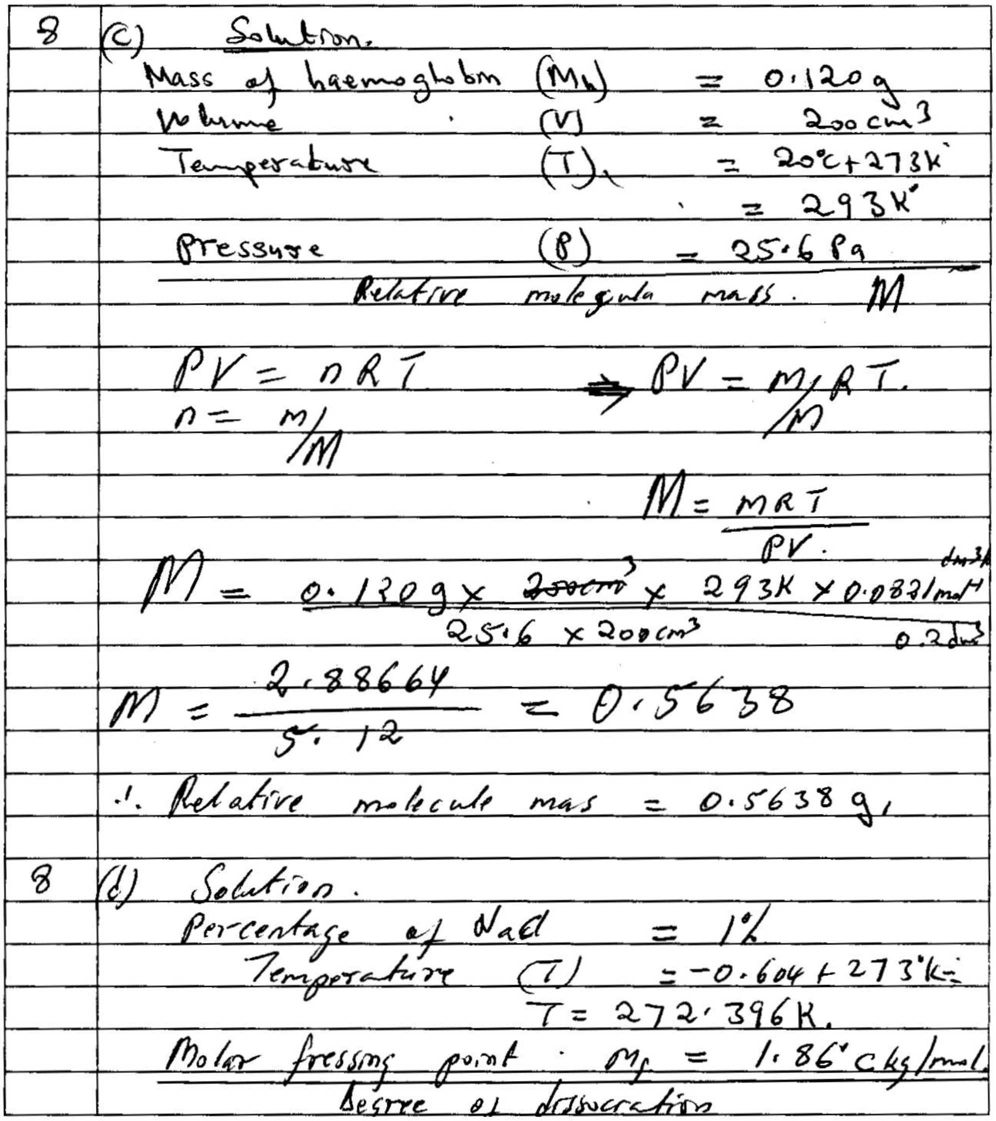
8 (c)(i) Cryoscopic constant is the constant by product of mass and Temperature per molarity.

(ii) PV = nRT.

n = M/M = PV = M/M

P = M/V (RT/M)

Where M/V = density, S



8 (c) Solution.

Mass of haemoglobin (M_h) = 0.120 g

Volume (V) = 200 cm^3

Temperature (T) = 20°C + 273K = 293K

Pressure (P) = 25.6 Pa

Relative molecular mass. M

$PV = nRT$ ⇒ $PV = \frac{m}{M}RT$

$n = \frac{m}{M}$

$M = \frac{mRT}{PV}$

$M = \frac{0.120g \times 200cm^3 \times 293K \times 0.0821}{25.6 \times 200cm^3}$ 0.2 dm^3

$M = \frac{2.88664}{5.12} = 0.5638$

∴ Relative molecule mas = 0.5638 g.

8 (d) Solution.

Percentage of NaCl = 1%

Temperature (T) = −0.604 + 273 K

T = 272.396 K.

Molar freezing point M_f = 1.86°C kg/mol.

Degree of dissociation

Extract 8.2: A sample of incorrect responses in question 8

Extract 8.2 displays the responses of a candidate who wrote the ideal gas equation instead of deriving the expression relating the van't Hoff factor (*i*) and the degree of dissociation (α). Hence, he/she ended up getting a wrong value for mass of ethylene glycol.

2.1.9 Question 9: Chemical Equilibrium

This question consisted of four parts, namely; (a), (b), (c) and (d). In Part (a) (i), the candidates were required to explain briefly the effect of changing pressure to a system at equilibrium, and to give a reason as to why a coca cola soda fizzes out when its bottle is opened in part (a) (ii). Part (b), (c) and (d) of the question were as follows:

(b) "Consider the following equilibrium

$$2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$$

Yellow — Orange

What would be observed when:

(i) Dilute NaOH is added to the equilibrium mixture?

(ii) Dilute HCl is added to the equilibrium mixture?

(c) The following equilibrium was established during the preparation of phosphorous (V) pentachloride:

$$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g) \qquad \Delta H = -92.5 \text{ kJ}$$

Explain what will happen on the amount of PCl_3 if the temperature is, (i) raised (ii) lowered.

(d) The following reaction occur during the Haber process

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(i) Calculate the equilibrium constant for the reaction at 127°C if the equilibrium concentrations observed at this temperature were 0.031mol/L for ammonia, 0.85 mol/L for nitrogen and 0.031 mol/L for hydrogen.

(ii) Using the same equilibrium concentrations in (d) (i), calculate the equilibrium constant at 127°C for the equilibrium:

$$2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g)$$"

The question was attempted by 20,362 candidates constituting 69.5 percent, making it the most attempted question in section B. Statistics shows that 29.8 percent scored 0 - 5.0, 40.0 percent scored 5.5 - 8.5, while 30.2 percent scored 9.0 - 15 marks. The summary of the performance of the candidates in this question is shown in Figure 9.

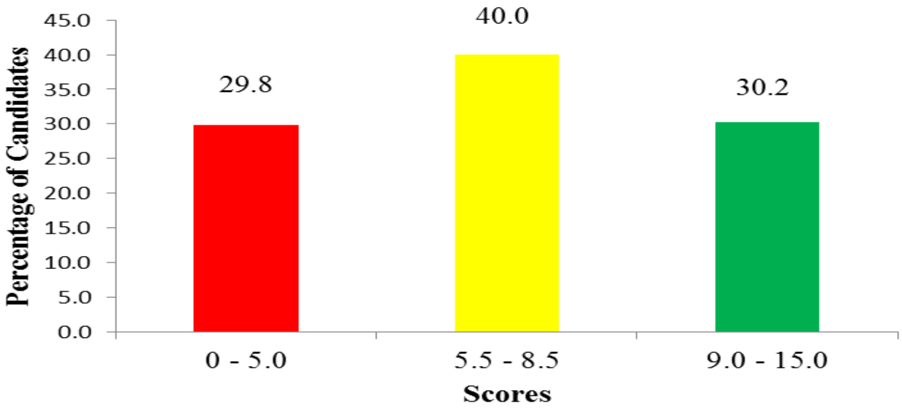
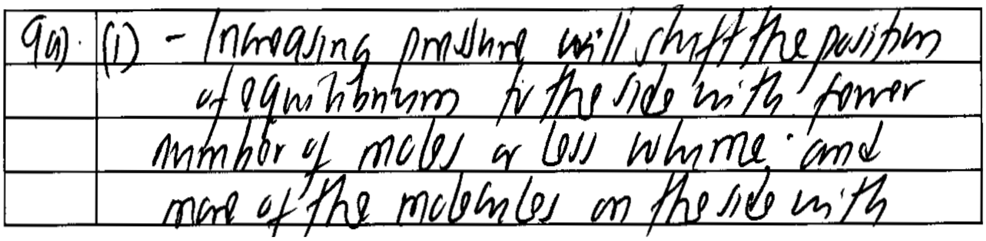


Figure 9: *Performance of the candidates in question 9*

Figure 9 indicates that the overall performance in this question was good as majority (70.2%) of the candidates scored above an average mark (> 5.5 marks).

The analysis of the candidates' responses shows that the candidates who scored high marks (5.5 - 15) understood properly the concepts regarding the Le Chatelier's principle and the factors affecting the equilibrium reactions. They managed to derive an equilibrium expression for the Haber process and used it to calculate the equilibrium constant of the reaction at 127°C. Extract 9.1 shows an example of good responses given by one of the candidates in this question.

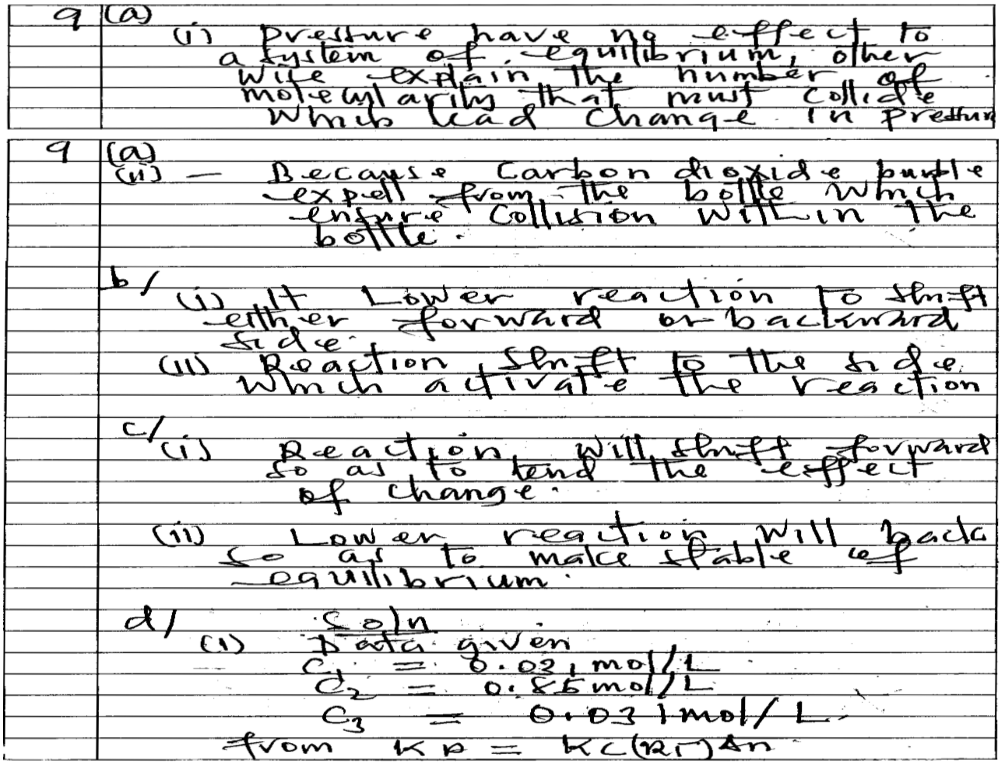

9(a). (i) - Increasing pressure will shift the position of equilibrium to the side with fewer number of moles or less volume and more of the molecules on the side with

9a)	(i) less number of moles or less volumes will be formed as those having greater volume (reacting moles) will be reduced.
	- Decreasing pressure will also shift the position of equilibrium to the side with few number of moles thus the molecules with few number of moles/volume will be formed at a higher rate compared to those with greater volumes/moles.
9a)	(ii) coca cola fizzes out when bottle is open because it contains gases when closed used as preservative that escape to the surrounding when open.
9b)	i) Adding NaOH will reduce concentration of H^+ ions thus lead to the formation of more H^+ ions and CrO_4^{2-} ions. Hence the backward reaction will be more favoured as $Cr_2O_7^{2-}$ and $H_2O_{(l)}$ will combine to form CrO_4^{2-} and H^+
	ie
	$NaOH \rightarrow Na^+ + OH^-$
	$OH^- + H^+ \rightarrow H_2O$
	$H_2O + Cr_2O_7^{2-} \longrightarrow H^+ + CrO_4^{2-}$
	Therefore, yellow colour become dominant as more CrO_4^{2-} is formed.

Extract 9.1: A sample of appropriate responses in question 9

Extract 9.1 represents the responses of a candidate who was able to explain the effect of change of pressure to a system at equilibrium and gave a proper reason as to why a coca cola soda fizzes out when its bottle is opened. The candidate accounted correctly for what would be observed when a dilute NaOH and HCl were added to the equilibrium mixture. He/she explained correctly the effect of raising and lowering temperature on the amount of PCl_3. Finally, the candidate used the appropriate formula to calculate the correct value for Kc.

On the other hand, the candidates who scored low marks proved to have insufficient skills to solve problems derived from the topic of *Chemical Equilibrium*. They had inadequate knowledge regarding the Le chatelier's principle. For instance, one of the candidates wrote "*when the temperature is raise, the reactions tend to increase because it is exothermic*:" This is an indication that this candidate had not mastered properly the concepts pertaining to the factors affecting the equilibrium reaction. Moreover, she/he had inadequate knowledge on the factors affecting equilibrium reactions, specifically the temperature. Hence, gave a wrong direction of the equilibrium position. This response implies that they had little understanding on the applications of equilibrium reactions. Extract 9.2 shows a sample of poor responses in this question.


9 (a) (i) Pressure have no effect to a system of equilibrium, otherwise explain the number of molecularity that must collide which lead change in pressure
9 (a) (ii) — Because carbon dioxide bubble expell from the bottle which ensure collision within the bottle.
b/ (i) It Lower reaction to shift either forward or backward side.
(ii) Reaction shift to the side which activate the reaction
c/ (i) Reaction will shift forward so as to tend the effect of change.
(ii) Lower reaction will back so as to make stable of equilibrium.
d/ Soln
(i) Data given
C_1 = 0.021 mol/L
C_2 = 0.85 mol/L
C_3 = 0.031 mol/L
from Kp = Kc(RT)Δn

Extract 9.2: A sample of incorrect responses in question 9

In part 9 (a) (i) of the Extract 9.2, a candidate disagreed with the requirement of the question and suggested his/her opinions. The candidate gave wrong explanation as to why the coca cola soda fizzes out when its bottle is opened. Not only the candidate gave wrong explanation in the subsequent sections, but also copied the given data for part 9 (d) without calculating the value of Kc.

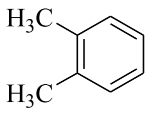
2.1.10 Question 10: Aromatic Hydrocarbons

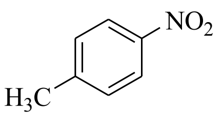
This question consisted of five parts, namely; (a), (b), (c), (d) and (e). In Part (a), the candidates were required to explain briefly why benzene though highly unsaturated, does not undergo addition reaction. In part (b), the candidates were required to name two examples in each of the following chemical groups (i) *Ortho –Para* directors and (ii) *Meta* directors. In part (c), the candidates were required to explain briefly why *ortho-para* directing groups are called activating groups and *meta*-directing groups are called deactivating groups. In part (d), the candidates were required to determine the structural formulae of the following compounds:

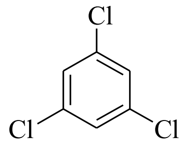
(i) 1, 3, 5-trimethylbenzene

(ii) (1-methylethyl) benzene.

In part (e), the candidates were required to give the names of the following aromatic compounds:

(i) 

(ii) 

(iii) 

The question was attempted by 20,359 candidates equivalent to 69.5 percent. This question was also among the most attempted questions by the candidates in section B. Statistical data shows that 66.2 percent of the candidates scored 9.0 – 15 marks, 20.1 percent scored 5.5 - 8.5 marks while 13.7 percent scored 0 - 5.0 marks. The summary of the candidates' performance of the in this question is shown in Figure 10.

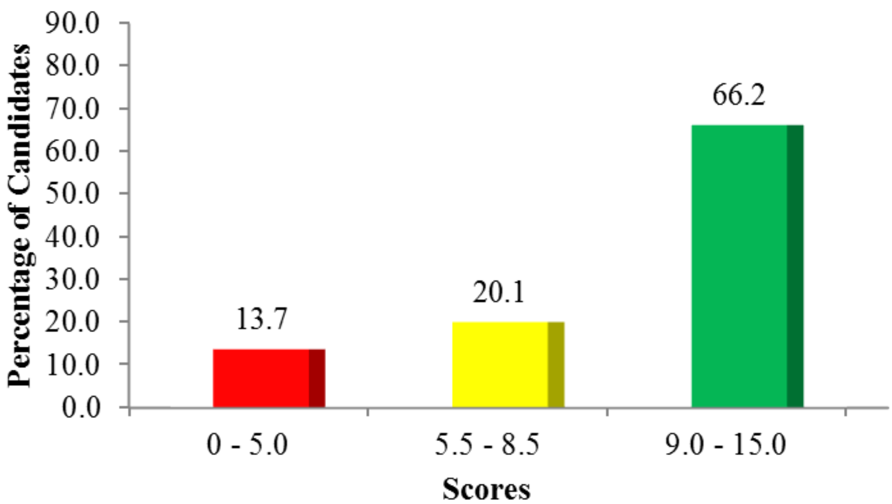
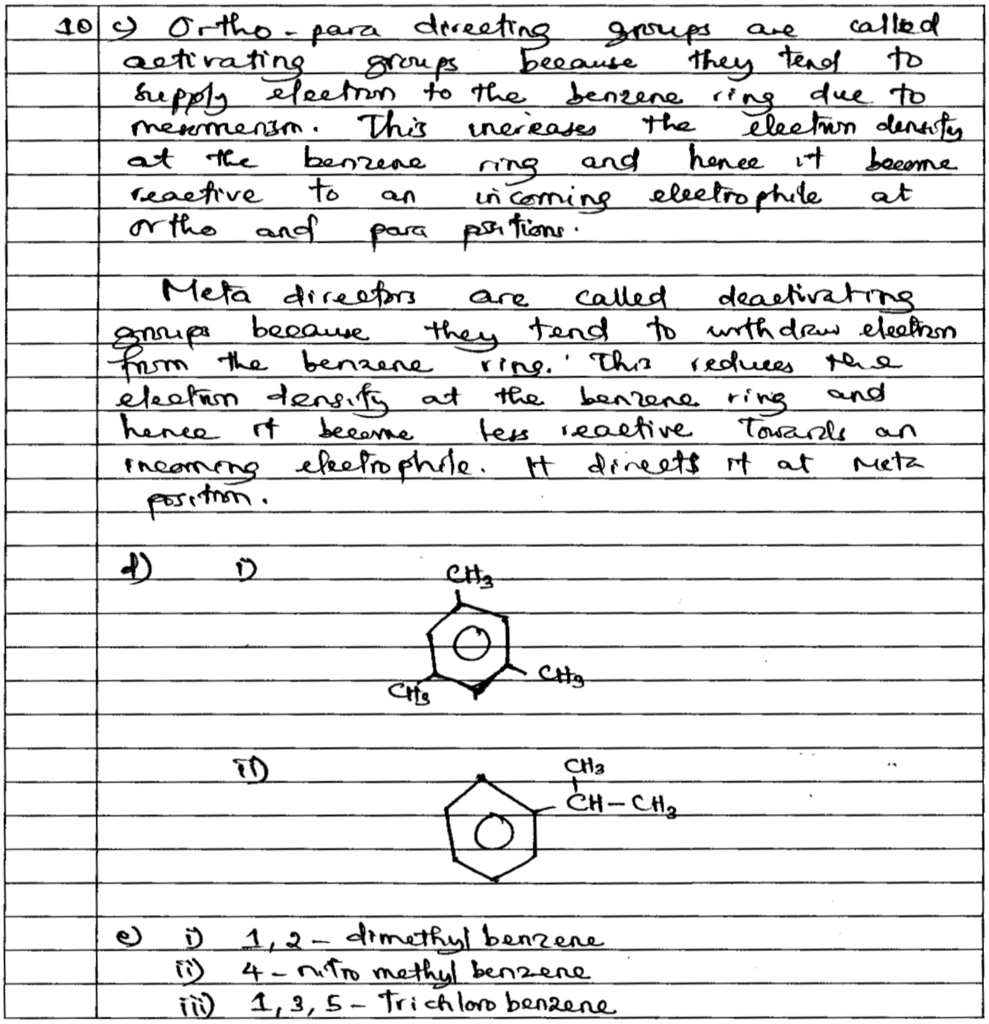


Figure 10: *Performance of the candidates in question 10*

The general performance in this question was good as 17,577 (86.3%) candidates scored 5.5 marks or above, making it the second-most highly performed question by the candidates in this paper. The candidates who scored high marks had good background on aromatic hydrocarbons, especially the structure of benzene, IUPAC rules for naming benzene and its derivatives, activators and deactivators with their influences on benzene ring. They also managed to provide proper reasons as to why benzene, though highly unsaturated, does not undergo addition reaction. Moreover, they managed to give the names for the *ortho-para* and *meta* directors. Extract 10.1 shows responses of a candidate who performed well in this question.

10	a) Benzene according to resonant structure consists of π-bonded electrons which are in mesomerism. The bond electron pairs are not localized. Due to delocalization of electrons caused by mesomerism addition reaction can not take place. This is because large extra energy is required to break the resonance and then break the π-bonded electron so as addition can take place.
	- this is only attained at high temperature and pressure which are normally not reached hence addition reaction become impossible.
	(b) i) Ortho para-directors includes
	(a1) $-\ddot{O}H$
	(a2) $-\dot{N}H_2$
	ii) Meta directors includes
	(a1) $-\overset{O}{\overset{\parallel}{C}}-OH$
	(a2) $-\overset{O}{\overset{\parallel}{C}}-NH_2$


10 c) Ortho-para directing groups are called activating groups because they tend to supply electron to the benzene ring due to mesomerism. This increases the electron density at the benzene ring and hence it become reactive to an incoming electrophile at ortho and para positions.

Meta directors are called deactivating groups because they tend to withdraw electron from the benzene ring. This reduces the electron density at the benzene ring and hence it become less reactive towards an incoming electrophile. It directs it at meta position.

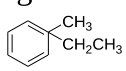
d) i)

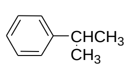
ii)

e) i) 1, 2 – dimethyl benzene
ii) 4 – nitro methyl benzene
iii) 1, 3, 5 – Trichloro benzene

Extract 10.1: A sample of correct responses in question 10

In Extract 10.1, a candidate gave appropriate explanation on the stability of benzene ring basing on resonance theory. He/she explained properly the directive influences of activators and deactivators on benzene ring with correct examples. Finally, the candidate named correctly the compounds asked.

However, the candidates who scored low marks had insufficient background knowledge on the topic of *Aromatic Hydrocarbons*. For example, in part 10 (d) (ii), one of the candidates gave the structural formulae of (1-methylethyl)benzene as 

instead of 

. Such responses show incompetency in applying the IUPAC rules to name organic compounds. They also gave wrong explanation on deactivators and activators, a case attributed to the lack of proper knowledge on resonance theory. Extract 10.2 is a sample of poor responses in this question.

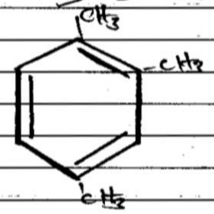
10. (a) Benzene does not undergo addition reaction because it have more benzene rings
— Also it has high and more carbon atom compared to other element

(b) (i) Ortho – para directors – is the group of the element which alter the rate of the reaction hence it activate the rate of the reaction.
Example i) $N_{2(g)} + 3H_2 \rightleftharpoons 2NH_{3(g)}$

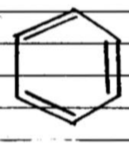
10. (b)
(ii) Meta directors – is the group of of the element in which the reaction are directed downward hence it deactivate the chemical reaction.

Meta-directing group are called deactivating group because it alter the rate of the chemical reaction

(d)
i) 1,3,5-trimethyl benzene



(ii). (1-methylethyl) benzene



Benzene.

10 (e) (i) 2,4 methyl benzene
(ii) 3, methyl-6 nitrono benzene
(iii) 1,3,5-titrechloro benzene.

Extract 10.2: A sample of incorrect responses in question 10

In Extract 10.2, a candidate explained incorrectly as to why benzene ring does not undergo addition reaction. The candidate defined incorrectly the *ortho-para* directors, instead of defining a catalyst. Moreover, he/she wrote incorrect names for the aromatic compounds asked.

2.2 132/2-CHEMISTRY 2

This paper had a total of six (6) questions. Each question carried 20 marks. Candidates were required to answer 5 questions. The pass mark in each question was 7.0 marks.

2.2.1 Question 1: Two Component Liquid Systems

This question had three parts, namely; (a), (b) and (c). In part (a), the candidates were provided with the information that "Ethanol and water form an azeotropic mixture which boils at 78.1 °C and contains 95.6% ethanol at standard pressure. If the boiling points of pure water and ethanol are 100 °C and 78.4 °C, respectively,

(i) Draw and label a temperature versus mole fraction phase-diagram of ethanol and water solution.
(ii) What happens when a dilute ethanol solution of less than 50% is boiled and condensed several times?
(iii) How would you increase the percentage of ethanol after obtaining a 95.6% ethanol- water mixture?"

In part (b), the candidates were provided with the information that "When 500 cm^3 of an aqueous solution containing 4 g of a solute G per litre was shaken with 100 cm^3 of pentan-1-ol, 1.5 g of the solute G was extracted. Assuming the molecular state of the solute remained the same in both solvents". Then they were asked to calculate:

(i) Partition coefficient of the solute G between pentan-1-ol and water.
(ii) Mass of the solute G which remained in the aqueous solution after a further shaking with 100 cm^3 of pentan -1-ol.

Part (c) required the candidates to write two practical applications of the partition law.

This question was attempted by 28,301 (96.7%) candidates out of which 19,665 (69.5%) scored 0 - 6.5, 6986 (24.7%) scored 7 – 11.5 and 1650

(5.8%) scored 12 – 20 marks. The summary of the performance of candidates in this question is shown in Figure 11.

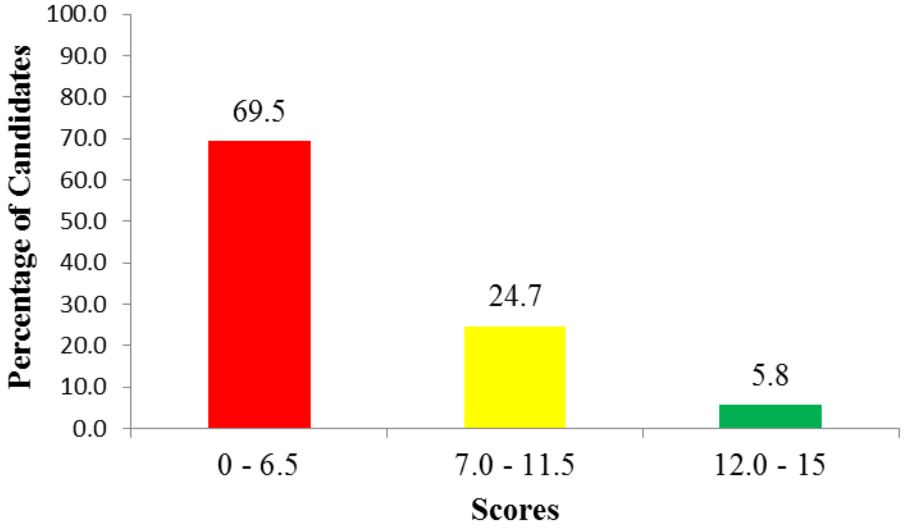


Figure 11: *Performance of the candidates in question 11*

Generally, the overall performance in this question (Figure 11) was poor as majority (69.5%) of the candidates scored below the pass mark (*i.e* < 7 marks).

The candidates who scored low marks showed incompetency in most parts of the topic of *Two component Liquid System*. The candidates were not able to describe the vapour pressure diagrams. Furthermore, they lacked knowledge on the application of fractional distillation as well as the distribution law. For instance, one of the candidates in responding to part (a) (ii) wrote "*When condensed and boiled water will be denser than ethanol so water will be at the top or upward and ethanol will stay down*.". This was contrary to the fact that when the dilute solution of ethanol is boiled (fractional distillation), the distillate will be richer in ethanol than pure water because ethanol is more volatile and hence, escapes easily into the vapour phase than pure water. This also accounts for the low boiling point of ethanol as compared to that of pure water.

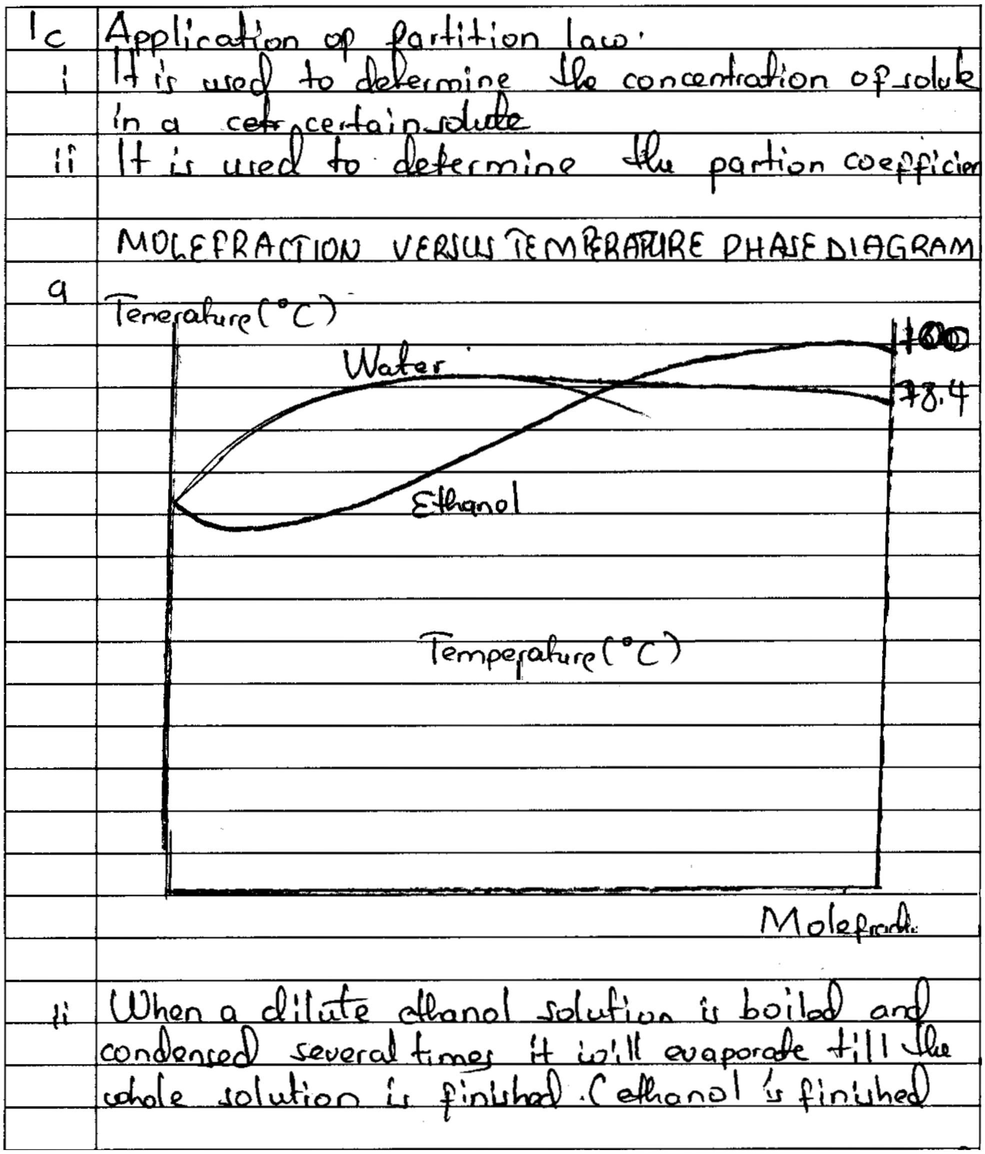
In part 1 (a) (iii), a candidate wrote "*The percentage of ethanol will be increased by boiling the mixture and water will evaporate so the amount of ethanol in the mixture will increase*.", contrary to the truth that, due to the formation of azeotropic mixture, as soon as the azeotropic composition is attained, the percentage of ethanol in the mixture cannot be increased further by boiling. The candidates were expected to apply methods such as using drying agents (CaO, etc), steam distillation and/or distillation with a third component.

In part (b), some of the candidates used the formula $k_d = \frac{[G] \text{ in water}}{[G] \text{ in pentanol}}$ instead of $k_d = \frac{[G] \text{ in pentanol}}{[G] \text{ in water}}$ to calculate the mass of solute G that remained in the aqueous solution. The challenge that faced the candidates was to identify the denominator and numerator in the formula. Thus, most of them got a wrong value for the mass of solute G. Extract 11.1 represents responses from a candidate who gave incorrect answers.

1b Data given
Volume of aqueous solution = 500cm³
Mass of solute = 4g.
Volume of pentan-1-ol = 100cm³
Mass of solute = 1.5g

Kd = Concentration of solute in solvent g/cm³ / Concentration of solute g/cm³
= 1.5/100cm³ / 4/500 = 0.015 / 4/500
= 6.25
Kd = 6.25
Partition coefficient of solute 5 = 6.25

ii Required = Mass of solute.
Kd = Concentration of solute in solvent / Concentration of solute
6.25 = ~~1.5~~ X /100cm³ / 4/500
0.05 = ~~1.5~~ X / 100   0.05 = X/100
0.05 = X / 100
0.05 X100 = X
X = 5
Mass of solute G which remained in aqueous solution is 5g



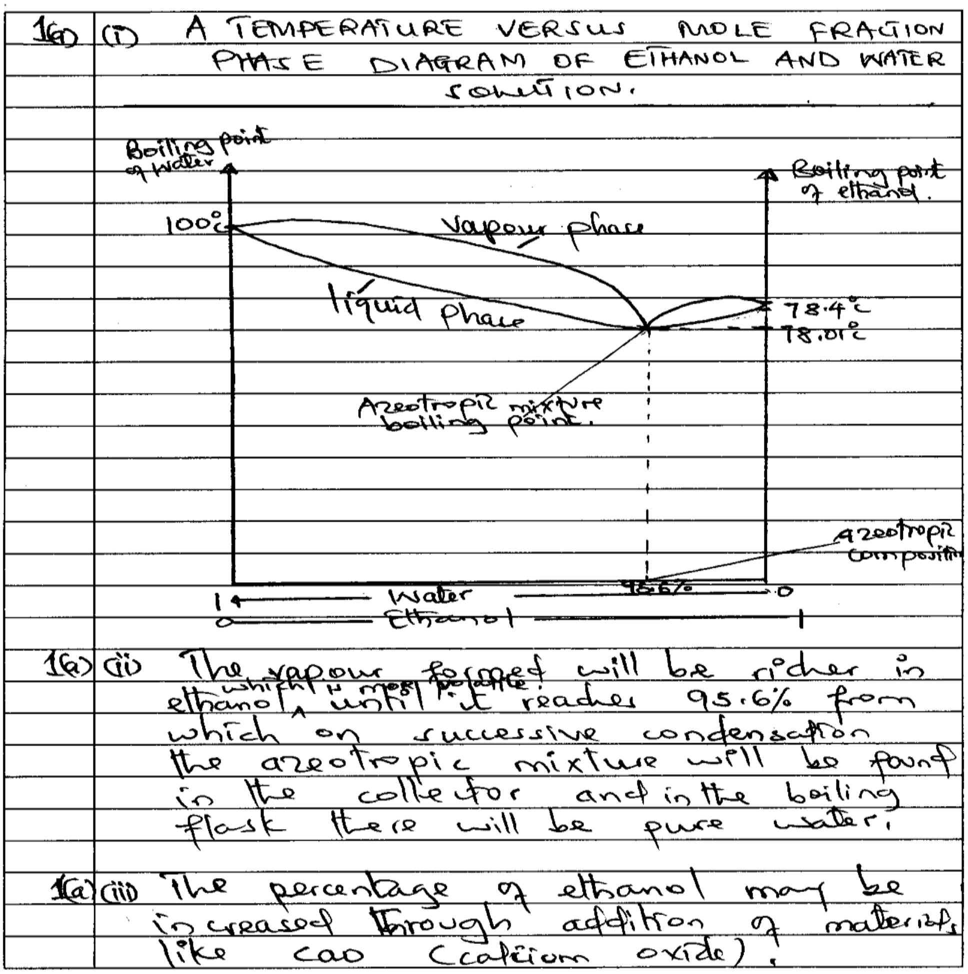
1c	Application of partition law.
i	It is used to determine the concentration of solute in a ~~cetr~~ certain solute
ii	It is used to determine the partion coefficien
	MOLEFRACTION VERSUS TEMPERATURE PHASE DIAGRAM
a	Tenerature (°C)

ii	When a dilute ethanol solution is boiled and condensed several times it will evaporate till the whole solution is finished. (ethanol is finished)

Extract 11.1: A sample of incorrect responses in question 1

Extract 11.1 shows the responses of a candidate who incorrectly sketched the temperature versus mole fraction phase-diagram for ethanol-water system and incorrectly calculated the mass of solute G. Furthermore, he/she wrote incorrect practical applications of the partition law.

Some of the candidates performed well in this question. These candidates proved to have appropriate competencies in the topic of *Two Component Liquid System,* particularly on the concept of fractional distillation for both ideal and non-ideal solutions. Moreover, the candidates understood properly the distribution law and its application on how to extract an organic solute from a solvent. Thus, they were able to correctly draw and label the temperature versus mole fraction phase-diagram of ethanol and water system. Then, they correctly explained what happens when a dilute ethanol solution is boiled and condensed several times. The candidates correctly applied the formula for solvent extraction to calculate the partition coefficient of solute G between pentan-1-ol and water and gave plausible answers regarding the application of partition law in daily life activities. Extract 11.2 shows the responses from one of the candidates who performed well in this question.



1(a) (i) A TEMPERATURE VERSUS MOLE FRACTION PHASE DIAGRAM OF ETHANOL AND WATER SOLUTION.

1(a) (ii) The vapour formed will be richer in ethanol, which is more volatile, until it reaches 95.6% from which on successive condensation the azeotropic mixture will be found in the collector and in the boiling flask there will be pure water.

1(a) (iii) The percentage of ethanol may be increased through addition of materials like CaO (calcium oxide).

1(b) Data given.

Volume of aquous solution (V_a) = 500 cm³

Mass of solute G per litre (M_s) = 4 g/L

Volume of pentanol (V_p) = 100 cm³

Mass of solute G extracted = 1.5 g

(i) Distribution coefficient (kd) = ?

from

Mass of solute in grams.

4 g of solute G ⟶ 1000 cm³

x ? ⟵ 500 cm³

$$x = \frac{4g \times 500 cm^3}{1000 cm^3}$$

x = 2g

∴ Mass of solute in gram = 2g.

Then

Distribution coefficient (kd) = $\dfrac{\text{concentration of solute in upper layer}}{\text{concentration of solute in lower layer}}$

$$kd = \frac{\frac{1.5g}{100cm^3}}{\frac{(2-1.5)g}{500cm^3}}$$

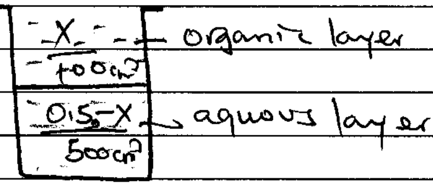
$$Kd = \frac{1.5g}{100cm^3} \times \frac{500cm^3}{0.5}$$

Kd = 15

1(b)(i) ∴ Partition (Distribution coefficient) of solute G between pentan-1-ol and water

1(b) it will be 15.

1(b) (ii) from



kd = concentration of solute in upper layer / concentration of solute in lower layer

$kd = \frac{X}{100cm^3} \times \frac{500cm^3}{0.5g - X}$

$\frac{15}{1} = \frac{5X}{0.5 - X}$

$15(0.5 - X) = 5X$

$7.5 - 15X = 5X$

$\frac{7.5}{20} = \frac{20X}{20}$

$X = 0.375g$

Then mass of solute G remained after further shaking with 100cm³ of pentan-1-ol will be

$0.5 - 0.375g$

$= 0.125g$

∴ Mass of solute G which will remain on further shaking with 100cm³ of pentan-1-ol = 0.125g

1(c) Two practical applications of partition law are:

(i) Separation of the immiscible solvents

(ii) extraction of solute from immiscible solvents.

Extract 11.2: A sample of correct responses in question 1

Extract 11.2 shows the responses of a candidate who correctly sketched the temperature versus mole fraction phase-diagram of ethanol and water solution. He/she correctly explained what happens when a dilute ethanol solution of less than 50% is subjected to fractional distillation. The candidate correctly calculated the mass of solute G that would be extracted after a further shaking with a given amount of a solvent.

2.2.2 Question 2: Chemical Kinetics

This question had three parts, namely; (a), (b) and (c). Part (a) (i) required the candidates to explain the effects of a catalyst on the activation energy of a reaction. Part (a) (ii) required the candidates to describe how temperature, concentration, light, pressure and surface area can affect the rate of a chemical reaction. Part (b) of the question was as follows: "The decomposition of hydrogen peroxide at 25 °C was studied by titrating portions of the reaction mixture with a standard potassium permanganate solution at different intervals. The results obtained were tabulated as follows:

Volume of $KMnO_4$ (cm^3)	75	47	30	13	7.20
Time (min)	0	6	9	20	29

(i) Show that the reaction is a first order.

(ii) Without using a graph, calculate the rate constant at the given temperature.

Part (c) of the question was as follows:

"The reaction $NH_2NO_2(aq) \rightarrow N_2O(g) + H_2O(l)$ is a first order with $k = 2.2 \times 10^{-5}\ sec^{-1}$.

(i) Find the percentage of NH_2NO_2 that would be decomposed on heating at 310 °C for 90 minutes.

(ii) If the rate of reaction triples when the temperature is raised from 20 °C to 50 °C. Calculate the activation energy of the reaction in kJ/mol.

The question was attempted by 28,406 candidates, equivalent to 97.1 percent. Statistical data indicates that 41.2 percent of the candidates scored 0 – 6.5, 44.3 percent scored from 7.0 - 11.5 and 14.5 percent scored 12 – 20 marks, which indicates poor, average and good performance, respectively. The candidates' performance is summarized in Figure 12.

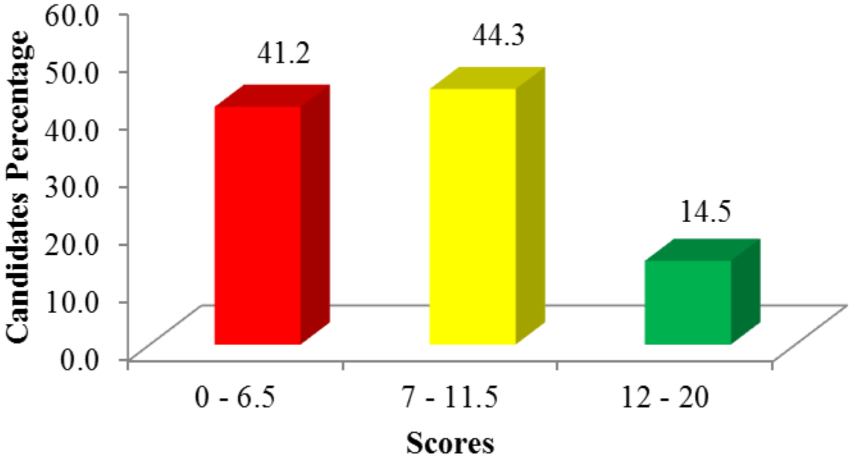


Figure 12: *Performance of the candidates in question 2*

The statistical data in Figure 12 shows that majority (58.8%) of the candidates scored the pass mark or above (≥7.0 marks). Hence, the general performance in this question was average. Further statistical analysis (not shown in Figure 12) indicates that only one candidate was able to score full marks while three candidates scored 19 marks.

The analysis of the responses from the candidates who performed well showed that the candidates were conversant with the topic of *Chemical Kinetics*. The candidates seem to have understood properly the factors affecting the rate of a chemical reaction, since they managed to describe the effect of those factors on the reaction given.

These candidates correctly justified the order of the reaction by using the experimental results provided. Moreover, they calculated the rate constant at a given temperature without using a graph. The candidates also seemed to be familiar with the Arrhenius equation as they applied it to determine the activation energy of the reaction. Extract 12.1 shows responses from one of the candidates who performed well in this question.

2a) i) Positive catalyst lowers the activation energy of the reaction whereas negative catalyst raises the activation energy of the reaction.

ii) → Temperature increases the rate of chemical reaction by increasing the kinetic energy of the reactants and hence increase in their collision frequency.

- Concentration also increases the rate of reaction for, first and higher orders of reaction as increase in concentration increases the number of the collisions per second.

2a iii) - Light also increases the rate of reaction of the free radical reactions which require u.v light for initiation.

- Pressure also increases the rate of reaction for gaseous reactions. However, it does not alter the rate of reaction for solid and liquid phase reactions.

- Surface area; The large the surface area of the reactants, the higher the collision frequency and hence the higher the rate of reaction when one of the reactants is solid.

2b) i) From the equation of the first reaction.

$\ln(A) - \ln(A_0) = -Kt$.

where $A_0 = 75$.

at $t = 6$.

$\ln(47) - \ln(75) = -6K$.

$-0.467 = -6K$.

$K_1 = 0.0779 \text{ min}^{-1}$.

when: $t = 9$.

$\ln(30) - \ln(75) = -9K_2$.

$K_2 = 0.1018 \text{ min}^{-1}$.

when $t = 20$.

$\ln 13 - \ln 75 = -20K_3$.

$K_3 = 0.0876 \text{ min}^{-1}$.

when $t = 29$.

$\ln(7.20) - \ln 75 = -29 K_4$

$K_4 = 0.0808 \text{ min}^{-1}$.

∴ Since $K_1 \approx K_2 \approx K_3 \approx K_4$, the reaction is first order.

2b ii) Calculating, $K_{av} = \frac{K_1 + K_2 + K_3 + K_4}{4}$

$= \frac{(0.0779 + 0.1018 + 0.0876 + 0.0808)}{4} \text{ min}^{-1}$

∴ Rate constant $= 0.0870 \text{ min}^{-1}$.

2c) i) From:

$R = K[NH_4NO_2]$

But

$\ln A - \ln A_0 = -Kt$

$\ln\left(\frac{A}{A_0}\right) = -Kt$

$A/A_0 = e^{-Kt}$

But: $A/A_0 = e^{(-2.2\times10^{-5} \times 90\times60)}$

$\frac{A}{A_0} = 0.888$

But $\frac{A}{A_0}$ = Fraction remained.

Fraction decomposed $= 1 - \frac{A}{A_0}$

$= 1 - 0.888$

$= 0.112$

% of decomposed $= 0.112 \times 100\% = 11.2\%$

∴ 11.2% will be decomposed.

2c ii) From Arrhenius equation:

$\ln K_1 = -\frac{E_A}{RT_1} + \ln A$ ---(i)

$\ln K_2 = -\frac{E_A}{RT_2} + \ln A$ ---(ii)

Subtracting eqn (i) from equation (ii),

$\ln\left(\frac{K_2}{K_1}\right) = \frac{E_A}{RT_1} - \frac{E_A}{RT_2}$

$\ln\left(\frac{K_2}{K_1}\right) = \frac{E_A}{R}\left(\frac{T_2 - T_1}{T_1 T_2}\right)$

But.

$K_2 = 8K$, $T_2 = 50°C = 323K$, $T_1 = 20°C = 293K$.

$R = 8.31\ J mol^{-1} K^{-1}$

$\ln\left(\frac{3K_1}{K_1}\right) = \frac{Ea}{8.31\ J mol^{-1} K^{-1}}\left(\frac{323K - 293K}{323K \times 293K}\right)$

$\frac{\ln 3}{3.8146\times10^{5}}\ J mol^{-1} = Ea.$

$Ea = 28,800.12\ J mol^{-1}$

But $1\ KJ mol^{-1} = 1000\ J mol^{-1}$

$? = 28,800.12\ J mol^{-1}$

$= \frac{28\ 800.12}{1000}\ KJ mol^{-1}$

$= 28.8\ KJ mol^{-1}$

$\therefore$ The activation energy $= 28.8\ KJ mol^{-1}$.

Extract 12.1: A sample of correct responses in question 2

In Extract 12.1, the candidate correctly explained the effect of catalysts on the activation energy of a reaction. The candidate described properly the factors affecting the rate of a reaction. Moreover, he/she correctly justified the fact that, the reaction given was of the first order. The candidate also provided correct responses to the remaining part of the question.

On the other hand, the candidates who scored poorly seemed to have a number of challenges in the topic of *Chemical Kinetics*. Some of the candidates did not understand how the order of reaction could be justified using the given information. For example, some of them drew graph contrary to the requirement of the question while deducing the rate constant. For instance, in part 2 (b) (i), a candidate responded as follows:

"*Difference in volume of $KMNO_4$ are* :

$75 - 47 = 28, 47 - 30 = 17, 30 - 13 = 17, 13 - 7.2 = 5.8$

differences $= 28, 17, 17, 5.8$

Differences in time are $6 - 0 = 6, 9 - 6 = 3, 20 - 9 = 11, 29 - 20 = 9$

differences $= 6, 3, 11, 9$

$$\text{The rate constant} = \frac{\sum \text{diffrences in volume}}{\sum \text{diffrences in time}} = \frac{28 + 17 + 17 + 5.8}{6 + 3 + 11 + 9} = \frac{67.8\ cm^3}{29\ \text{min}}$$

The rate const. $= 2.34\ cm^3/\text{min}$"

The candidate's approach to answer the question in part (b) was not correct hence, loss of marks. The candidates were expected to use such an approach as:

Calculate, K for each time using log $V_0 = \frac{2.303}{t}\log\left(\frac{V_0}{V_t}\right)$

at t = 6 min $K_1 = \frac{2.303}{6}\log(\frac{75}{47}) = 0.0779\ min^{-1}$

at t = 9 min $K_2 = \frac{2.303}{9}\log(\frac{75}{30}) = 0.102\ min^{-1}$

at t = 20 min $K_3 = \frac{2.303}{20}\log(\frac{75}{13}) = 0.0876\ min^{-1}$

at t = 29 min $K_4 = \frac{2.303}{29}\log(\frac{75}{7.2}) = 0.0807\ min^{-1}$

so $K = \frac{K_1 + K_2 + K_3 + K_4}{4} = \frac{0.0779 + 0.0102 + 0.0876 + 0.0807}{4}$

$K = 0.0871\ min^{-1}$ OR $K = 0.1$

Moreover, some of the candidates incorrectly described the factors affecting the rate of a chemical reaction, and used wrong formulae to derive an expression for the first order reaction. Extract 12.2 shows one of the poor responses from a candidate who performed poorly in this question.

2. (a) (i)

Light:- Light favour foward reaction to take place and form more product and in absence of light reaction will proceed but it will take much time for product to be formed.

Pressure;- pressure favour foward reaction to take place and lead to formation of more products

Surface area: in small surface area the reaction take place fast because it increase collision of of molecules with the wall of the container' which while: in large surface area the reaction proceed slowly due to no enough collision of molecules to form product fast as in small surface area.

(b)

(i) Show that the reaction is a first order.

Rate = K[Reactants]

Rate = K[KMnO$_4$]'

K = Rate / [KMnO$_4$]'

K = molL^{-1} sec^{-1} / molL^{-1}

∴ K = sec^{-1}

∴ The reaction is first order

2 (b)

(ii) Data:

$K = ?$

$T = 25^\circ C$

Volume of $KMnO_4$ (cm^3)	75	47	30	13	7.20
Time (min)	0	6	9	20	29
Rate 1/t	0	2.77×10^{-3}	1.85×10^{-3}	0.05	0.03

Expre

Portion 1

$$Rate = K[reactants]$$

$$\frac{Rate}{[reactants]} = \frac{K[reactants]}{[reactants]}$$

$$K = \frac{Rate}{[reactants]}$$

$$K = \frac{0}{75}$$

$$\therefore K = 0 \ sec^{-1}$$

Portion 2

$$K = \frac{2.77 \times 10^{-3}}{47}$$

$$\therefore K = 5.9 \times 10^{-5}$$

Portion 3

$$K = \frac{1.85 \times 10^{-3}}{30}$$

$$\therefore K = 6.17 \times 10^{-5}$$

2 (b) Portion 4

$$K = \frac{0.05}{13}$$

$$\therefore K = 3.85 \times 10^{-3}$$

Portion 5

$$K = \frac{0.03}{7.20}$$

$$\therefore K = 4.17 \times 10^{-3}$$

2 (c) Data:

$K = 2.2 \times 10^{-5} \ sec^{-1}$

$Rate = 1.85 \times 10^{-4} \ mol \ L^{-1} sec^{-1}$

$$Rate = K[reactants]$$

$$\frac{Rate}{K} = \frac{K[NH_2NO_2]}{K}$$

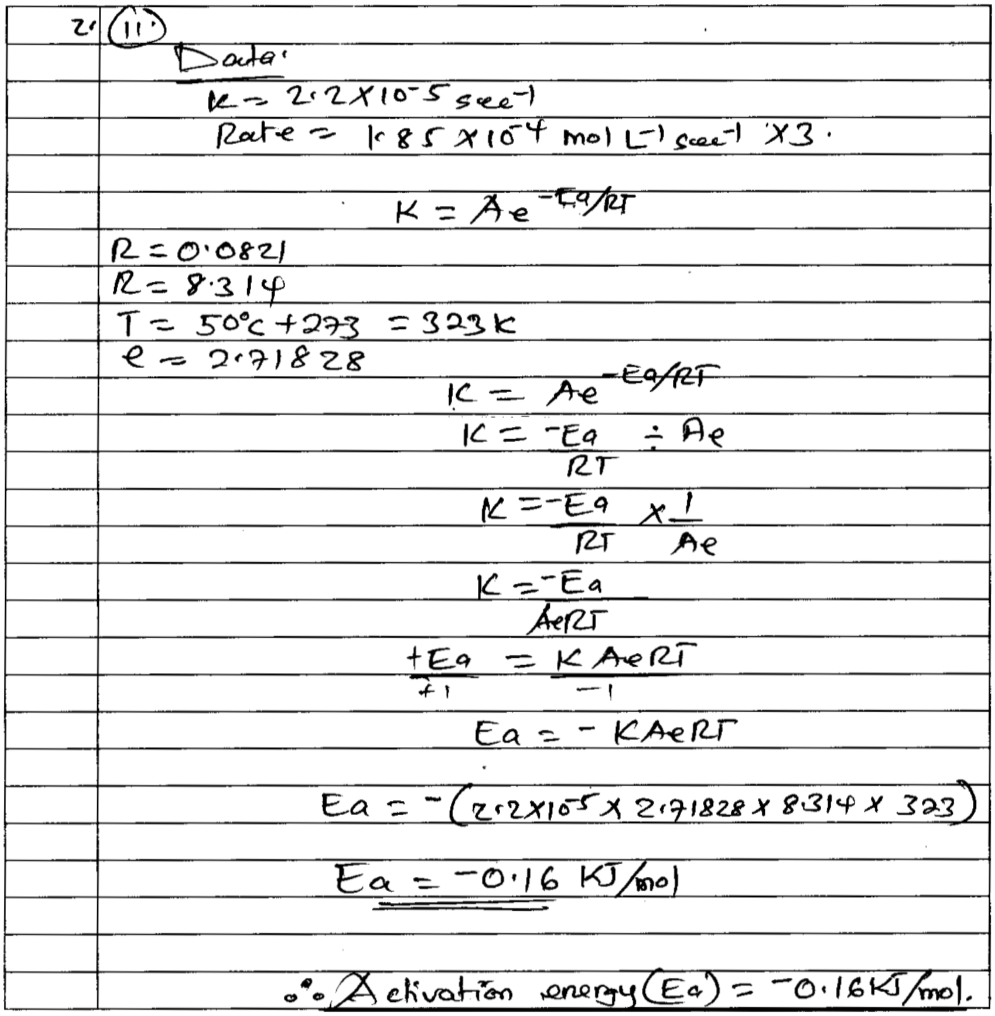
$$[NH_2NO_2] = \frac{Rate}{K}$$

$$= \frac{1.85 \times 10^{-4}}{2.2 \times 10^{-5}}$$

$$\therefore [NH_2NO_2] = \frac{8.4}{100}$$

$$\therefore [NH_2NO_2] = 0.084\%$$

$$\therefore NH_2NO_2 = 0.084\%$$


2. (ii)
Data:
$k = 2.2 \times 10^{-5} sec^{-1}$
$Rate = 1.85 \times 10^{-4} mol L^{-1} sec^{-1} \times 3.$
$K = Ae^{-Ea/RT}$
$R = 0.0821$
$R = 8.314$
$T = 50°c + 273 = 323K$
$e = 2.71828$
$K = Ae^{-Ea/RT}$
$K = \frac{-Ea}{RT} \div Ae$
$K = \frac{-Ea}{RT} \times \frac{1}{Ae}$
$K = \frac{-Ea}{AeRT}$
$\frac{+Ea}{+1} = \frac{KAeRT}{-1}$
$Ea = -KAeRT$
$Ea = -(2.2 \times 10^{-5} \times 2.71828 \times 8.314 \times 323)$
$Ea = -0.16 KJ/mol$
$\therefore$ Activation energy (Ea) = $-0.16 KJ/mol$.

Extract 12.2: A sample of incorrect responses in question 2

In Extract 12.2, the candidate incorrectly explained the factors affecting the rate of chemical reaction and used incorrect formula to calculate the rate constant. Furthermore, he/she wrongly manipulated the Arrhenius equation to calculate the activation energy of a given reaction.

2.2.3 Question 3: Acids, Bases and Salts

This question consisted of three parts, namely: (a), (b) and (c). Part (a) required the candidates to calculate the pH of a solution when:

(i) 1.0 cm^3 of 0.10 M NaOH is added to 100 cm^3 of 0.001 M HCl.

(ii) 1.0 cm^3 of 1.0 M HCl is added to a 1000 cm^3 of a solution mixture prepared by dissolving 0.04 moles of CH_3COOH. The candidates were given the ka value of CH_3COOH as 1.84 x 10^{-5}.

In part (b), the candidates were asked "How does Bronsted-Lowry concept account for the relative strength of acid-base conjugate pairs?" Part (c) required the candidates to indicate the acid-base conjugate pairs in each of the following equilibria:

(i) $NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$

(ii) $H_2SO_4 + H_2O \rightleftharpoons HSO_4^- + H_3O^+$

(iii) $AH + H_2O \rightleftharpoons A^- + H_3O^+$

The question was attempted by a total of 28,519 (97.5%) candidates, making it the most attempted question in paper 2. The statistical analysis shows that 8.7 percent of the candidates scored 12.0 - 20.0, 50.7 percent scored 7.0 - 11.5 and 40.6 percent scored 0 - 6.5 marks. Figure 13 summarizes the data.

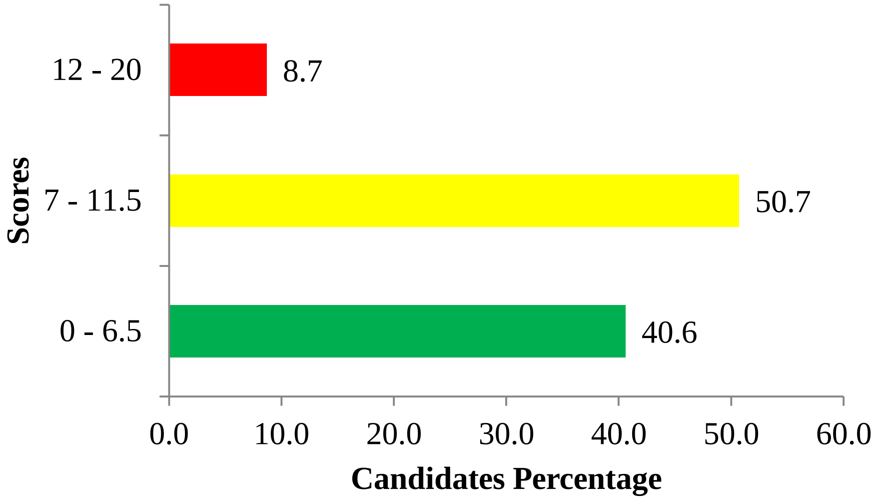


Figure 13: *Performance of the candidates in question 3*

The data in Figure 13 shows that 59.4 percent of the candidates scored (7.0 – 20 marks). Most of the candidates in this category were competent in the subtopics of *Acids and Bases*, *Ionic Equilibrium of Acids and Bases* as well as the *Ionic Product of Water and pH*. Thus, they were able to account for the strength of acids basing on the Bronsted-Lowry concept, and they correctly performed the related calculations in the remaining part of the question. Extract 13.1 illustrates an example of good responses from one of the candidates.

3a) Data

molarity of NaOH $(M_b) = 0.10M$

(i) volume of ~~H2O~~ NaOH $(V_b) = 1cm^3$.

Volume of acid $(V_a) =$ ~~0.001M~~ $100cm^3$

molarity of acid $(M_a) = 0.001M$.

$NaOH + HCl \rightarrow NaCl + H_2O$

1 : 1

number of moles of NaOH = Molarity x volume of NaOH

$= 0.10 \times \frac{1}{1000}$

$= 1 \times 10^{-4}$ moles.

number of moles of HCl = molarity of HCl x volume of HCl

$= 0.001 \times \frac{100}{1000}$

$= 1 \times 10^{-4}$ moles.

Since number of moles of HCl = number of moles of NaOH

$\therefore [H^+] = [OH^-] = 10^{-7}$ mol/dm^3

$PH = -\log(10^{-7})$

$PH = 7$

$\therefore$ PH of solution is 7

(ii) $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$

At t=0   1   0   0

At equilibrium; $1-\alpha$ α α

Concentration at equilibrium $(1-\alpha)c$ αc αc

$[H^+] = \alpha c$

But $\alpha = \sqrt{\frac{ka}{c}}$

$[H^+] = \sqrt{kac}$

But concentration is = $\frac{\text{number of moles}}{\text{volume of solution}}$

Concentration (c) = $\frac{0.04}{1}$

3a(ii) $c = 0.04M$

$[H^+] = \sqrt{1.84 \times 10^{-5} \times 0.04}$

$[H^+] = 8.579 \times 10^{-4} M$

3b) According to Bronsted lowry;

Acid; is any hydrogen containing specie that is capable of donating ~~them~~ to H^+ to bases

Bases are any species that are capable of accepting H^+ donated by acids.

According to Bronsted lowry theory he accounted for relative strengths of acid-base conjugate pair as follows;

⇒ If the acid is strong, its conjugate base is weak.

Example:

$HCl + H_2O \rightleftharpoons H_3O^+ + Cl^-$

strong acid — weak conjugate base.

⇒ If the acid is weak, its conjugate base is strong.

Example;

$CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$

weak acid — strong conjugate base.

⇒ If the base is strong its conjugate acid is weak.

⇒ If the base is weak its conjugate acid is strong.

$NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$

weak base — strong conjugate acid

3c) (conjugate pairs)

$NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$

(conjugate pairs)

NH_4^+/NH_3 and H_3O^+/H_2O − conjugate acid base pairs.

3cii) (conjugate pairs)

$H_2SO_4 + H_2O \rightleftharpoons HSO_4^- + H_3O^+$

(conjugate ~~base~~ pairs)

H_2SO_4/HSO_4^- and H_3O^+/H_2O − conjugate acid base pairs

3ciii) (conjugate pairs)

$AH + H_2O \rightleftharpoons A^- + H_3O^+$

(conjugate pairs)

AH/A^- and H_3O^+/H_2O − conjugate acid-base pairs.

Extract 13.1: A sample of correct responses in question 3

Extract 13.1 displays the responses of a candidate who correctly calculated the value of pH. The candidate applied appropriately the Bronsted-Lowry concept to account for the relative strength of acid-base conjugate pairs.

Finally, he/she correctly identified the acid-base conjugate pairs for the ionic equilibria given.

On the other hand, the analysis of responses from the candidates who performed poorly shows that they were not competent in the topic of *Acids, Bases and Salts* despite the fact that some parts of the topic are taught in the lower classes. The candidates showed incompetency in applying the Bronsted-Lowry theory to account for the strength of acid and bases. Moreover, they seemed to lack appropriate knowledge pertaining to the ionization of weak acids in water with their related calculations. Most of these candidates were not knowledgeable in expressing the strength of a solution in terms of pH.

For instance, in responding to part 3 (b), a candidate wrote "*Acid conjugate is the substance which act as proton donor*" and "*Base conjugated is the substance which act as proton receptor*". These definitions are correct despite the fact that they do not meet the requirement of the question to justify the relative strength of acid and bases as per Bronsted-Lowry theory. The candidates also calculated incorrectly the pH of solution asked in part (a) using the Henderson-Hasselbalch equation for acidic buffer solution. They manipulated wrongly the concentration of acid and bases into the formulae and got an incorrect answer. For instance, one of the candidates responded as follows:

$$pH = pka + \log\left(\frac{salt}{acid}\right)$$

$$pH = 4.735 + \log\frac{1.0}{4\times10^{-5}}$$

$$pH = 25$$

The candidate could easily get the correct pH by using such an approach as:

$[H^+]$ in a mixture = $\frac{Molarity \times Volume}{total\ volume\ of\ the\ mixture}$

$[H^+]$ form HCl = $\frac{1\times0.001}{1.001}$ = $9.99\times10^{-4}\ M$

$[CH_3COOH]$ = $\frac{0.04\times1}{1.001}$ = 0.03996 M

Since, $K_a = 1.84\times10^{-5}$ Then,

$[H^+]$ from $\sqrt{K_aC} = \sqrt{1.84\times10^{-5}\times0.03996} = 8.575\times10^{-4}$

[H^+] remained = 9.99×10^{-4} *M* - 8.575×10^{-4} = 1.415×10^{-4} *M*

Thus, pH = -log[H^+], that is pH = -log 1.415×10^{-4} = 3.85
pH = 3.85

Extract 13.2 is also a poor response provided by one of the candidates.

3(a)	(i) Data given
	volume of NaOH = 1.0 cm³
	Molarity of NaOH = 0.10 M
	Volume of HCl = 100 cm³
	Molarity of HCl = 0.001 M
	∴ The total volume = 1.0 cm³ + 100 cm³ = 101 cm³
	Mass of NaOH = 0.1/1000 = 0.0001 Kg = 0.1 g
	Mass of HCl = 0.001 g × 100 = 0.1 g
	The PH = Total mass / Total volume ~~= 0.1 g~~
	= (0.1 g + 0.1 g) / 101 cm3 = 0.2 g / 101 cm3
	= ~~1.98 g/cm³~~ 1.98 × 10⁻³ g/cm³
	= 1.98 × 10⁻³ PH
	(ii) Data given
	Volume of ~~Na~~ HCl = 1.0 cm³
	Molarity of HCl = 1.0 M
	Volume of Solution mixture = 1000 cm³
	Number of moles of mixture = 0.04 moles of CH₃COOH
	Ka (CH₃COOH) = 1.84 × 10⁻⁵
	∴ Total volume = (1000 + 1) cm³ = 1001 cm³
	Total number of moles = 0.04 + 0.001
	= 0.041 moles
	acidic (PH) = Total moles × 1.84 × 10⁻⁵ / Total volume
	= (0.041 × 1.84 × 10⁻⁵) moles / 1001 cm³
	PH = 7.54 PH.

3(b)	Bronsted lowry Concept account for the relative
	strength of acid-base Conjugate pairs
	because it obey the concept.
(c)	(1) In $NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$
	The acid base Conjugate pair are Nitrogen N
	and Oxygen O
	(II) In $H_2SO_4 + H_2O \rightleftharpoons HSO_4^- + H_3O^+$
	acid base Conjugate pair are Hydrogen H
	Oxygen O and Sulphur S
	(III) In $AH + H_2O \rightleftharpoons A^- + H_3O^+$
	acid base Conjugate pair are Oxygen O
	and Hydrogen H

Extract 13.2: A sample of incorrect responses in question 3

Extract 13.2 displays the responses of a candidate who used an incorrect approach to calculate the pH. The candidate wrongly justified the Brønsted-Lowry concept to account for the relative strength of acid-base conjugate pairs. He/she further indicated incorrect conjugate pairs for both acid and bases.

2.2.4 Question 4: Periodic Classification

This question had three parts, namely: (a), (b) and (c). Part (a) required the candidates to describe four characteristics of *s*-block elements. Part (b) (i) required them to explain the word electronegativity whereas part (b) (ii) required the candidates to explain three factors that affect the size of electronegativity. In part (c), the candidates were required to explain briefly on how the hydrides of period 2 react with water, acids and bases. They were also required to support their answers with reaction equations.

This question was attempted by 25,113 (85.8%) candidates out of which 17,848 (71.1%) scored 0 - 6.5, 5938 (23.6%) scored 7 – 11.5 and 1327 (5.3%) scored 12 - 20 marks. Figure 14 summarizes the performance of the candidates in this question.

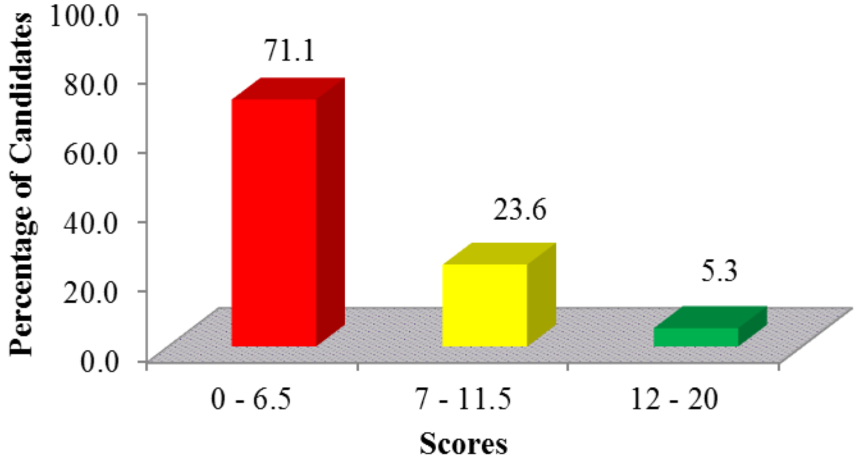


Figure 14: *Performance of the candidates in question 4*

Statistical analysis (Figure 14) indicates that the overall performance in this question was poor as majority of the candidates (17,848 corresponding to 71.1 percent) scored below an average mark (< 7 mark). Further analysis (not shown in Figure 14) revealed that 1100 (3.8%) candidates scored a zero mark. This question was the most poorly performed by the candidates in the 2020 ACSEE.

The candidates who scored low marks seemed to have lacked knowledge on the concept of periodicity, main features of the modern periodic table and ability to apply it to deduce the periodic trends of various elements/compounds in groups and periods. As a result, the candidates explained incorrectly the concept and factors that influence the electronegativity. Similarly, they failed to explain how hydrides of period 2 react with water, acids and bases. It was observed that, although some of candidates managed to explain the properties of hydrides of period II, they failed to support their answers with reaction equations. In addition to that, some of the candidates used interchangeably the elements in period 2 with those in group 2. This indicates the lack of basic knowledge pertaining to the arrangement of elements in the periodic table. Extract 14.1 represents one of the poor responses in this question.

4 (a) Four characteristics of s-block elements are:-
- It found in s-orbital with group one element. For example ~~oxy~~ Hydrogen atom.
- They have ability to lose electron from the outmost shell.
- They characterised by share of feature in form of halogens and alkaline features for example, hydrogen with chlorine in formation of diatomic gas.
- They obey Aufbau principle in explaination the main energy level from the periodic state.

b/
(i) Electronegativity refers to the tendency of an atom to attract itself from the atom. For example fluorine have greater electronegativity atom from the periodic table.

(ii) Three factors that affect the size of electronegativity
- Small cationic size and anionic size have greater tendency of electronegativity for example, oxygen atom.

4 b/
(ii) Complex compound formation consist several legand and cordinate by central atom have greater electronegativity.
- Low ionization power have greater efficiency in high affect the size of electronegativity.

c/ The following are the example of hydride of period 2 react with water, acids and bases as follows
- reaction with water
$Li_2 + H_2O \rightarrow Li(OH)_2 + H_2$
When hydride react with period 2 it form Lithium and Hydrogen gas
- $Li_{2(g)} + HCl_{(aq)} \rightarrow LiCl_2 + H_2$
Also, in reaction of base, group and period 2 it form the following.
for example
$Li_2 + NaOH \rightarrow LiOH + Na_2$
It form Lithium hydroxide and sodium gas.
- also $Be + SO_4 \rightarrow BeSO_4$
It form barium sulphate due to compound with base.

Extract 14.1: A sample of incorrect responses in question 4

Extract 14.1 displays the responses of a candidate who wrote inappropriate characteristics of *s*-block elements. The candidate gave incorrect factors affecting the size or magnitude of electronegativity. Moreover, the candidate incorrectly identified the hydrides of period 2, hence gave incorrect chemical equations.

On the other hand, the candidates who scored high marks showed to have understood properly the concepts of periodicity as well as the main features of the modern periodic table. The candidates also showed to have accumulated appropriate competencies in deducing the periodic trends in chemical properties. On account of the aforementioned competencies, the candidates were able to explain: four characteristics of *s*-block elements, the meaning of the word electronegativity, three factors that can affect the size of electronegativity, chemical properties of the hydrides of period 2, and they gave reaction equations when hydrides of period 2 react with water, acids and bases. Extract 14.2 represents a sample of one of the candidates' good responses in this question.

04 a) i. They have large atomic size.

ii. They have low electronegativity due to large atomic size.

iii. They have high metalic characterst com pare to other blocks

iv. They have large eletron affinity due to the larger atomic size.

b) i. Electronegativity is an ability of atom to atract electrons toward it self.

ii) > Atomic size.
Increasing atomic size cause to deceasing in electronegativity due to decreasing in nuclear atractive force

> Effective nuclear charge
Increasing in effective nuclear charge cause to increasing of electronegativity.

4c- Element of period ~~three~~ two are
Li Be /B/ C N O F

Its hydrides are
LiH BeH_2 BH_3 CH_4 NH_3 H_2O HF

First case are,
a. NH_3 H_2O HF.

~~The NH3 is~~ i) NH_3
> Reaction with water (NH_3)
~~with NH3~~
When NH_3 react with water it result to ammonia solution (NH_4OH) which is basic in nature
It can turn red litmus paper blue
ie
$NH_3 + H_2O \longrightarrow NH_4OH$.

> Reaction Between NH_3 and acid.
When NH_3 treated with strong acid it will result to salt and water

~~HCl~~ $NH_4OH + HCl \longrightarrow NH_4Cl + H_2O$

> Reaction of NH_3 with bases
Because NH_3 is base it has no reaction with other Bases

$NH_3 + NaOH \longrightarrow$ No reaction

04 c) ii: H_2O
Water is amphoteric in nature since it can act as a base or an acid.

> Reaction of H_2O and Acid.
When H_2O is treated with strong acid it will act as a base

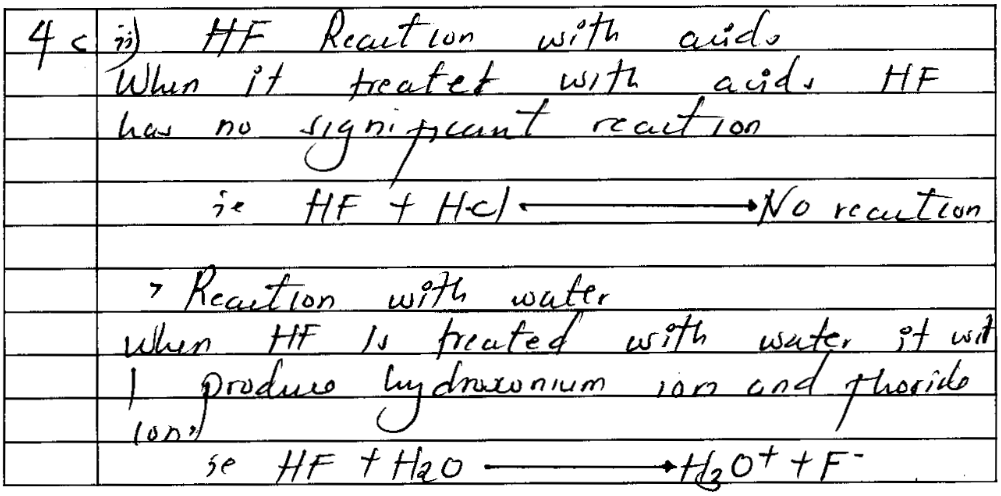
$HCl + H_2O \longrightarrow H_3O^+ + Cl^-$

> Reaction of water and Base
When H_2O reacting with strong bases it will act as the acid

ie $HCO_3^- + H_2O \longrightarrow H_3O^+ + CO_3^{2-}$

> Reaction between H_2O and H_2O,
Because it is the same compound there is no reaction between
$H_2O + H_2O \longrightarrow$ No reaction

iii) HF
HF is an acid in nature, when treated with strong Base it will form salt and water
ie $HF + NaOH \longrightarrow NaF + H_2O$



4 c	ii) HF Reaction with acids
	When it treatet with acids HF
	has no significant reaction
	ie $HF + HCl \longrightarrow$ No reaction
	Reaction with water
	When HF is treated with water it will
	produce hydroxonium ion and floride
	ion;
	ie $HF + H_2O \longrightarrow H_3O^+ + F^-$

Extract 14.2: A sample of correct responses in question 4

Extract 14.2 shows the responses of a candidate who described properly the characteristics of s-block elements. He/she also correctly explained the concept of electronegativity as well as the factors affecting its magnitude. Finally, the candidate explained the chemical properties of hydrides of period 2 when react with water, acids and bases, and supported his/her responses with appropriate chemical equations.

2.2.5 Question 5: Amines

This question had four parts, namely; (a), (b), (c) and (d). Part (a) required the candidates to show with the aid of chemical equations, how dimethylamine reacts with the following compounds:

(i) $CH_3C(=O)-Cl$ (ii) $CH_3C(=O)-O-CH_3$

Part (b) required the candidates to give the structural formula of:

(i) Tripropylamine
(ii) Dipentylamine
(iii) 2,4-dimethyl-3-hexanamine.

In part (c), the candidates were asked as follows:

(i) Show how to carry out the conversion starting from propanoylchloride to dipropylamine.
(ii) Write the equation to show the reaction between benzaldehyde (C_7H_6O) and warm phenylamine.

(iii) Write the general formula and functional group of secondary amine and tertiary amine.

(iv) Write the equation for the equilibrium that exists when diethylamine dissolves in water.

Part (d) required the candidates to give the structural formula for compounds B through E which had undergone the following sequence of reactions:

$$\textbf{B}\ (C_7H_8) \xrightarrow{Cl_2/\text{light}} \textbf{C}\ (C_7H_7Cl) + HCl$$

$$\textbf{C} \xrightarrow{NH_3} \textbf{D}\ (C_7H_{10}NCl) \xrightarrow{OH^-} \textbf{E}\ (C_7H_9N) + Cl + H_2O$$

The question was opted by 14,042 (48.0%) candidates out of which 7981 (56.9%), 4233 (30.1%) and 1828 (13.0%) scored 0 - 6.5, 7.0 - 11.5 and 12 - 20 marks, respectively. Figure 15 summarizes the performance of the candidates in this question.

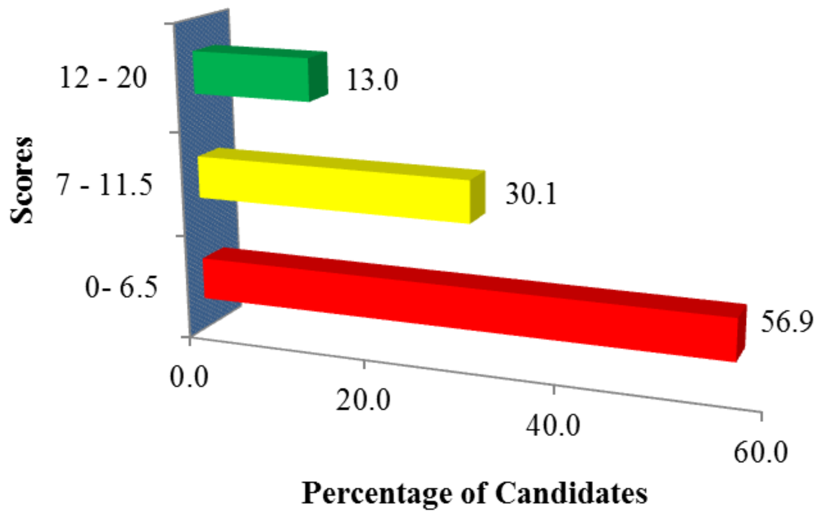
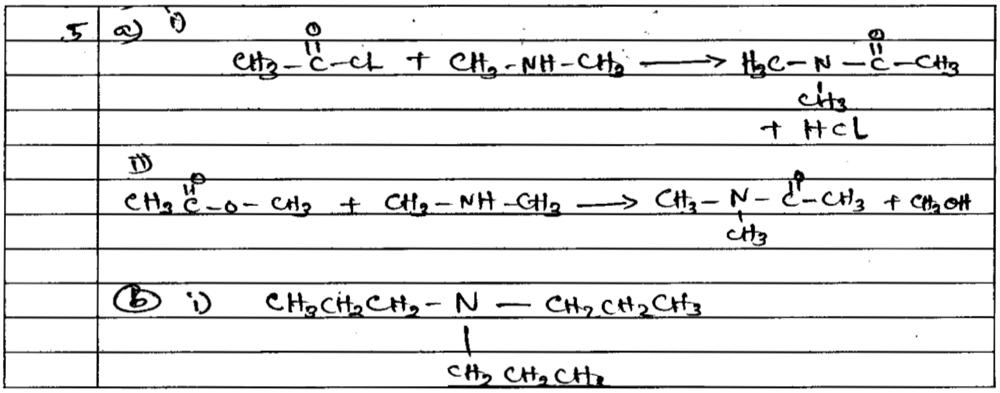


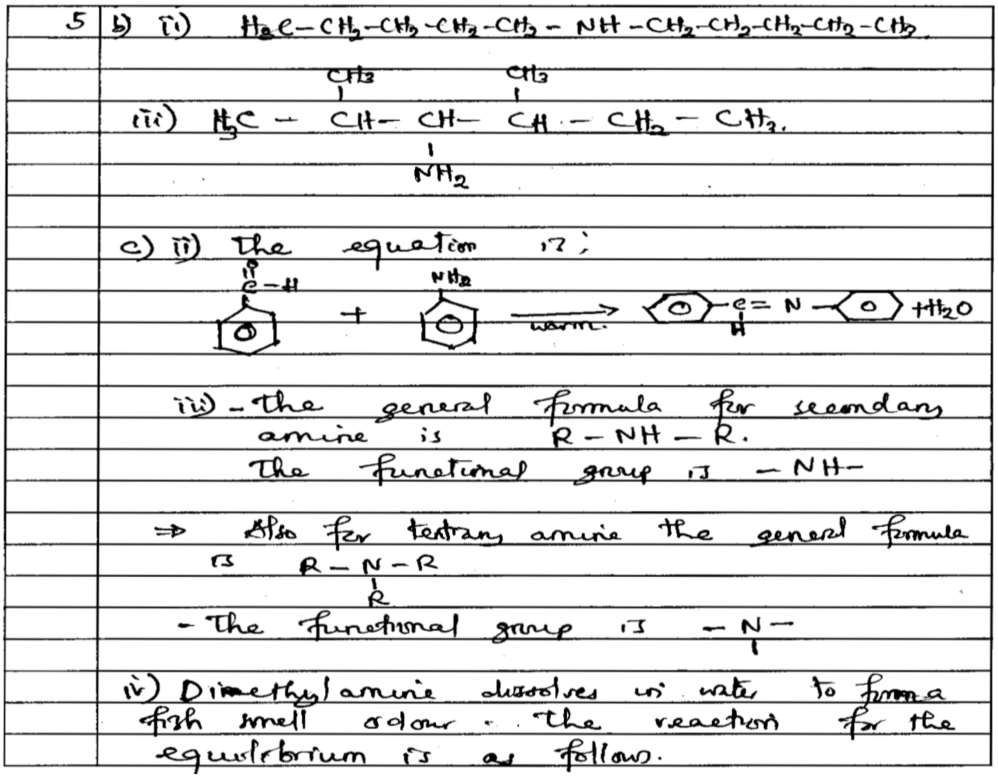
Figure 15: *Performance of the candidates in question 5*

The overall performance was average as 6061 (43.1%) candidates scored an average mark or above (7 – 20). The candidates who scored high marks showed to have properly mastered the concepts in the topic of *Amines*, specifically on systematic nomenclature, preparation of different classes of amines and their chemical properties. Moreover, the candidates showed competency in the interconvertibility of amine into various functional groups. It should be noted that competencies in interconverting various functional groups in organic chemistry is, among otherthings, the corner stone towards good performing in organic chemistry. Thus, the candidates were able to give appropriate chemical equation for the reaction between dimethylamine with the given compounds. Moreover, the candidates gave correct structures for part (b) and suggested appropriate functional group interconversion for the rest part of the question. Extract 15.1 represents good responses from one of the candidates.


5 a) i) $CH_3-C(=O)-Cl + CH_3-NH-CH_3 \longrightarrow H_3C-N(CH_3)-C(=O)-CH_3 + HCl$

ii) $CH_3C(=O)-O-CH_3 + CH_3-NH-CH_3 \longrightarrow CH_3-N(CH_3)-C(=O)-CH_3 + CH_3OH$

(b) i) $CH_3CH_2CH_2-N(CH_2CH_2CH_3)-CH_2CH_2CH_3$


5 b) (i) $H_3C-CH_2-CH_2-CH_2-CH_2-NH-CH_2-CH_2-CH_2-CH_2-CH_3$.

(ii) $H_3C-CH(CH_3)-CH(NH_2)-CH(CH_3)-CH_2-CH_3$.

c) (ii) The equation is;

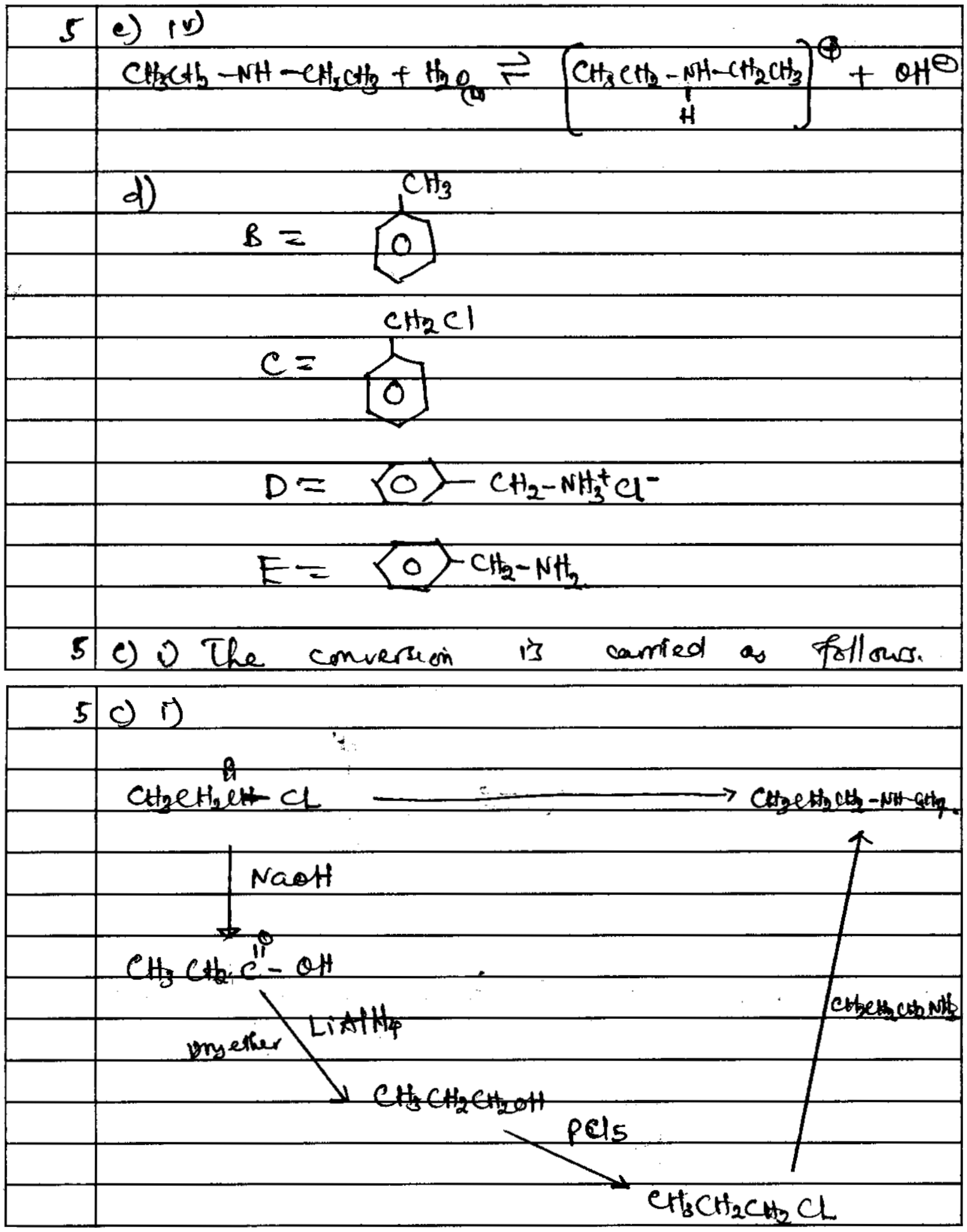
benzaldehyde + aniline $\xrightarrow{\text{warm}}$ $C_6H_5-CH=N-C_6H_5 + H_2O$

(iii) - the general formula for secondary amine is R-NH-R.
The functional group is -NH-

⇒ Also for tertiary amine the general formula is R-N(R)-R

- The functional group is -N(-)-

iv) Dimethylamine dissolves in water to form a fish smell odour. The reaction for the equilibrium is as follows.

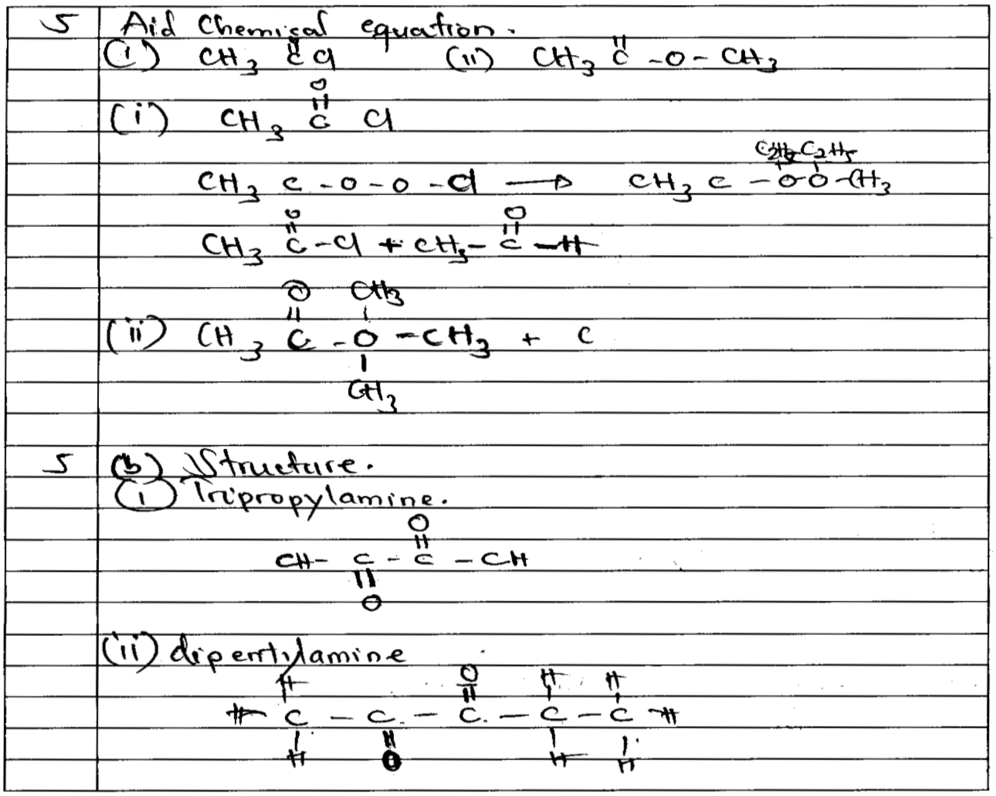


Extract 15.1: A sample of correct responses in question 5

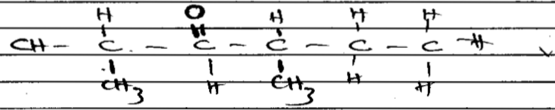
Extract 15.1 shows responses of a candidate who gave the correct chemical equation for the reaction between dimethylamine and the given compounds. He/she gave correct structural formulae and appropriately interconverted the functional groups given.

On the other hand, the candidates with low scores showed lack of appropriate skills in organic chemistry. The candidates showed incompetence in the topic of *Amines*, specifically the classes of amine with their respective functional groups. They manifested little understanding of regarding the preparation, chemical reactions and functional group interconversion of amines.

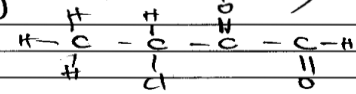
In addition, some of the candidates manifested poor English language proficiency which was revealed when few of them failed to understand the meaning of "B *through E*" in part 5 (d). Thus, they identified only compound B and E instead of B, C, D and E. The draw-backs accounted were further justified when; in part 5 (a), one of the candidates wrote dimethylamine as "$CH_3CH_3NH_2$" instead of $(CH_3)_2NH$ which led to incorrect chemical equations. Besides those, there were candidates who gave incorrect structural formula for propanoylchloride and dipropylamine; as they wrongly named the given compounds, provided incorrect functional group interconversion and incorrectly applied the IUPAC rules. Extract 15.2 is a sample of incorrect responses.



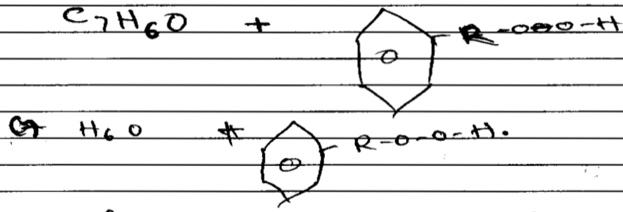
5(b) 2,4,-dimethyl-3-hexanamine.



c (i) Starting from Propanoylchloride to dipropylamine



(ii) Reaction btn Benzaldehyde (C_7H_6O) and Phenyamine

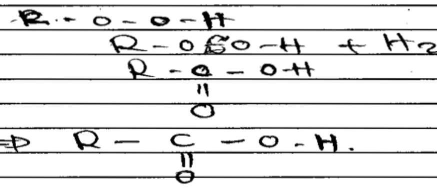


(iii) General formula of Secondary and ~~primary~~ tertrary Amine.

⇒ Secondary Are the type of Amine.

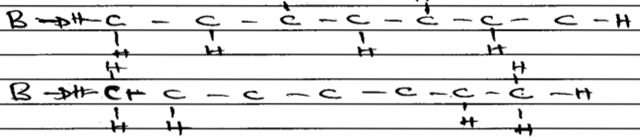
⇒ Tertiary Are the ~~three~~ type of Amine.

5 (iv) Diethyamine disolve in water

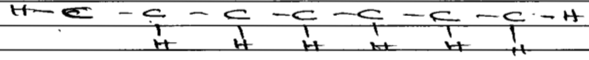


(v) Structure formular of B through E

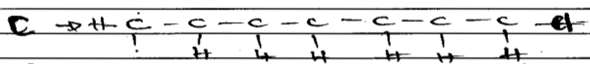
B⇒(C_7H_8) ⟶ C(C_7H_7Cl) + HCl



B ⇒ CH_3 CHCCCC CH CH_3

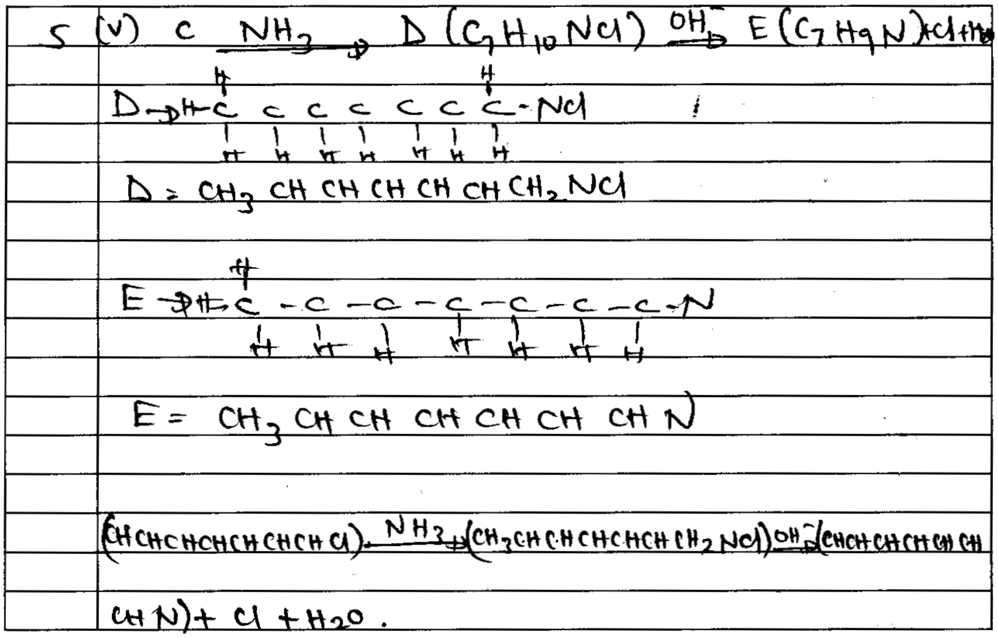


∴ B ⇒ CH CHCH CH CH CH CH_2



C ⇒ CH CH CH CH CH CH CH Cl + HCl

B(CH CH CH CH CH CH CH_2) Cl_2/light ⇒ CHCHCHCH CH CHC HCl



Extract 15.2: A sample of incorrect responses in question 5

In Extract 14.2, a candidate gave incorrect structural formula for the given amines and wrote incorrect chemical equations. In part (c), the candidate wrote incomplete equations for the functional group interconversion. In the last part, the candidate incorrectly identified the structural formulae of B, C, D and E.

2.2.6 Question 6: Polymers

This question consisted of four parts, namely; (a), (b) (c) and (d). Part (a) required the candidates to explain briefly the following and give one example for each:

(i) Thermoplastic polymers
(ii) Thermosetting polymers
(iii) Natural polymers

In part (b), the candidates were asked to write the monomers used in synthesis of the following polymers:

(i) Polyvinylchloride (PVC)
(ii) Teflon
(iii) Bakelite

In part (c), the candidates were asked the following:

(i) Why cationic polymerization is more favored than anionic polymerization when vinylic monomers contain an electron donating group?
(ii) Why styrene undergo anionic polymerization easily? Briefly explain.
(iii) Differentiate addition from condensation polymers basing on the mode of polymerization. Give one example for each type.

In part (d), the candidates were required to write down with reasons, the use of each of the following polymers:
(i) Butyl-rubber
(ii) Polyacrylonitriles
(iii) Polyhaloalkene

This question was attempted by 19,701 candidates corresponding to 67.3 percent. Data analysis shows that the candidates who scored from 12 – 20, 7.0 - 11.5 and 0 - 6.5 marks were equivalent to 5.5, 36.6 and 57.9 percent, respectively. Figure 16 summarizes the data.

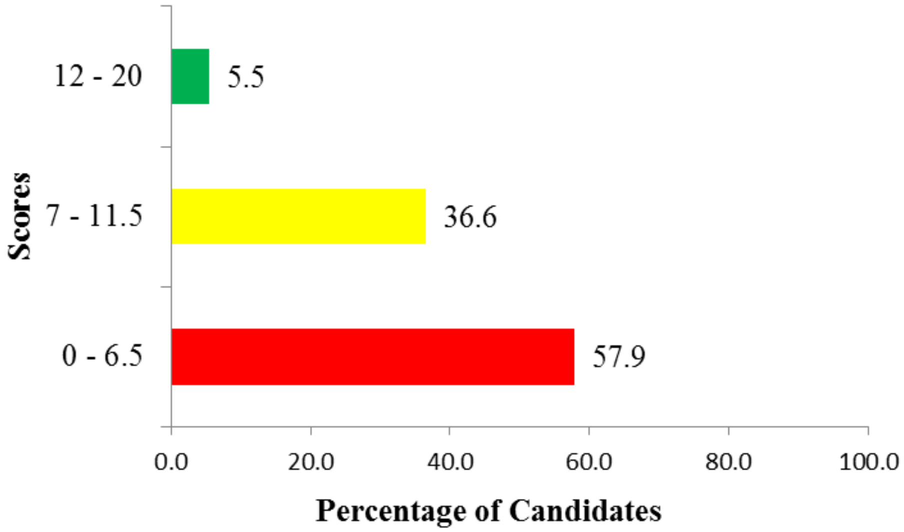
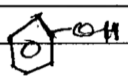


Figure 16: *Performance of the candidates in question 6*

The general performance in this question was average as 42.1% (Figure 16) of the total candidates who attempted this question scored a pass mark or above (7 – 20 marks). The candidates with good performance were able to provide correct responses in most parts of the question. These candidates had good knowledge regarding polymers, specifically types of polymers, characteristics, their uses and the types of polymerization. They managed to relate the common names of the given polymers with systematic names.

Hence, gave the correct monomers used to synthesize the given polymers. The candidates had good knowledge on the modes of polymerization which enabled them to correctly differentiate addition from condensation polymerization. Lastly, they suggested proper uses/application of polymers based on their properties. Extract 16.1 shows a sample of good responses.

06(a)	i) Thermoplastic polymers.
	Are the polymers which can be melted wi
	thout decomposition when heated.
	Example is polyethylene.
	ii) Thermosetting polymers.
	Are the polymers which are hard and canbe
	melted with decomposition when heated.
	Examples are bakelite and melamine.
	iii) Natural polymers.
	Are the polymers which are found naturally in
	plants and animals.
	Example is cellulose and protein.
(b)	i) $CH_2 = CHCl$
	ii) $CF_2 = CF_2$
	iii) HCHO and 
c)	i) cationic polymerization is more favoured than
	anionic polymerization when vinyle monomers
	contains the electron donating group because there
	is the formation of stable carbenium ion in whi
	ch the electron donating groups increase the
	stability by donating the electron pairs to the
	positive carbon by the inductive effect.

06(c) ii) Styrene undergoes anionic polymerization easily due to the formation of stable carbanion in the carbon of the intermediate state due to the stabilization brough about by the phenyl group by the negative inductive effect in which phenyl group attract the electrons of the carbon with negative charge hence stable.

iii) Addition polymers are the polymers which are formed by the combination of the unsaturated monomers through addition reaction example is the polyvinyl chloride $-(CH_2-CH(Cl))_n-$

while.

Condensation polymer is the polymer which is formed by combination of of small molecules or monomers with the evolvement of small molecule such as HCl and H_2O. Example is Nylone 6 which is $-(O-\overset{O}{\overset{\|}{C}}-(CH_2)_4\overset{O}{\overset{\|}{C}}-NH-(CH_2)_6NH)-$

06(d) i) Butyl rubber is used in the manufacturing of car tyres, because

- It posses the few cross links in its chains which can makes them to be retain their shapes and size after force acting on them.
- They have considerably elasticity

- They can withstand higher temprature during operation since they are of higher boiling point and melting point.
- They are non-reactive hence not attacked easily.

6(b) ii) polyacrylonitriles :
- They are used in the manufactures of the carpets
because of the following reasons;
- They are non reactive hence does not attacked
easily by the chemicals.
- They are hard hence cannot change their shapes
easily during operation.

iii) Polyhaloalkane
(a) They are used in the manufacturing of plastic
products such as crates, bottles and strings because
- They are not reactive hence not not easily
attacked by the chemicals or water.
- They can be moulded and formed in to differe
nt shapes when heated.
- They have not very larger or very low boili
ng point.
- can be recycled to manufacture other
facilities or vessels.

(b) They can be used in manufacturing of fishing
nets, because they are insoluble in water.

(c) They can be used in manufacturing of clothes,
in the mixture with other elements and polymer
such as fibres.

Extract 16.1: A sample of correct responses in question 6

Extract 16.1 shows responses of a candidate who described properly different types of polymers given. The candidate correctly wrote the monomers constituting the polymers asked and appropriately differentiated the terms in part 6 (c). Finally, he/she appropriately derived the uses/application of polymers based on their properties.

Some of the candidates (57.9%) scored poorly in this question. This was attributed to insufficient competences in the topic of *Polymers*. The analysis of the candidates' responses reveals that they lacked knowledge on important properties of polymers, modes of polymerization process, identification of monomers from a given polymer and uses of polymers. Some parts of the question seemed difficult to candidates. Part (b) (ii) and (iii) appeared difficult to them because they incorrectly related the common names of polymers with their systematic names. For example, the candidates failed to recognize that Teflon (common name in a market) is the same as polytetrafluoroethene (PTFE). They also deduced incorrectly the monomers for Bakelite polymer. This shows that these candidates were not conversant with various types of polymers we encounter in our daily life activities.

Moreover, the candidates responded incorrectly to part (c) (i), (ii) and (iii) due to poor understanding of different types of organic reactions and the characteristics of organic reactants. In part (d) (i) - (iii), the candidates gave inappropriate uses of polymers. This is attributed to lack of competency regarding the nature of polymers hence, their applications. Extract 16.2 is a sample of poor responses from one of the candidates.

06 d/

(i) Butyl- rubber
→ provide fibres materials that used to join up the monomer

(ii) polyacrylonitriles
→ provide nylon material that used to make the polymer

(iii) polyhaloalkene
→ provide full number of hydrogen to be synthesis during polymerization

b/ i/ NaBr and $Cl-CH_2=CH_2$

(ii) $NH_2-\underset{H}{\overset{R}{C}}-\overset{O}{\overset{\|}{C}}-OH$

(iii) 1,6 - hexammed
1,6 - hexanoic acid

c/ i/ Cationic polymerization is most favored because contain positive change that donating a group

(ii) Because is very Ionizable in air

06 c/
(iii) Addition polymerization
is the type of polymerization
which forming products through
adding
while
Condensation polymerization
is the types of polymerization
that give structure through conden
ng.

06 b/
(iii) Natural polymer
is the simple molecular having low
molecular mass of combination inter-
molecular almost affinity

(iv) Thermosetting is the type of polymer
which obtained through setting the
monomer

Extract 16.2: A sample of incorrect responses in question 6

Extract 16.2 shows responses of a candidate who gave inappropriate uses of polymers as well as incorrect monomers. The candidate incorrectly differentiated addition from condensation polymerization.

3.0 ANALYSIS OF THE CANDIDATES' PERFORMANCE IN EACH TOPIC

A total of sixteen (16) topics were examined in Chemistry paper 1 and 2. The candidates performed well in the following topics: *Aliphatic Hydrocarbons* (86.6%), *Aromatic Hydrocarbons* (86.3%), *Gases* 83.6%), *Soil Chemistry* (82.5%), *The Atom* (79.8%), *Chemical Equilibrium* 70.2%) and *Relative Molecular Masses in Solution* (61.3%).

The good performance in the aforementioned topics was attributed to the fact that most of the candidates had adequate knowledge and clearly understood the requirements of the respective questions. Moreover, they were competent in mathematical manipulations. The candidates' English language proficiency helped them to express their ideas properly, especially in answering the questions which required detailed explanations.

The candidates had an average performance in the topics of *Acids, Bases and Salts* (59.4%), *Chemical Kinetics* (58.8%), *Energetics* (54.8%), *Amines* (43.1%), *Polymers* (42.1%), *Selected Compounds of Metals* (41.3%) and *Chemical Bonding* (35.4%). The candidates who performed averagely in these topics provided partial answers. Most of them seemed not to have grasped all the requirement of the question.

Further analysis shows that the candidates had weak performance in the topics of *Two Components Liquid System* (30.5%) and *Periodic Classification* (28.9%). The poor performance in the stated topics is to a great extent attributed to the inadequate knowledge and incompetence in writing appropriate chemical formulae and equations as well as tackling problems involving mathematical manipulations.

The summary of the candidates' performance in different topics is presented in the appendix.

4.0 CONCLUSIONS

The question-wise analysis of the performance in Chemistry paper 1 and 2 for the 2020 ACSEE has shown that the overall performance of the candidates is average.

The analysis shows that seven (7) topics had good performance, seven (7) topics had an average performance and two (2) topics had poor performance. Good performance was attributed to good mastery of the concepts tested in the respective topics and understanding of the questions' demands.

However, the analysis on individual items indicated that some of the candidates experienced difficulties in answering the questions due to inadequate knowledge. This was obvious in the analysis made on the poorly and averagely performed questions (Appendix). Among other factors, unsatisfactory performance could be greatly attributed to:

(a) Lack of mathematical manipulation skills and inadequate knowledge on the tested topics. It was evident from some of the candidates who gave responses which were not relevant with the questions asked. Most of them were not able to transpose the formulae and plug in the data provided to arrive at the correct value of the items required.

(b) Inability of the candidates to follow the required steps in answering questions. This was shown by some of the candidates who substituted data into formulae without unit's agreement while at the same time skipping a couple of necessary steps.

(c) Lack of English language proficiency. This was manifested by the candidates who gave incorrect sentences to the extent of not being able to communicate their answers. Others failed to understand the requirement of the questions.

(d) Failure to apply appropriate formulae and chemical equations. The failure to integrate classroom lessons with the real life situations was another reason. This was observed from candidates who failed to relate the common names for polymers used in our daily life with those named according to IUPAC rules.

5.0 RECOMMENDATIONS

In order to improve the candidates' performance in Chemistry, the following measures are recommended:

(i) Teachers should put more emphases on mathematical-based concepts and skills in the topics of *Acids, Bases and Salts, Chemical Kinetics, Energetics* and *Two Components Liquid System*.

(ii) Teachers should put more emphases on the use of models and wall charts in the topic of *Periodic Classification*. This will boost and rise the interest of prospective candidates to learn. Thus, grasp more concepts and build the long term memory.

(iii) The prospective candidates should be encouraged and involved in tasks which can help to nurture and develop their language skills. Among other approaches in this matter, the English speaking programme through both inter and intra schools debate competitions as well as morning speeches on chemistry topics, are hereby highly recommended as a possible remedy.

(iv) Teachers are emphasized to integrate both theory and practicals in their teaching. This will allow the prospective candidates to build confidence and appropriate competencies in the subject matter.

(v) Educators (teachers) should emphasize on the use of chemical symbols, formulae and equations according to the IUPAC system. These are the cornerstones in Chemistry.

(vi) In addition, teachers should teach the proper use of units and dimensions in line with the System International unit (SI Unit). This will help prospective candidates to be aware of the importance of unit agreement whenever they encounter a problem incorporating mathematical manipulations.

Appendix: Summary of Performance of the Candidates Topic-wise

S/N	Topic	2020		
		Number of Questions	The Percentage of the Candidates who scored an Average of 35 or Above	Remarks
1	Aliphatic Hydrocarbons	1	86.6	Good
2	Aromatic Hydrocarbons	1	86.3	Good
3	Gases	1	83.6	Good
3	Soil Chemistry	1	82.5	Good
5	The Atom	1	79.8	Good
6	Chemical Equilibrium	1	70.2	Good
7	Relative Molecular Masses in Solution	1	61.3	Good
8	Acids, Bases and Salts	1	59.4	Average
9	Chemical Kinetics	1	58.8	Average
10	Energetics	1	54.8	Average
11	Amines	1	43.1	Average
12	Polymers	1	42.1	Average
13	Selected Compounds of Metals	1	41.3	Average
14	Chemical Bonding	1	35.4	Average
15	Two Components Liquid system	1	30.5	Weak
16	Periodic Classification	1	28.9	Weak