THE NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

CANDIDATES' ITEM RESPONSE ANALYSIS REPORT FOR THE ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION (ACSEE) 2018

132 CHEMISTRY

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TABLE OF CONTENTS

FOREWORD

The National Examinations Council of Tanzania has prepared this Candidates' Items Response Analysis (CIRA) report in order to provide feedback to the stakeholders such as students, teachers, parents, policy makers and the public in general, on the performance of the candidates who sat for Chemistry examination for the Advanced Certificate of Secondary Education Examinations (ACSEE) in May 2018.

The Advanced Certificate of Secondary Education Examination marks the end of two years of Advanced Secondary Education. It is a summative evaluation which, among other things, shows the effectiveness of the educational system in general and education delivery system in particular. Essentially, the candidates' response to the examination questions is a strong indicator of what the education system was able or unable to offer to students in their two years of advanced secondary education.

The analysis presented in this report is intended to contribute towards understanding of some of the reasons behind the performance of the candidates in Chemistry subject. The report highlights some of the factors that contributed to candidates to score high marks. It also includes 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 administrators, school managers, teachers and students to identify proper measures to be taken in order to improve the candidates' performance in future examinations administered by the Council.

The Council would like to thank Chemistry Coordinators, Examiners and all others who participated in the preparation of this report. The Council would also like to express sincere appreciation to all the staff who participated in analyzing the data used in this report.

The National Examinations Council of Tanzania will highly appreciate constructive comments and suggestions from teachers, students and the public in general to improve future reports.

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 for Chemistry Paper 1 and Chemistry Paper 2 in 2018. The examination was set according to the ACSEE format, which was revised in 2011 to suit the 2010 ACSEE Chemistry syllabus.

Paper 1 consisted of three sections; A, B and C. Section A consisted of six (6) questions whereby the candidates were required to attempt only four (4). Section B and C had four (4) questions each and the candidates were required to answer three (3) questions from each section respectively.

Paper 2 had three sections; A, B, and C. Section A had four (4) questions, and section B and C had three (3) questions each. The candidates were required to answer a total of five (5) questions, choosing at least one (1) question from each section.

A total of 33,248 candidates sat for the chemistry examination in 2018. 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. In the year 2018, 92.71 percent of the candidates passed the examination compared to 88.31 percent who passed the examination in 2017. Hence, the performance in 2018 has increased by 4.4 percent.

This report is presented in four sections. It starts with the introduction, followed by the analysis of the candidates' performance in each question. The analysis of performance in each topic is also given inorder to enable education stakeholders to take action on challenges facing candidates in answering questions. Finally, the report gives conclusions and recommendations.

2.0 ANALYSIS OF THE CANDIDATES' PERFORMANCE BY 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 of the candidates' responses have also been inserted in appropriate sections to illustrate the cases presented.

The performance is classified as either poor/weak, average or good, on the basis of the percentage of the candidates who passed (scored 35 percent or more of the marks allocated in a particular question). If the percentage lies from 0 to 34 it is termed to be poor/weak, 35 to 59 as average and 60 to 100 as good. Furthermore, green, yellow and red colours have been used in different figures to show good, average and poor performance respectively.

2.1 132/1-CHEMISTRY 1

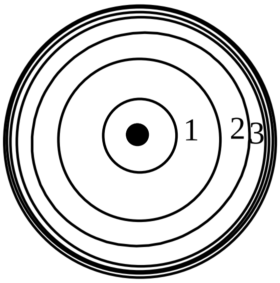
This paper had a total of 14 questions each carrying 10 marks. The pass mark in each question was 3.5 marks.

2.1.1 Question 1: The Atom

The question consisted of three parts; (a), (b) and (c). In part (a), the candidates were presented with a diagram of Bohr's atomic model of hydrogen atom and were required to:

(i) State three basic postulates which led to the Bohr's atomic model and apply mathematical expressions, if any, which qualify the postulate.

(ii) Give a sketch of Bohr's atomic model and show how Lyman and Paschen spectral lines are formed.



In part (b), the candidates were given the information that, “the energy difference between ground and excited state of atoms of a certain element was found to be 4.4×10^{-19} J". They were required to calculate wavelength and wavenumber of photons that excited the atoms by showing their works clearly, including manipulations of units. In part (c), the candidates were provided with the information that “Dalton's atomic theory consists of four main postulates" and were asked to briefly describe an experiment or a discovery which is against the following postulates:

(i) Atoms can neither be created nor destroyed.

(ii) All atoms of the same element are alike.

The question was attempted by 25,622 candidates corresponding to 77.1 percent. The majority of the candidates (47.1 %) scored marks ranging from

6.0 - 10 with 1.3 percent scoring full marks whereas 32.2 percent scored 3.5 - 5.5 marks. Candidates who scored 0 - 3.0 marks were 20.7 percent. Figure 1 shows distribution of the candidates’ scores.

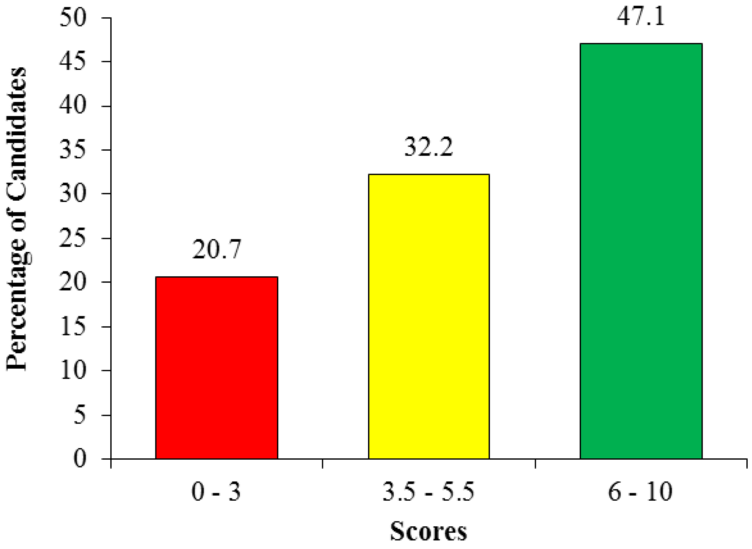


Figure 1: *Performance of the candidates in question 1.*

Figure 1 shows that 79.3 percent of the candidates scored 3.5 marks and above, an indication that the performance was good in this question. The candidates who scored all the 10 marks in this question managed to state correctly three basic postulates which led to Bohr’s atomic model in the necessary mathematical expressions. They also sketched Bohr’s atom with well arranged Lyman and Paschen spectral series. In calculating wavelength and wave number of photons, the candidates showed appropriate manipulation of the units. Extract 1.1 illustrates a sample of good responses for this question.

Extract 1.1

1. (a) i) Bohr's pastulates on atomic model

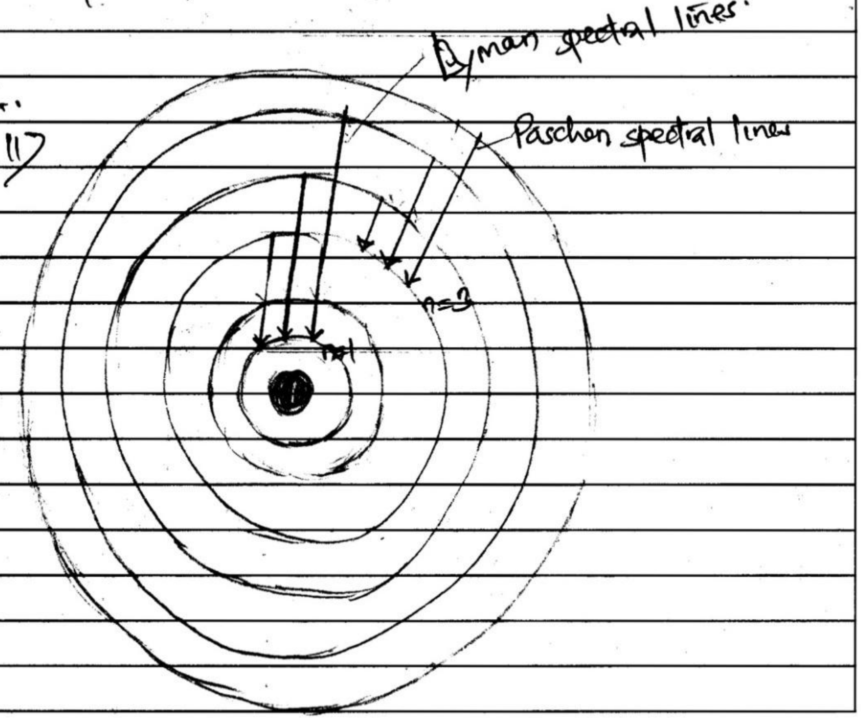
— Electrons in an atom tend to ocupy stationary states where as in these states they donot emit any form of energy

— The angular momentum of the orbits of electrons is an integral multiple of $nh/2\pi$.

$$MVr = \frac{nh}{2\pi}.$$

— Electrons tend to jump from lower energy levels to higher energy levels, and on doing this they emit energy in form of quanta.

ii)



1; (b) Given :

Energy difference $\Delta E = 4.4 \times 10^{-19} J$

Energy $\Delta E = nhf$.

$$\Delta E = nh\frac{c}{\lambda}.$$

$$4.4 \times 10^{-19} J = \frac{6.6 \times 10^{-34} Js \times 3 \times 10^{8} m/s}{\lambda}.$$

$$\lambda = \frac{1.98 \times 10^{-25} Jm}{4.4 \times 10^{-19} J}$$

$$\lambda = 4.5 \times 10^{-7} m$$

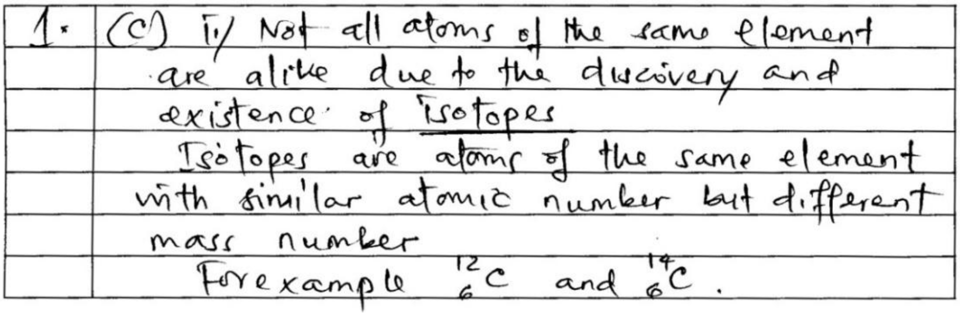
$\Rightarrow$ Wavelength $= \underline{4.52 \times 10^{-7} m}$.

Wavenumber $\upsilon = 1/\lambda$.

$$= \frac{1}{4.52 \times 10^{-7} m} = 2.212 \times 10^{6} m^{-1}.$$

$\Rightarrow$ Wavenumber $= \underline{2.212 \times 10^{6} m^{-1}}$

(c) i) It is not true that atoms can neither be created nor destroyed due to the discovery of nuclear bombardment activities. which lead to breaking of atoms into smaller particles.



1. (c) ii/ Not all atoms of the same element
are alike due to the discovery and
existence of Isotopes
Isotopes are atoms of the same element
with similar atomic number but different
mass number
Forexample $^{12}_{6}C$ and $^{14}_{6}C$.

Extract 1.1 shows that the candidate correctly stated Bohr’s postulates, gave the discoveries against Dalton’s atomic theory and stated correctly the five gas laws. Furthermore, the candidate correctly performed the calculations in part (b) and wrote relevant responses in part (c).

On the other hand, some of the candidates scored low marks. Specifically, those who scored zero mark, failed to write the formula of angular momentum which is among the three basic postulates of the Bohr's atomic model. They could not sketch the Bohr's atom so as to show how the Lyman and Paschen spectral series are formed. This implies that they were unable to associate the atomic structure of hydrogen with the Bohr's atomic model. Others failed to identify the ground state of electron transition in the Lyman and Paschen spectral series as well. Moreover, some candidates failed to calculate the wavelength and wavenumber of the photons signifying that the candidates lacked mathematical skills and did not know the proper formula. Furthermore, the candidates were unable to describe experiments which are against the postulates "atoms can neither be created nor destroyed" and "all atoms of the same element are alike". This is an indication that the candidates had insufficient knowledge about nuclear fission and fusion, and the concept of isotopes of elements. Extract 1.2 shows a sample of poor responses from one of the candidates.

Extract 1.2

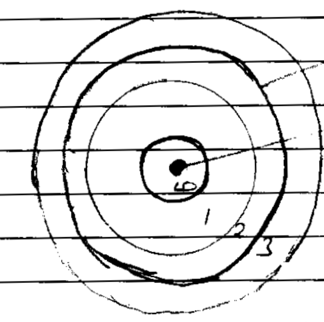
01. a) i) To state three basic postulates which lead to Bohr's atomic model.

(i) ~~Atom~~ Bohr's postulate that, atom is sorounded by ring collaf shells.

ii) Atom con either be created ner destoyed

(iii) Atom of the same element are identical but are different when the element is differs.

01 (a) ii)



Above are the sketch of Bohr's atom show how lyma and paschen spectral series are formed.

1 (b) Data.

Temperature = 4.4×10^{-19}

Ryberge constant (R_H) = 1.09678×10^{7} m.

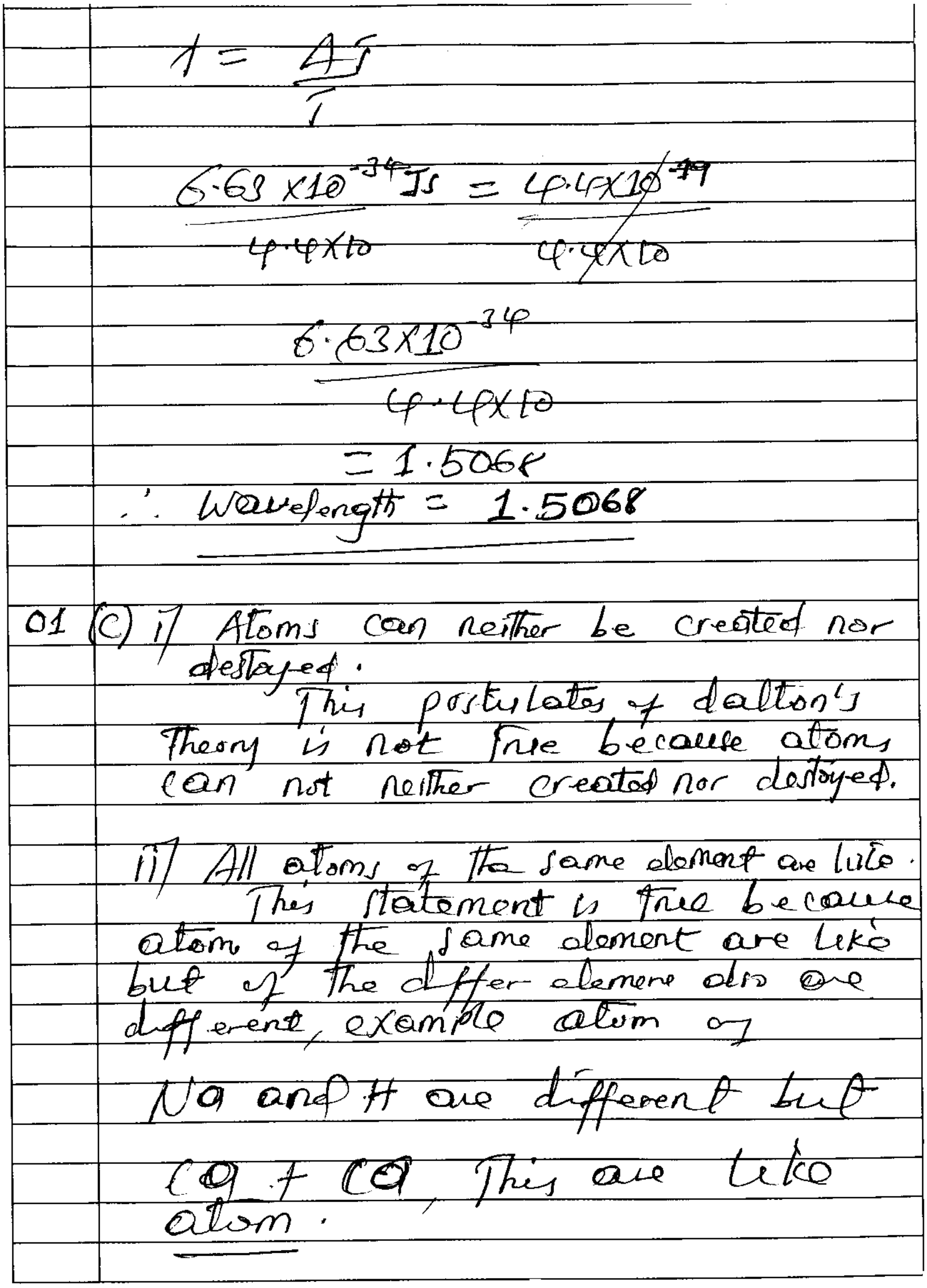
wavelength = ?

wave number = ?

Soln

from

wave length = $\frac{AT}{\text{Time taken}}$



$$\lambda = \frac{AJ}{f}$$

$$\frac{6.63\times10^{-34}Js}{4.4\times10} = \cancel{\frac{4.4\times10^{-49}}{4.4\times10}}$$

$$\frac{6.63\times10^{-34}}{4.4\times10}$$

$$= 1.5068$$

∴ Wavelength = 1.5068

01 (c) i/ Atoms can neither be created nor destroyed.

This postulates of dalton's Theory is not true because atoms can not neither created nor destroyed.

ii/ All atoms of the same element are like.

This statement is true because atom of the same element are like but of the differ element also are different, example atom of

Na and H are different but

Cl + Cl, This are like atom.

In Extract 1.2 the candidate mentioned ideas pertaining to Dalton's atomic theory instead of Bohr's atomic model in part (a). He/she used an incorrect formula in part (b) and supported the postulate in (c)(ii) instead of condemning it.

2.1.2 Question 2: Gases

This question had four parts; (a), (b), (c) and (d). In part (a), the candidates were required to state Boyle's, Charles', Avogadro's laws, Dalton's law of partial pressure and Graham's law of diffusion. In part (b) (i), the candidates were given the information that "A certain amount of a gas was found to occupy 100 cm^3 at 33 $^\circ C$ and 97×10^3 N m^{-2}". They were then required to calculate the volume of the gas at standard temperature and pressure. In part (b) (ii), the candidates were given the information that "At 1.0 atmosphere pressure and 30 $^\circ C$, 1.236 g of a gas was found to occupy a volume of 512 cm^3", from which they were required to calculate the relative molecular mass of the gas by showing clearly the manipulations of units. In part (c), candidates were required to write an expression for the compressibility factor Z of a gas and show the values of Z when a real gas behaves ideally and when it deviates both positively and negatively from ideality. Part (d) required candidates to calculate the molecular mass (in two decimal places) of a gas which was found to diffuse through a porous material 1.49 times faster than chlorine gas.

This question was attempted by 96.8 percent of the candidates of which 50.1 percent scored 6.0 - 10 marks, 40.1 percent scored 3.5 - 5.5 marks and 9.8 percent scored 0 - 3.0 marks. The performance in this question is as shown in Figure 2.

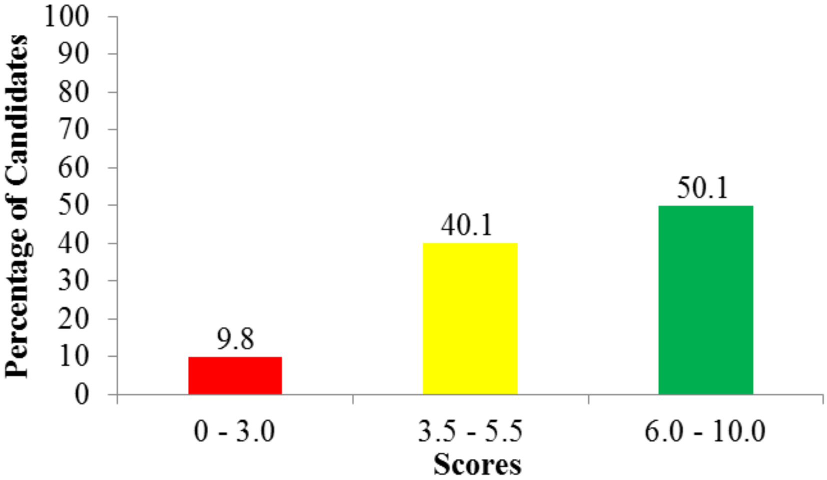
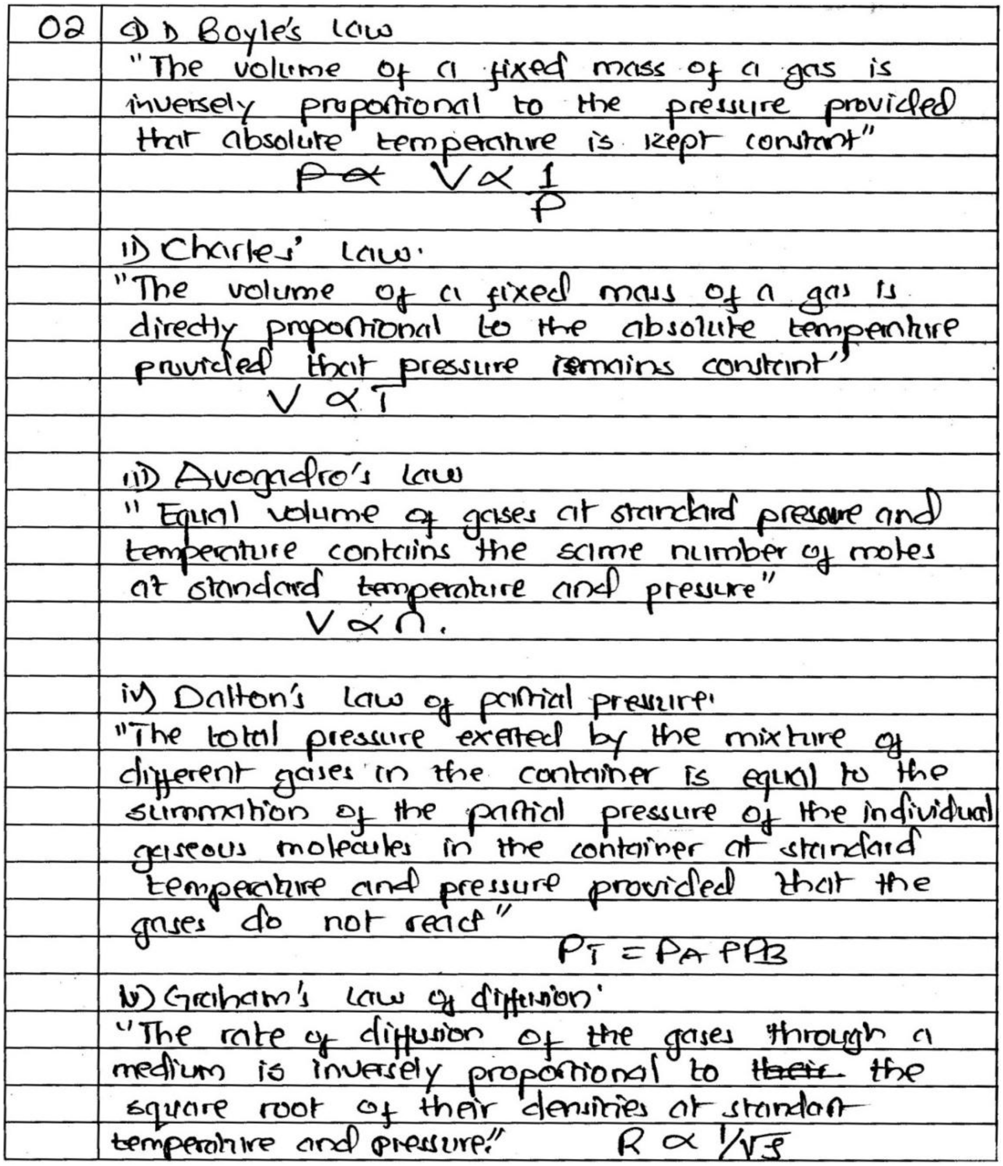


Figure 2: *Performance of the candidates in question 2.*

Figure 2 shows that 90.2 percent of the candidates scored 3.5 marks or above, indicating that the general performance in this question was good.

Candidates who performed good in this question were able to state the required gas laws in part (a) clearly. The candidates computed the volume of the gas and calculated the relative molecular mass plausibly using the proper formulae in part (b) (i) and (ii). The expression and values of the compressibility factor Z were properly presented by candidates in this category as well. Only few candidates managed to calculate correctly the value of molecular mass of the gas in part (d). Extract 2.1 portrays a sample of good responses from one of the candidates in this question.

Extract 2.1



02 (a) i) Boyle's law
"The volume of a fixed mass of a gas is
inversely proportional to the pressure provided
that absolute temperature is kept constant"
~~$P \propto$~~ $V \propto \frac{1}{P}$

ii) Charles' law.
"The volume of a fixed mass of a gas is
directly proportional to the absolute temperature
provided that pressure remains constant"
$V \propto T$

iii) Avogadro's law
" Equal volume of gases at standard pressure and
temperature contains the same number of moles
at standard temperature and pressure"
$V \propto n$.

iv) Dalton's law of partial pressure.
"The total pressure exerted by the mixture of
different gases in the container is equal to the
summation of the partial pressure of the individual
gaseous molecules in the container at standard
temperature and pressure provided that the
gases do not react"
$P_T = P_A + P_B$

v) Graham's law of diffusion.
"The rate of diffusion of the gases through a
medium is inversely proportional to ~~their~~ the
square root of their densities at standard
temperature and pressure." $R \propto 1/\sqrt{\rho}$

02 b) i) soln.

Data; Initial volume $(V_1) = 100\,cm^3$

Initial temperature $(T_1) = 33^\circ c = 306K$

Initial pressure $(P_1) = 97 \times 10^3 N/m^2$

~~final te~~

standard temperature $(T_2) = 273K$

standard pressure $(P_2) = 101.3 \times 10^3 N/m^2$

Standard volume $(V_2) = ?$

From the General gas equation'

$$\frac{PV}{T} = \text{constant} = K.$$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$V_2 = \frac{P_1V_1T_2}{P_2T_1}$$

$$V_2 = \frac{97 \times 10^3 \cancel{N/m^2} \times 100cm^3 \times 273\cancel{K}}{101.3 \times 10^3 \cancel{N/m^2} \times 306\cancel{K}}$$

$$V_2 = 85.43\,cm^3$$

∴ The volume of a gas at standard temperature and pressure is $85.43cm^3$

02 c)i) Compressibility factor used to determine ideality or non-ideality of real gases is ~~de~~ given by the expression

$$Z = \frac{PV}{nRT}$$

where; P = Pressure of a gas
V = volume of a gas
n = number of moles of a gas
T = Absolute temperature.
R = Universal molar gas constant

ii) A real gas shows ideal behaviour when the value of compressibility (Z) is equal to one

ie $Z = 1$ ideal gas

ie, $$Z = \frac{PV}{nRT}$$

when $z = 1.$

$$1 = \frac{PV}{nRT}$$

$$PV = nRT$$

A real gas shows positive deviation when the value of compressibility (Z) is greater than one.

$Z > 1$

$\frac{PV}{nRT} = Z > 1$ positive deviated real gas.

02 (b) ii) A real gas shows negative deviation when compressibility factor (z) is less than one

$Z < 1$

$\frac{PV}{nRT} = z < 1$ negative deviated gas

d) <u>soln.</u>

Data:

Rate of diffusion of a gas $= R_G$

Rate of diffusion of chlorine gas $= R_{Cl_2}$.

But Given that:

$R_G = 1.49\, R_{Cl_2}$.

From Graham's law of diffusion:

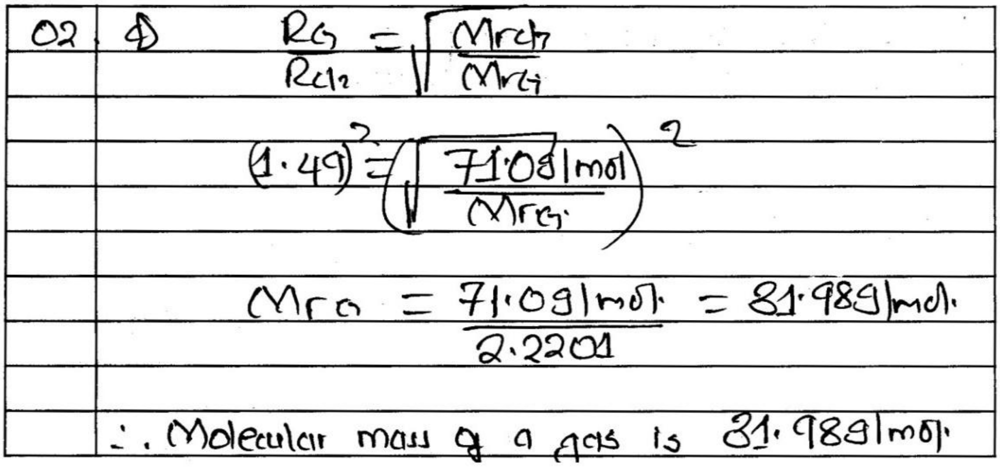
$$R_G = \frac{K}{\sqrt{\rho_G}}$$

$$R_{Cl_2} = \frac{K}{\sqrt{Cl_2}}.$$

$$\frac{R_G}{R_{Cl_2}} = \left(\frac{K}{\sqrt{\rho_G}}\right)\left(\frac{\sqrt{\rho_{Cl_2}}}{K}\right) = \sqrt{\frac{\rho_{Cl_2}}{\rho_G}}.$$

But: from ideal gas equation $\rho \propto Mr$

then, $\frac{R_G}{R_{Cl_2}} = \sqrt{\frac{Mr_{Cl_2}}{Mr_G}}$



02 d) $\frac{R_G}{R_{Cl_2}} = \sqrt{\frac{Mr_{Cl_2}}{Mr_G}}$

$(1.49)^2 = \left(\sqrt{\frac{71.0g/mol}{Mr_G}}\right)^2$

$Mr_G = \frac{71.0g/mol}{2.2201} = 31.98g/mol$

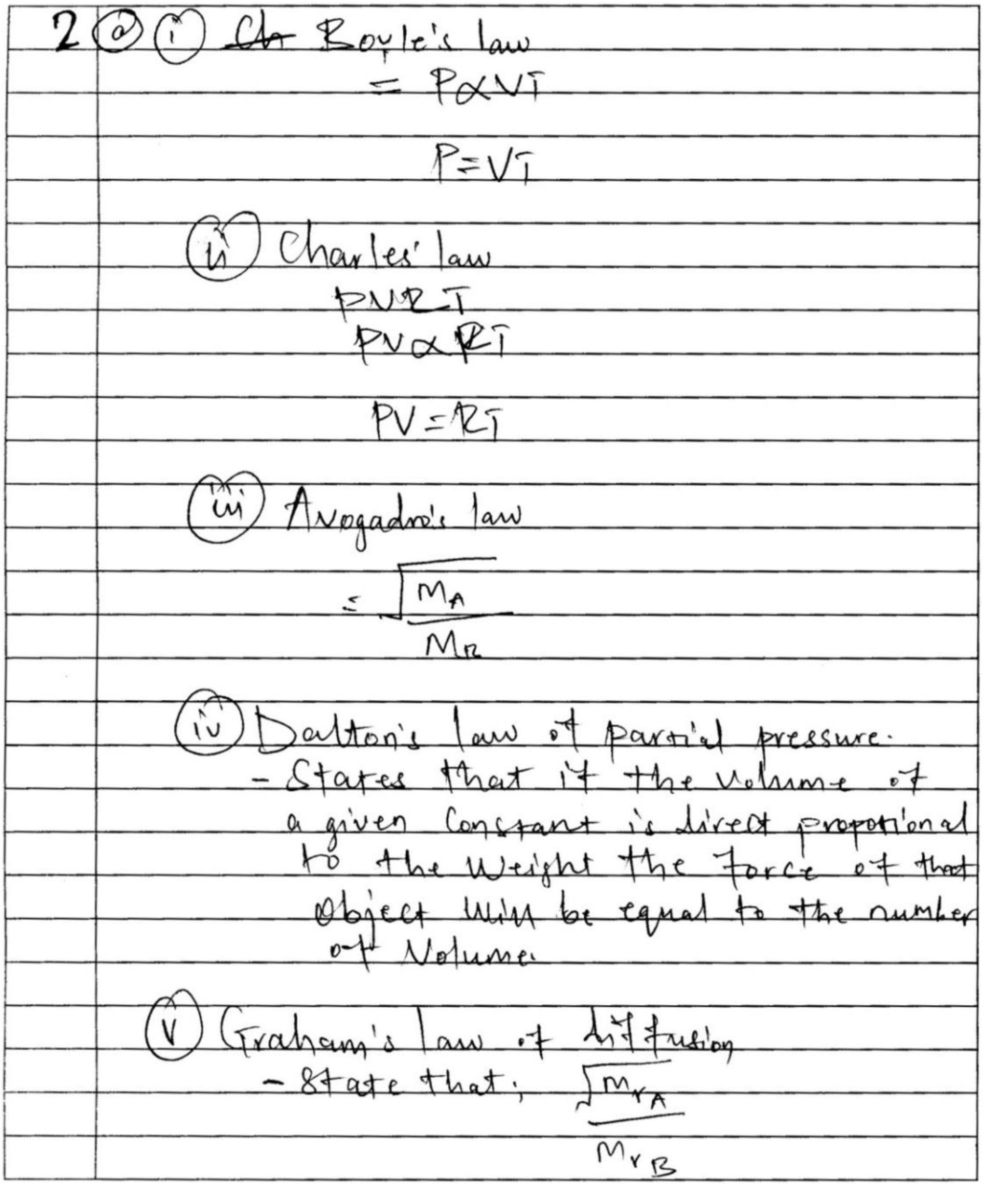
∴ Molecular mass of a gas is 31.98g/mol.

In Extract 2.1 the candidate stated the required gas laws supported with proper mathematical expressions, stated correctly the values of constant Z and used proper formulae to calculate the required parameters.

On the other hand, some candidates who scored low marks interchanged between Boyle's law and Charles' law while others interchanged between Dalton's law of partial pressure and Graham's law of diffusion. Some of them failed to calculate the volume of the gas at standard temperature and pressure because they could not apply the correct formula. Few of them could hardly give values of the compressibility factor to satisfy the stated conditions. This shows that the candidates were not familiar with the mathematical relationship between parameters related to gases. They also showed little understanding regarding gas laws. Many candidates in this category incorrectly substituted data in the formula and thus got wrong values for molecular mass of the gas in part (d). Failure of the candidates is due to lack of sufficient knowledge and competence on the behaviour of gases and associated computation skills.

An example of responses which did not meet the requirements of the question is given in Extract 2.2.

Extract 2.2



2 (a) (i) ~~Ch~~ Boyle's law

$= P \propto VT$

$P = VT$

(ii) Charles' law

$PVRT$

$PV \propto RT$

$PV = RT$

(iii) Avogadro's law

$= \sqrt{\frac{M_A}{M_B}}$

(iv) Dalton's law of partial pressure.

- States that if the volume of a given Constant is direct proportional to the Weight the force of that Object will be equal to the number of Volume.

(v) Graham's law of diffusion

- State that; $\sqrt{\frac{M_{r_A}}{M_{r_B}}}$

Extract 2.2 shows responses of a candidate in part (a) who stated the laws using irrelevant mathematical expressions and did not attempt other parts of the question.

2.1.3 Question 3: Gases

This question had three parts; (a), (b) and (c). In part (a), the candidates were required to state the meaning of ideal gas. Part (b) required the candidates to state two postulates of the kinetic molecular theory of gases which are incorrect for real gases. They were also required to express the corresponding corrections and derive the van der Waals' equation. In part (c), the candidates were required to calculate the pressure exerted by 1.00

mole of methane in 250 mL container at 300 K and show clearly the manipulations of units given van der Waals' constants a = 2.253 $(dm^3)^2$ atm mol^{-2} and b = 0.0428 $dm^3 mol^{-1}$.

The question was attempted by 24,439 candidates equivalent to 73.5 percent. The analysis showed that 18.3 percent of the candidates scored 6.0 - 10 marks, 45.8 percent scored 0 - 3.0 marks and 35.9 scored 3.5 - 5.5 marks. Figure 3 summarizes performance of the candidates in question 3.

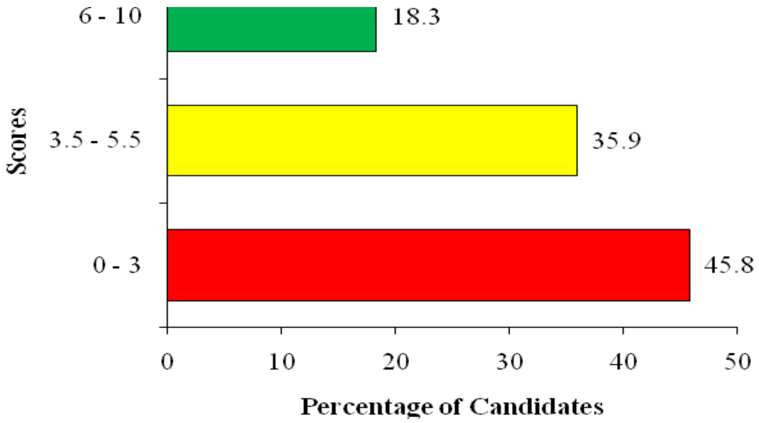
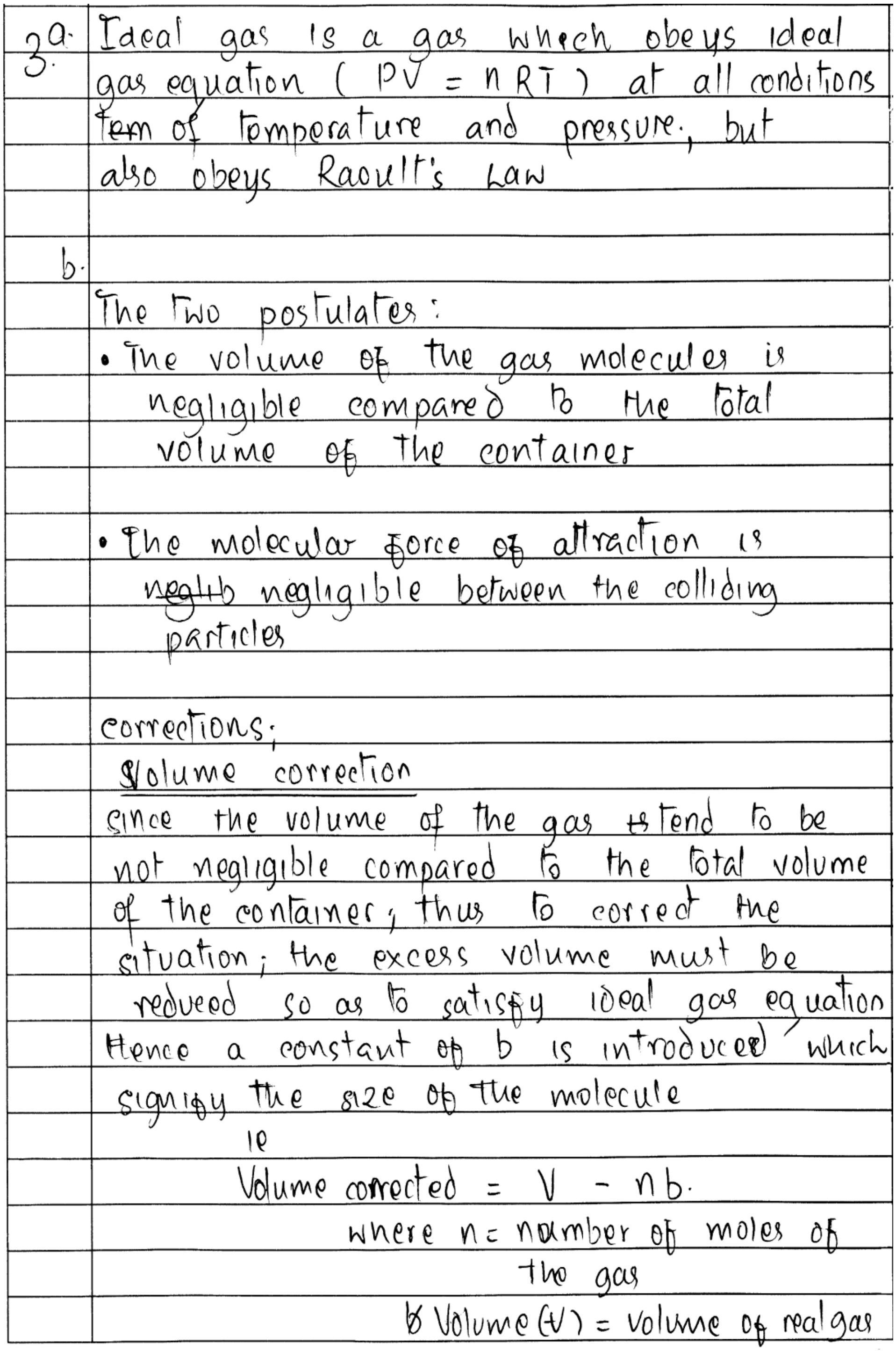


Figure 3: *Performance of the candidates in question 3.*

The statistical analysis showed that the overall performance was average as 54.2 percent of the candidates scored 3.5 marks or above. The candidates who scored high marks gave correct responses to most parts of the question. Extract 3.1 is a good sample from one of the candidates who performed well in this question.

Extract 3.1



3a. Ideal gas is a gas which obeys ideal gas equation ($PV = nRT$) at all conditions ~~tem~~ of temperature and pressure, but also obeys Raoult's Law

b.

The Two postulates:

- The volume of the gas molecules is negligible compared to the total volume of the container
- The molecular force of attraction is ~~neglib~~ negligible between the colliding particles

corrections;

Volume correction

since the volume of the gas ~~is~~ tend to be not negligible compared to the total volume of the container; thus to correct the situation; the excess volume must be reduced so as to satisfy ideal gas equation Hence a constant of b is introduced which signify the size of the molecule

ie

$$\text{Volume corrected} = V - nb.$$

where n = number of moles of the gas

~~b~~ Volume (V) = volume of real gas

Pressure correction

Since the ~~pres~~ intermolecular forces of attraction between molecules is not negligible So; the molecules attacking / colliding with the walls of the container will hit the container with a less pressure than when there were no intermolecular force. So the pressure of the real gas is less than that of ideal and so; to correct it is experimentally done that;

$$P_{corrected} = P + P'$$

where

$$P' \propto \left(\frac{n}{V}\right)^2$$ where n/V = concentration

$$P' = \frac{an^2}{V^2}$$

where a signify the force of attraction of the molecules

So;

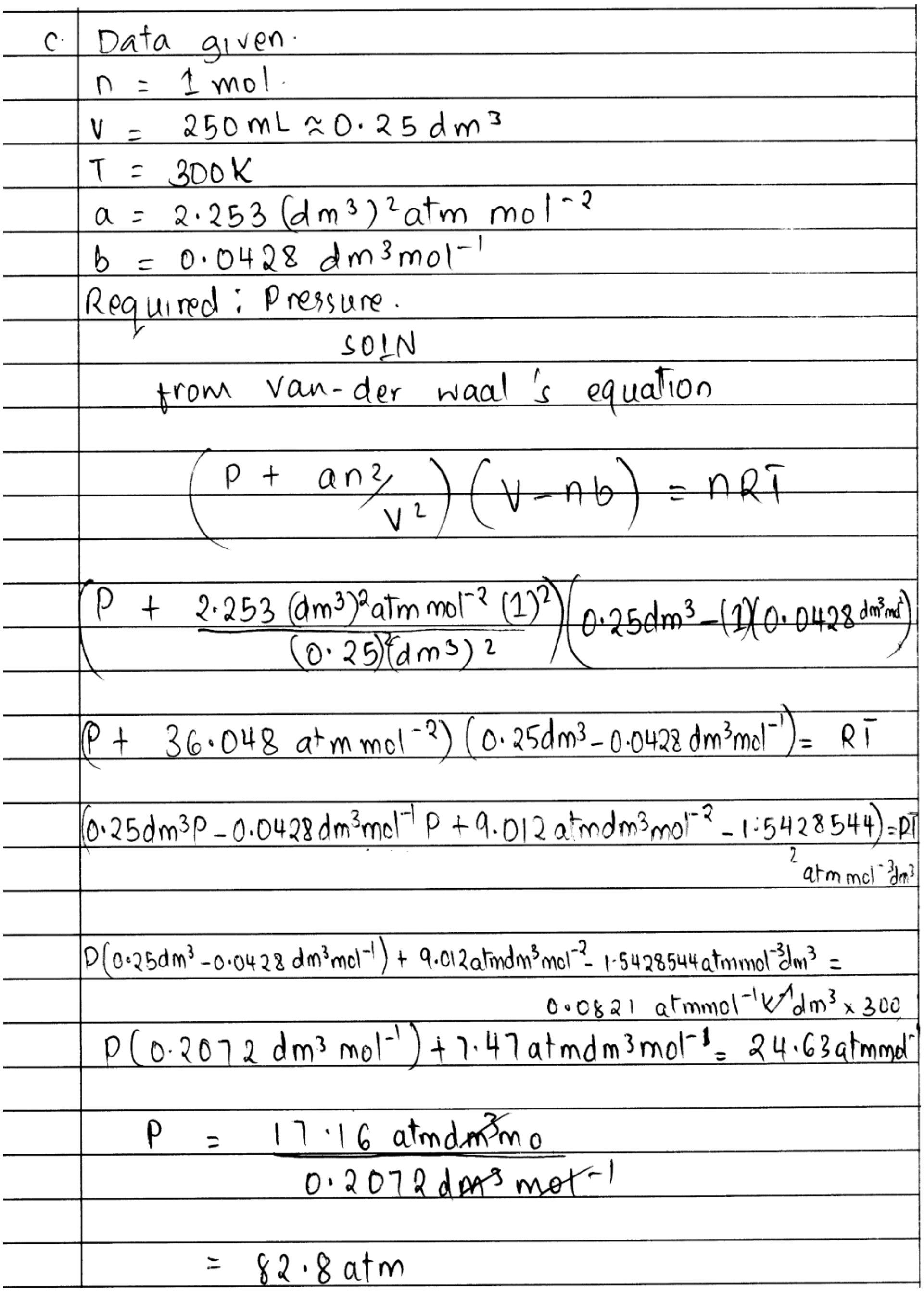
from Ideal gas equation

$$PV = nRT$$

The new one derived, that is, Vander waal's equation is

$$(P_{corrected})(V_{corrected}) = nRT$$

$$\cancel{\left(P + \frac{an^2}{V^2}\right)\left(V - nb\right) = nRT}$$



c. Data given.

$n = 1$ mol.

$V = 250\,mL \approx 0{\cdot}25\,dm^3$

$T = 300K$

$a = 2{\cdot}253\,(dm^3)^2 atm\,mol^{-2}$

$b = 0{\cdot}0428\,dm^3 mol^{-1}$

Required ; Pressure.

SOLN

from van-der waal's equation

$$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$$

$$\left(P + \frac{2{\cdot}253\,(dm^3)^2 atm\,mol^{-2}\,(1)^2}{(0{\cdot}25)^2(dm^3)^2}\right)\left(0{\cdot}25dm^3 - (1)(0{\cdot}0428\,dm^3mol^{-1})\right)$$

$$(P + 36{\cdot}048\,atm\,mol^{-2})(0{\cdot}25dm^3 - 0{\cdot}0428\,dm^3mol^{-1}) = RT$$

$$(0{\cdot}25dm^3P - 0{\cdot}0428\,dm^3mol^{-1}\,P + 9{\cdot}012\,atm\,dm^3mol^{-2} - 1{\cdot}5428544\,{}^{2}atm\,mol^{-3}dm^3) = RT$$

$$P(0{\cdot}25dm^3 - 0{\cdot}0428\,dm^3mol^{-1}) + 9{\cdot}012\,atmdm^3mol^{-2} - 1{\cdot}5428544\,atmmol^{-3}dm^3 = 0{\cdot}0821\,atmmol^{-1}K^{-1}dm^3 \times 300$$

$$P(0{\cdot}2072\,dm^3\,mol^{-1}) + 7{\cdot}47\,atmdm^3mol^{-1} = 24{\cdot}63\,atmmol^{-1}$$

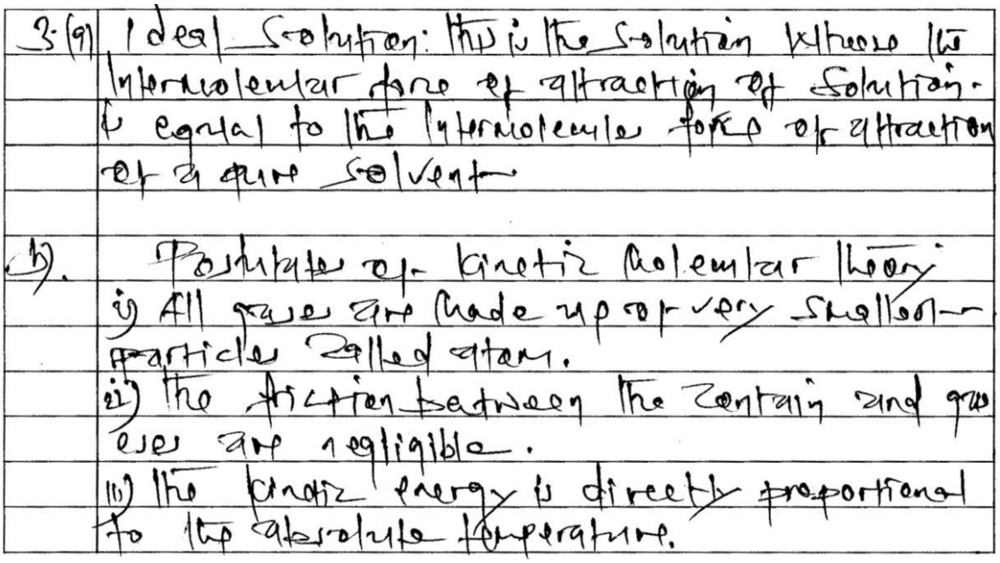
$$P = \frac{17{\cdot}16\,atmd\cancel{m^3}mo}{0{\cdot}2072\,d\cancel{m^3}\,\cancel{mol^{-1}}}$$

$$= 82{\cdot}8\,atm$$

Extract 3.1 shows responses from a candidate who gave a correct definition of an ideal gas, stated two correct postulates and derived the van der Waals' equation accordingly. He/she computed the value of pressure clearly using the van der Waals' equation and manipulated the units correctly.

Most of the candidates who scored low marks in this question gave the meaning of a real gas instead of an ideal gas. Most of them failed to state two postulates of the kinetic molecular theory of gases which are not applicable for real gases. They wrote postulates of the kinetic theory of gases which apply for real gases. Moreover, majority of them could neither give the required corrections in pressure and volume nor derive the van der Waals' equation for real gases. As a result, they failed to calculate the value of pressure in part (d). Similarly, it was observed that some candidates failed to convert units of volume from cubic centimeter into cubic decimeter as a prerequisite to use the van der Waals' equation. For example one candidate converted 250 mL into $2.5\times10^{3}\cdot dm^{3}$ instead of $2.5\times10^{-3}\cdot dm^{3}$, hence the candidate obtained an incorrect value of pressure. Other candidates were able to carry out the conversion, but substituted the values in wrongly written van der Waals' equation. An example of poor responses for part (a) and (b) is shown in Extract 3.2.

Extract 3.2



3. (a) Ideal Solution: this is the solution where the
Intermolecular force of attraction of Solution.
is equal to the Intermolecular force of attraction
of a pure solvent

(b). Postulates of kinetic molecular theory
i) All gases are made up of very smaller
particles called atom.
ii) the friction between the contain and gas
eses are negligible.
iii) the kinetic energy is directly proportional
to the absolute temperature.

In Extract 3.2, the candidate defined ideal solution instead of ideal gas in part (a) and stated postulates which were contrary to the requirement of the question in part (b).

2.1.4 Question 4: Two Components Liquid System

The question had two parts; (a) and (b). In part (a), the candidates were provided with the information that "Nitric acid (T_b = 87 °C) and water form a constant boiling mixture of T_b = 122 °C and composition of 65 % by mass nitric acid". They were required to:

(i) draw the boiling temperature-composition curve for nitric acid and water.

(ii) state what is meant by a constant boiling point mixture.

In part (b) the candidates were required to: (i) state Raoult's law, (ii) identify whether the mixture of nitric acid and water show a positive or a negative deviation from Raoult's law, (iii) distinguish positive deviation from negative deviation with reference to Raoult's law. (iv) provide the type of molecular interaction between nitric acid and water giving rise to the deviation identified in (b)(ii).

The question was attempted by 19,838 candidates corresponding to 59.7 percent out of which 20.9 percent scored 6 - 10 marks, 29.8 percent scored 3.5 - 5.5 marks and 46 percent scored 0 - 3.4 marks. Summary of the performance is shown in Figure 4.

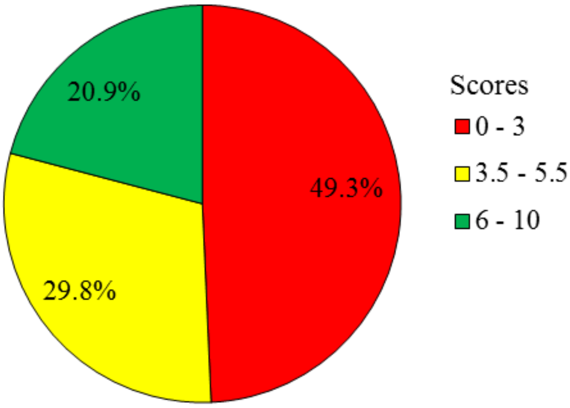


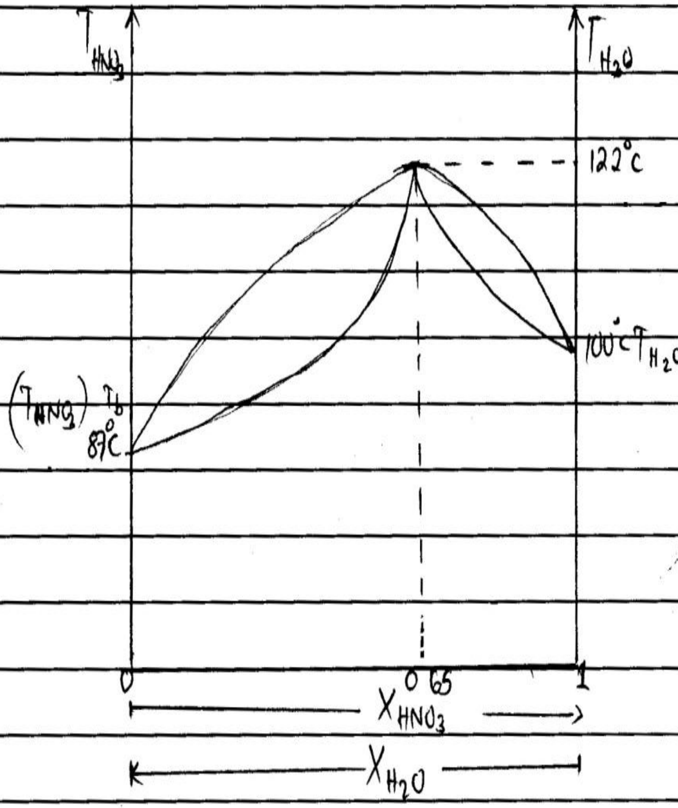
Figure 4: *Performance of the candidates in question 4.*

The overall performance in this question was average as 50.7 percent of the candidates scored 3.5 marks and above.

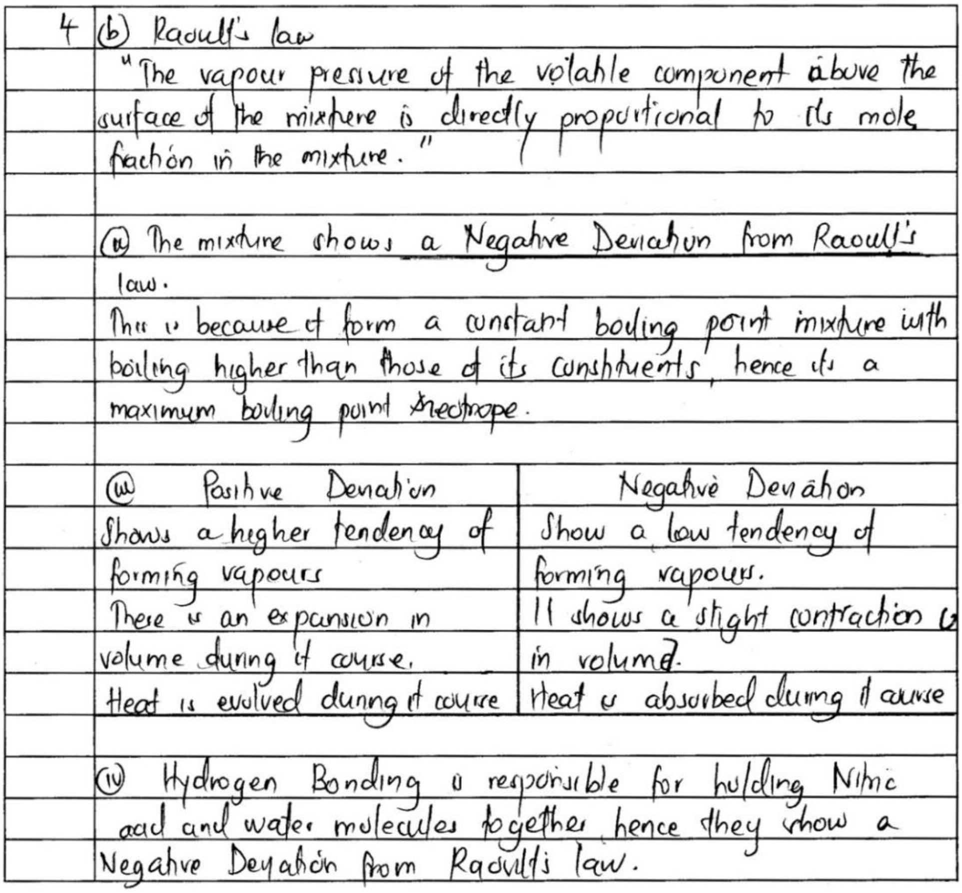
Some of the candidates who scored high marks managed to draw the exact boiling temperature-composition curve and defined “constant boiling point mixture” correctly. This shows that they had good understanding of the graphical representation of the properties of liquid mixtures. In part (b), many candidates stated Raoult's law precisely and some of them applied it correctly to answer the rest of the question. Candidates who managed to get high marks had good knowledge of principles governing properties of solution mixtures. Extract 4.1 is a good response from one of the candidates.

Extract 4.1

4. ⓐ ⓘ Boiling - Temperature Composition Curve



ⓘⓘ Constant Boiling Mixture is also called Azeotropic Mixture. It is a mixture which boils at a constant temperature and the composition of its gas vapours and liquid phase are constant



4 (b) Raoult's law

"The vapour pressure of the volatile component above the surface of the mixture is directly proportional to its mole fraction in the mixture."

(ii) The mixture shows a Negative Deviation from Raoult's law.

This is because it form a constant boiling point mixture with boiling higher than those of its constituents, hence its a maximum boiling point azeotrope.

(iii) Positive Deviation	Negative Deviation
Shows a higher tendency of forming vapours	Show a low tendency of forming vapours.
There is an expansion in volume during it course.	It shows a slight contraction in volume.
Heat is evolved during it course	Heat is absorbed during it course

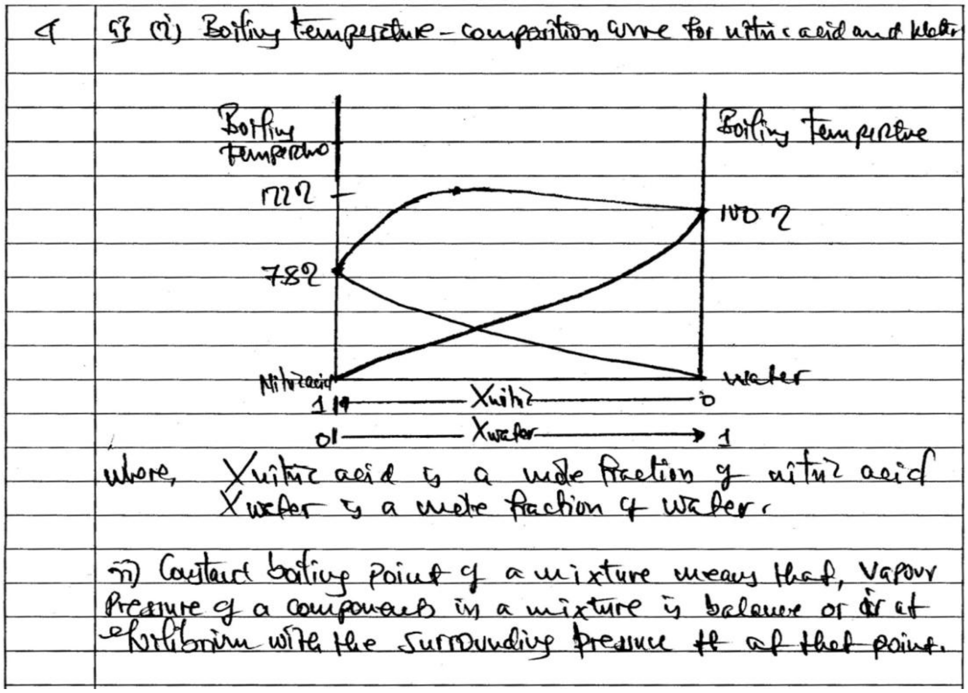
(iv) Hydrogen Bonding is responsible for holding Nitric acid and water molecules together hence they show a Negative Deviation from Raoult's law.

In Extract 4.1, the candidate correctly sketched the boiling temperature-composition curve in part (a), stated Raoult's law appropriately and gave appropriate responses to the rest of the items in part (b).

The analysis of the responses from candidates who scored low marks revealed that the candidates had insufficient knowledge about the tested concepts. Some of them drew the vapour pressure-composition curve of ideal solution instead of sketching the boiling point-composition curve. They also failed to locate 100 °C as the boiling point of water. Such a response is an indication that the candidates had insufficient knowledge regarding non-ideal behaviours.

This group of candidates had improper understanding of the concept of azeotropic mixtures. Most of them failed to locate the composition of 65 % by mass of nitric acid on the boiling temperature-composition curve. Some could not relate the effect of the intermolecular forces of attraction between the two components with the particular deviation from Raoult's law. Extract 4.2 illustrates an example of poor responses which were given in part (a) by one of the candidates.

Extract 4.2



4 b) (i) Boiling temperature-composition curve for nitric acid and water

where, X nitric acid is a mole fraction of nitric acid
X water is a mole fraction of water.

ii) Constant boiling point of a mixture means that, vapour pressure of a components in a mixture is balance or ~~ir~~ at equilibrium with the surrounding pressure ~~H~~ at that point.

In Extract 4.2, the candidate sketched a vapour pressure-composition curve instead of a boiling temperature-composition curve in part (a).

2.1.5 Question 5: Chemical Bonding

The question consisted of three parts; (a), (b) and (c). In part (a)(i) - (vi), the candidates were required to classify compounds HCl(g), NaCl(s), NCl_3, methane, tetrachloromethane and CO_2 as to whether ionic, polar covalent or covalent. In part (b)(i) - (iii), the candidates were asked to show from the electronic configuration, the type of hybrid orbital of the underlined atom and draw the geometry of the corresponding molecule in each of the following compounds:

(i) $\underline{Be}Cl_2$
(ii) $\underline{C}Cl_4$
(iii) $\underline{C}_2F_4$

Part (c) had two sub-parts whereby the candidates were asked to study the information given in the following table:

Name	Molecular weight	Boiling point, ^oC
Diethyl ether	74	35
n-butyl alcohol	74	118
Propionamide	73	213

In part (c)(i), the candidates were asked to account for the high boiling point of *n*-butyl alcohol compared to diethyl ether although the two compounds have the same molecular weight. Part (c)(ii) required the candidates to account for the low boiling point of *n*-butyl alcohol compared to that of propionamide despite its high molecular weight.

A total of 11,266 candidates equivalent to 33.9 percent attempted the question, out of which 39 percent scored 3.5 - 5.5 marks, 46 percent scored 0 - 3.0 marks and 15 percent scored 6.0 - 10 marks. Figure 5 shows the distribution of the candidates' scores.

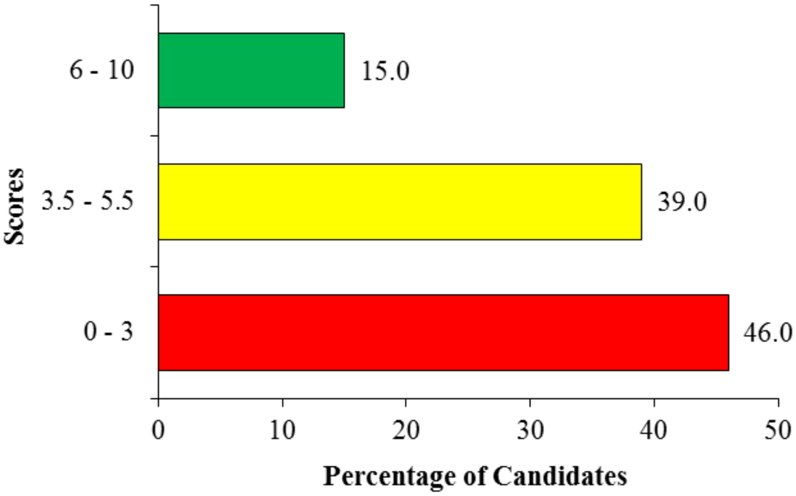
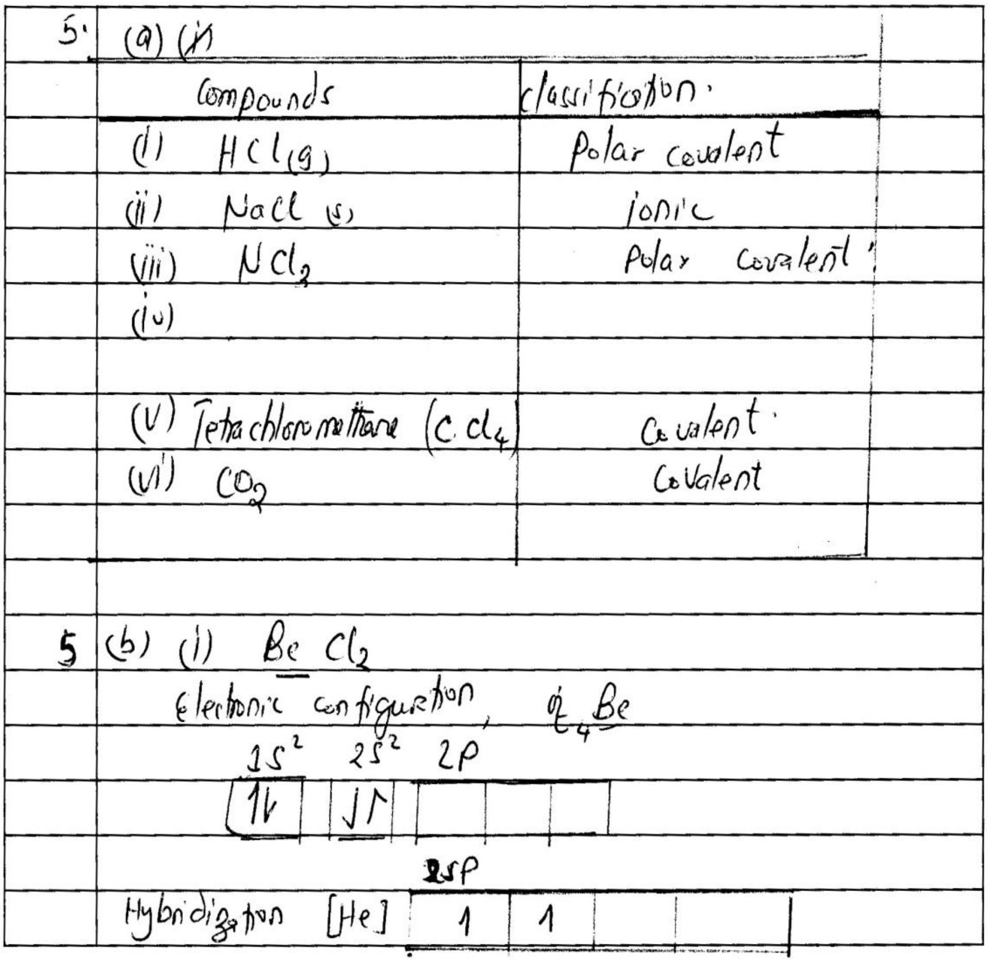


Figure 5: *Performance of the candidates in question 5.*

Figure 5 shows that 54 percent of the candidates scored 3.5 - 10 marks indicating an average performance in this question. Most of the candidates who scored high marks were able to classify the compounds stated in part (a) correctly. Most of them gave precise electronic configurations of atoms, hybridization of orbitals and displayed correct geometry of the molecules in part (b). This indicated that the candidates had good understanding of the concept of electronic configuration and hybridization of atomic orbitals. The few candidates who managed to answer part (c), gave relevant explanations regarding the differences in boiling points due to hydrogen bonding. Extract 5.1 displays an example of a good response from a candidate who scored high marks. However, he/she failed to identify the polar covalent bond in CCl_4 and stated the type of hybrid orbitals of carbon in C_2F_4 incorrectly.

Extract 5.1



5. (a) ~~(i)~~

Compounds	classification.
(i) $HCl_{(g)}$	Polar covalent
(ii) $NaCl_{(s)}$	ionic
(iii) NCl_3	Polar covalent
(iv)	
(v) Tetrachloromethane (CCl_4)	Covalent.
(vi) CO_2	Covalent

5 (b) (i) $BeCl_2$

electronic configuration, of $_4Be$ =

$1s^2$ $2s^2$ $2p$

↑↓	↓↑			

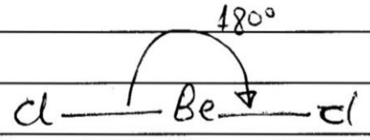
sp

Hybridization [He]	↑	↑		

3 (b) (i)

Type of hybrid orbital is $\underline{sp}$

Geometrical shape is Linear



(ii) $\underline{C}Cl_4$

Electronic configuration of ${}_6C$

${}_6C = [He]\ 2s^2\ 2p$

$\boxed{\downarrow\uparrow}$ $\boxed{1}\boxed{1}\boxed{\ }$

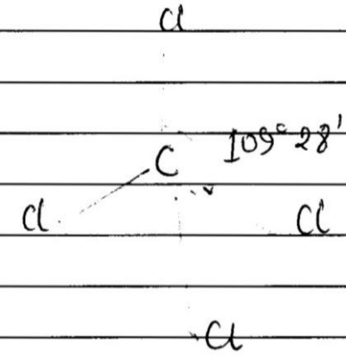
Upon hybridization

${}_6C = [He]\ 2sp^3$

$\boxed{1}\boxed{1}\boxed{1}\boxed{1}$

Type of hybrid orbital is $\underline{sp^3}$

Geometrical shape is Tetrahedral.

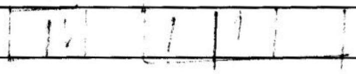


5 (b) (iii) C_2F_4

~~Hy~~

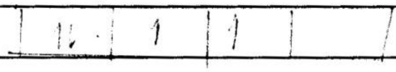
Electronic configuration of $_6C$

$_6C = [He]$ 2s 2P

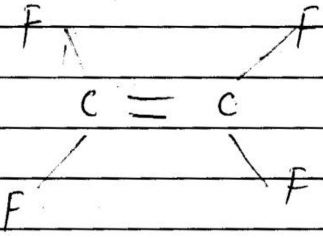


Hybridized:

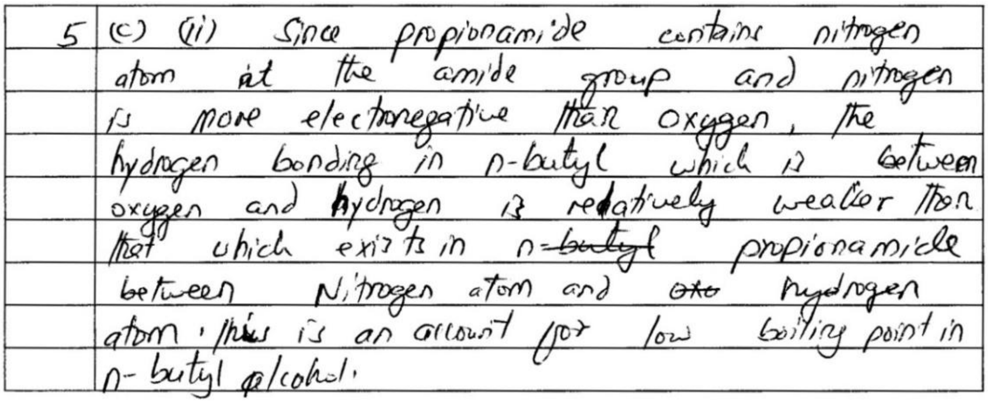
$_6C = [He]$ sP^2



Type of hybrid orbital is sP^2



(C)(i) The high boiling point of n-butyl is due to hydrogen bonding between Oxygen atom and hydrogen atom in -OH group. But in Diethyl ether hydrogen bonding doe not exist since the oxygen atom is bonded to two carbon atoms which are less ~~electro~~ electronegative.



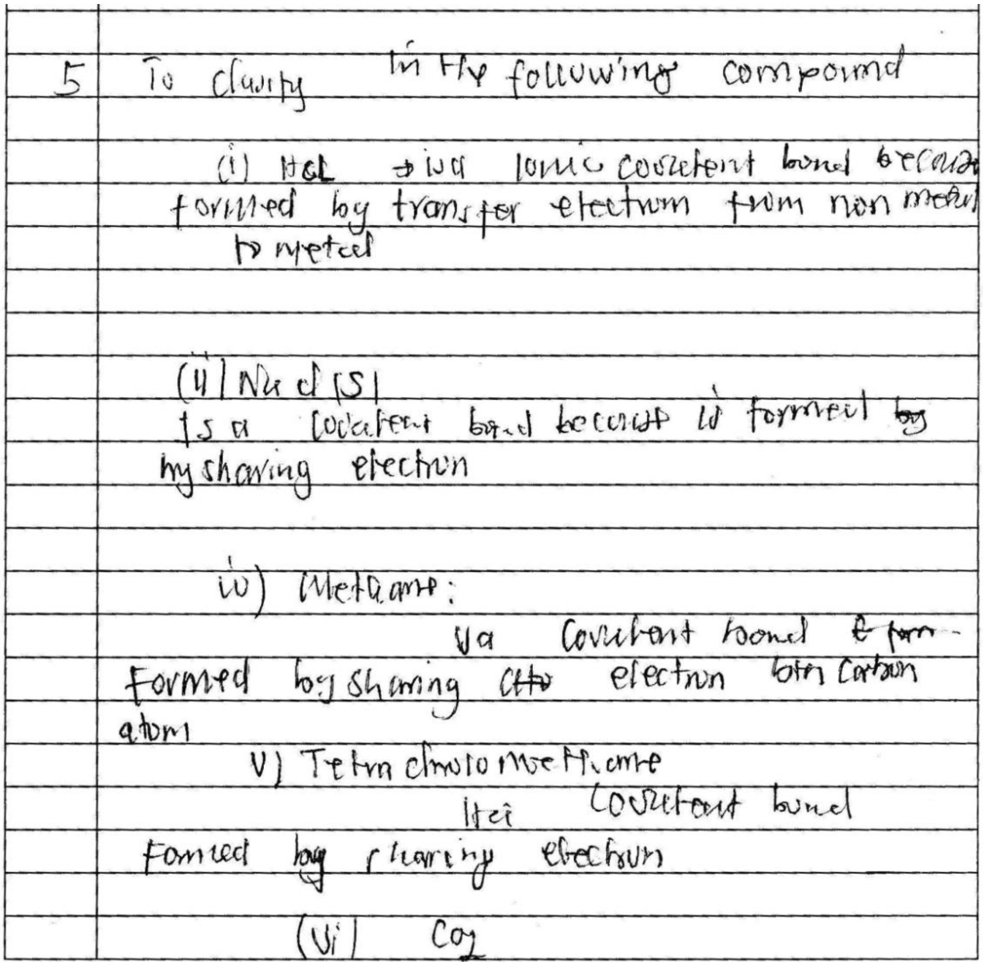
5 (c) (ii) Since propionamide contains nitrogen atom at the amide group and nitrogen is more electronegative than oxygen, the hydrogen bonding in n-butyl which is between oxygen and hydrogen is relatively weaker than that which exists in n-~~butyl~~ propionamide between Nitrogen atom and ~~oxo~~ hydrogen atom. This is an account for low boiling point in n-butyl alcohol.

In Extract 5.1, the candidate clearly classified most of the compounds in part (a) and followed a correct approach to attain the geometry of the molecules in part (b). In part (c), he/she referred correctly to the concept of hydrogen bonding to account for the stated observation.

Some of the candidates who scored low marks were unable to differentiate between normal covalent bond and polar covalent bond hence, failed to classify the given compounds as ionic, polar covalent or covalent. This indicated that the candidates had insufficient knowledge to apply the concept of electronegativity in determining types of bonds. Most of them were unable to show the electronic configuration, the type of hybrid orbital of the underlined atom and failed to draw the geometry corresponding to the compounds $\underline{\mathrm{Be}}\mathrm{Cl}_2$, $\underline{\mathrm{C}}\mathrm{Cl}_4$, and $\underline{\mathrm{C}}_2\mathrm{F}_4$. It is only few candidates in this category who managed to give correct electronic configurations. This indicates that the candidates had inadequate knowledge to apply the concept of hybridization in relation to the shapes of covalent molecules.

Furthermore, the candidates failed to account for the high boiling point of *n*-butyl alcohol compared to diethylether and were unable to account for the low boiling point of *n*-butyl alcohol compared to propionamide. This implies that the candidates had little understanding about the conditions necessary for hydrogen bond formation and its effects on boiling point. Most of them also failed to realize the effect of molecular mass on the boiling point in part (c). Extract 5.2. shows a portion of incorrect responses from one of the candidates.

Extract 5.2



5 To clasify In the following compound

(i) HCL → is a Ionic covalent bond because formed by transfer electrum from non metal to metel

(ii) NaCl(S) is a covalent bond because it formed by by sharing electron

iii) Methane: is a covalent bond & form- formed by sharing ~~CH~~ electron btn Carbon atom

V) Tetrachloromethane Itei covalent bond formed by sharing electrun

(vi) Co_2

In Extract 5.2 the candidate classified some of the compounds in part (a) incorrectly and supported the answers with irrelevant reasons.

2.1.6 Question 6: Energetics

This question had four parts; (a), (b), (c) and (d). In part (a), the candidates were asked to briefly give the meaning of the following phrases as used in chemical energetics: (i) heat of solution, (ii) spontaneous reaction, (iii) enthalpy of sublimation and (iv) endothermic reaction. Part (b) required the candidates to compare bond strengths of reactants and products during chemical reactions in case the overall reaction is: (i) exothermic and (ii) endothermic. Part (c) required the candidates to state the type of enthalpies in each of the following equations:

(i) $KOH(aq) + HCl(aq) \longrightarrow KCl(aq) + H_2O(l) \quad \Delta H^\circ = -57\ kJ\ mol^{-1}$

(ii) $H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(l) \quad \Delta H^\circ = -286\ kJ\ mol^{-1}$

(iii) $\frac{1}{2}H_2(g) + \frac{1}{2}Cl_2(g) + (aq) \longrightarrow HCl(aq) \quad \Delta H^\circ = -164\ kJ\ mol^{-1}$

(iv) $Cl(g) + e^- \longrightarrow Cl^-(g) \quad \Delta H^\circ = -347\ kJ\ mol^{-1}$

In part (d), the candidates were provided with the information that:

> *Two liquids, trichloromethane ($CHCl_3$) and ethoxyethane ($CH_3CH_2OCH_2CH_3$), form intermolecular hydrogen bonds when mixed. In a certain experiment, 0.05 moles of trichloromethane and 0.3 moles of ethoxyethane were weighed into the same calorimeter. When the temperature of both liquids had equalized, the liquids were mixed. The temperature increase of 5.4 °C was recorded upon mixing. Assume that the heat capacity of the calorimeter is negligible, while heat capacities of trichloromethane and ethoxyethane are 0.98 Jg^{-1} K^{-1} and 2.28 Jg^{-1} K^{-1}, respectively.*

The candidates were required to calculate: (i) Heat change in the experiment and (ii) Enthalpy change of mixing 1 mole of trichloromethane with excess ethoxyethane by showing the work clearly including manipulations of units. (Given atomic masses were: C = 12, H = 1, O = 16 and Cl = 35.5).

The question was attempted by 15,788 candidates constituting 47.5 percent, out of which 66.7 percent scored 0 - 3.0 marks with 4.7 percent scoring zero mark. Besides, 28.4 percent scored 3.5 - 5.5 marks while 4.9 percent scored 6.0 - 10 marks. The question was among the least attempted questions in the two papers. Performance in this question is shown in Figure 6.

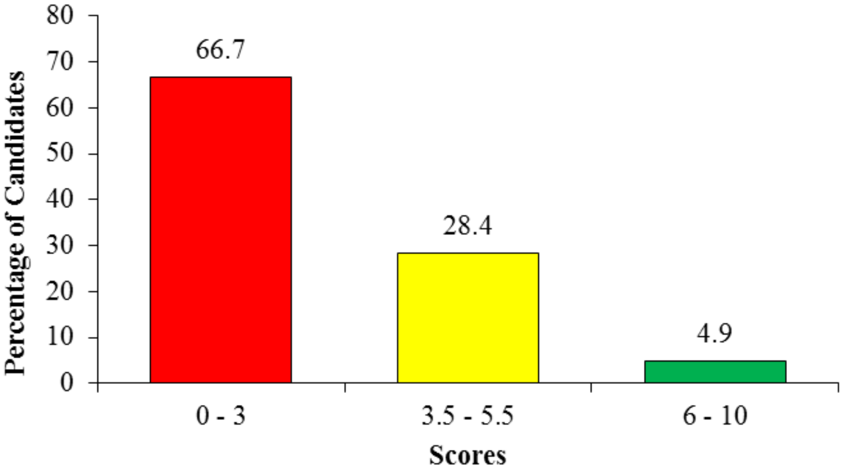
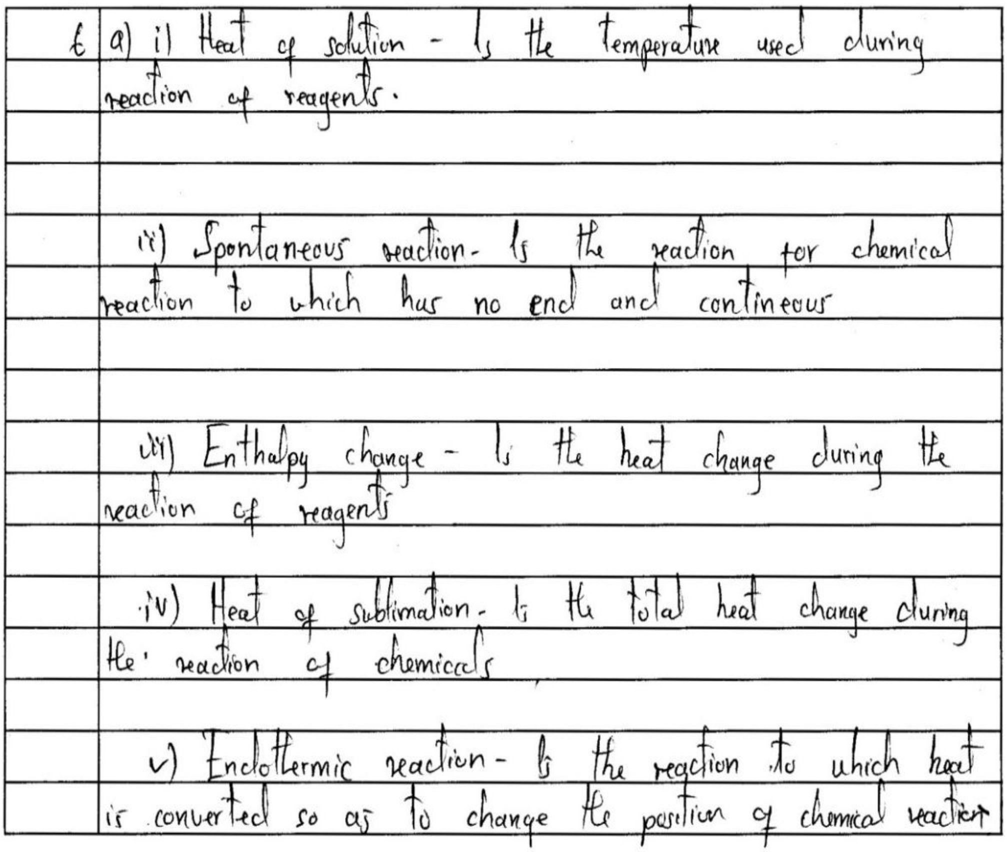


Figure 6: *Performance of the candidates in question 6.*

Figure 6 depicts that the general performance was poor as only 33.3 percent of the candidates scored 3.5 marks or above. In most cases, key words were missing in the definitions given by the candidates who performed poorly in this question. This indicated that the candidates had little understanding of technical terminologies in energetics and to some extent they had poor language proficiency. Likewise, the candidates faced difficulties in comparing the bond strengths in reactants and products both in the case of exothermic and endothermic reactions. This means that the candidates failed to relate the overall energy change with that of the reactants and products during chemical reactions. Most candidates who failed this question lacked ability to integrate the stability of reactants and products into the concept of exothermic or endothermic reactions. Furthermore, most of them lacked knowledge of interpreting formula equations by factor of enthalpy change. In part (d), majority of the candidates failed to compute the values of enthalpy and could not manipulate units properly. The incorrect responses given implies that the candidates lacked competence in both explaining concepts and carrying out computations in energetics. Extract 6.1 illustrates a sample of incorrect responses in this question.

Extract 6.1



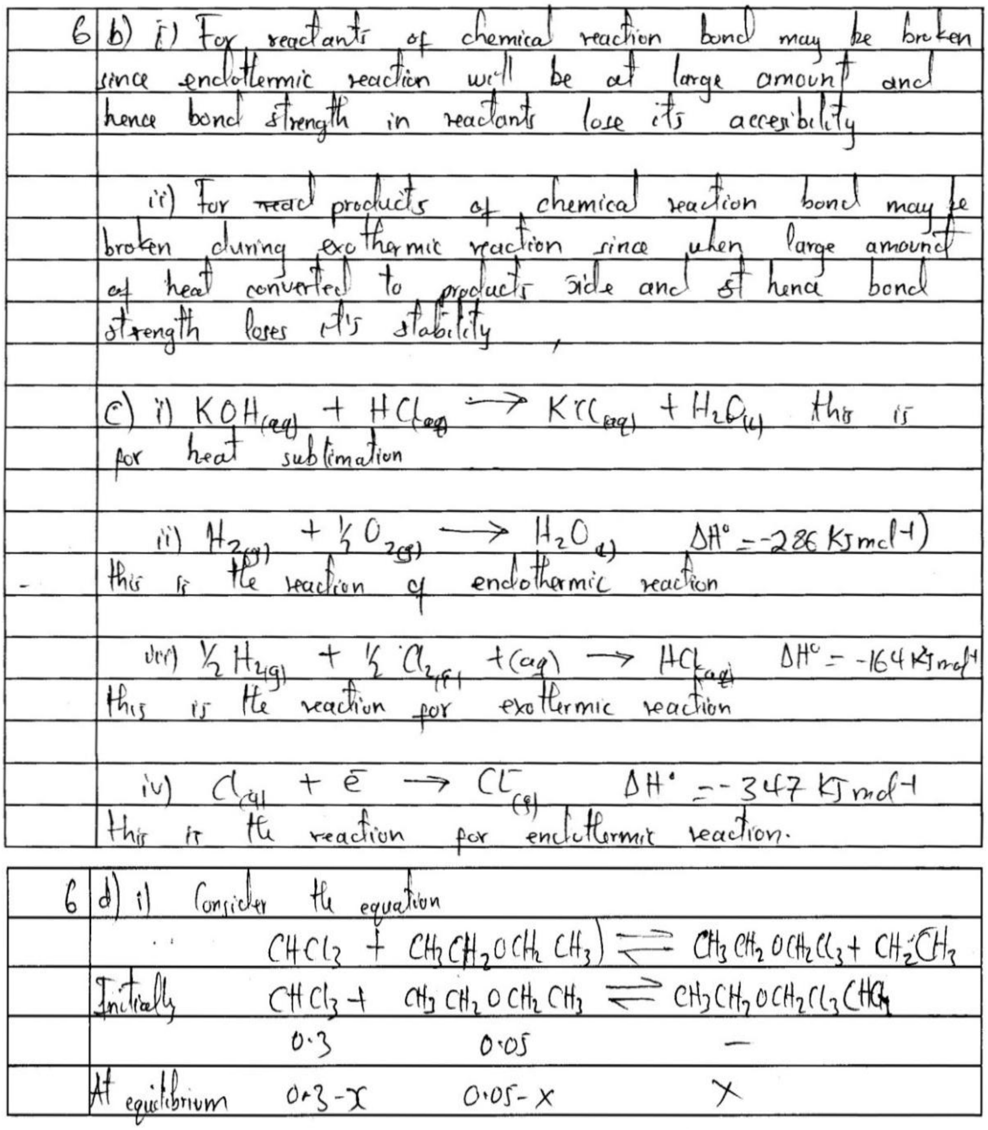
6 a) i) Heat of solution - Is the temperature used during reaction of reagents.

ii) Spontaneous reaction - Is the reaction for chemical reaction to which has no end and contineous

iii) Enthalpy change - Is the heat change during the reaction of reagents

iv) Heat of sublimation - Is the total heat change during the reaction of chemicals

v) Endothermic reaction - Is the reaction to which heat is converted so as to change the position of chemical reaction



6 b) i) For reactants of chemical reaction bond may be broken since endothermic reaction will be at large amount and hence bond strength in reactants lose its accesibility

ii) For ~~read~~ products of chemical reaction bond may be broken during exothermic reaction since when large amount of heat converted to products side and at hence bond strength loses it's stability ,

c) i) $KOH_{(aq)} + HCl_{(aq)} \rightarrow KCl_{(aq)} + H_2O_{(l)}$ this is for heat sublimation

ii) $H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)}$ $\Delta H^\circ = -286\ KJmol^{-1})$ this is the reaction of endothermic reaction

iii) $\frac{1}{2}H_{2(g)} + \frac{1}{2}Cl_{2(g)} + (aq) \rightarrow HCl_{(aq)}$ $\Delta H^\circ = -164\ KJmol^{-1}$ this is the reaction for exothermic reaction

iv) $Cl_{(g)} + e^- \rightarrow Cl^-_{(g)}$ $\Delta H^\circ = -347\ KJmol^{-1}$ this is the reaction for endothermic reaction.

6 d) i) Consider the equation

$CHCl_3 + CH_3CH_2OCH_2CH_3) \rightleftharpoons CH_3CH_2OCH_2Cl_3 + CH_2CH_3$

Initially $CHCl_3 + CH_3CH_2OCH_2CH_3 \rightleftharpoons CH_3CH_2OCH_2Cl_3CHCl$

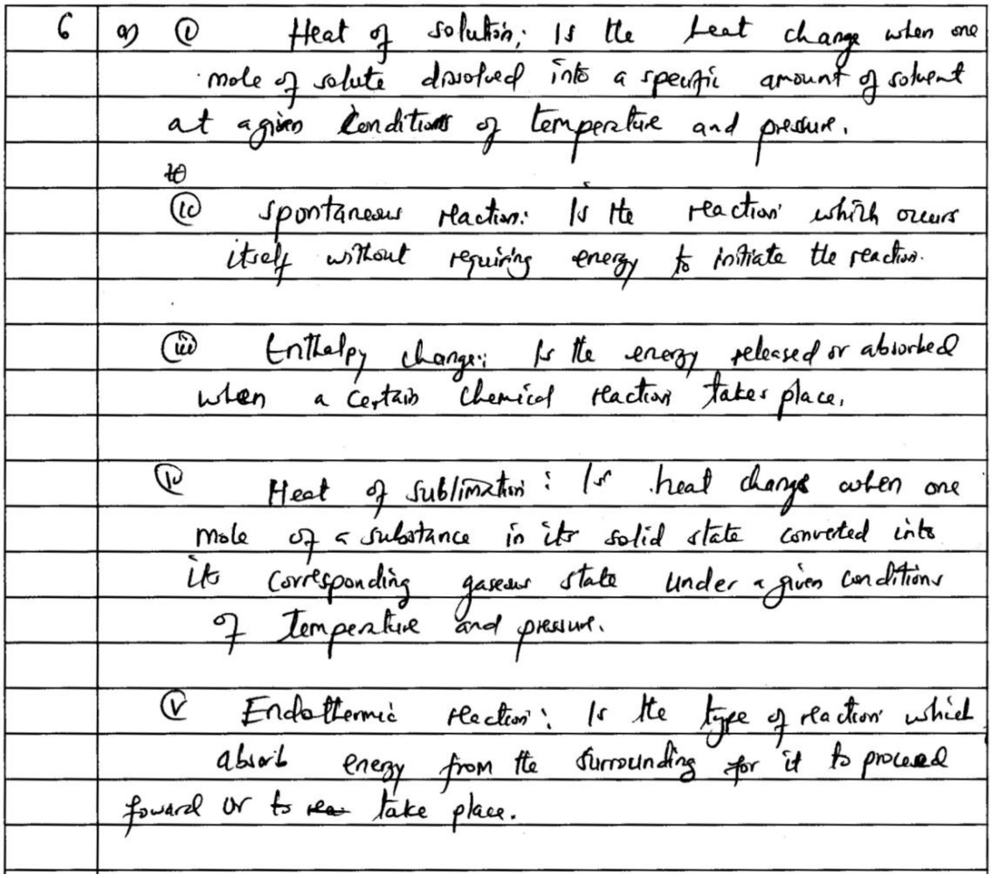
0.3 0.05 —

At equilibrium $0.3 - x$ $0.05 - x$ x

In Extract 6.1, the candidate gave incorrect meaning of the terms, improperly commented on the bond strengths and stated the types of enthalpies incorrectly. He/she incorrectly applied the concept of chemical equilibrium instead of enthalpy change in part (d)(i).

On the other hand, few candidates who scored high marks attempted correctly most parts of the question. However, none of the candidates managed to score full marks in this question. In the same way, some candidates interchanged the explanations for exothermic and endothermic reactions when comparing bond strengths hence they lost some marks. Part (c) was skipped by many candidates in this category. It is obvious that majority of them did not have necessary comprehension ability to make factual interpretation of formula equations specifically those related to energy changes. Extract 6.2 shows a portion of good responses from one of the candidates who attempted this question.

Extract 6.2



6 a) i) Heat of solution; Is the heat change when one mole of solute dissolved into a specific amount of solvent at a given conditions of temperature and pressure.

~~to~~

ii) Spontaneous reaction: Is the reaction which occurs itself without requiring energy to initiate the reaction.

iii) Enthalpy change: Is the energy released or absorbed when a certain chemical reaction takes place,

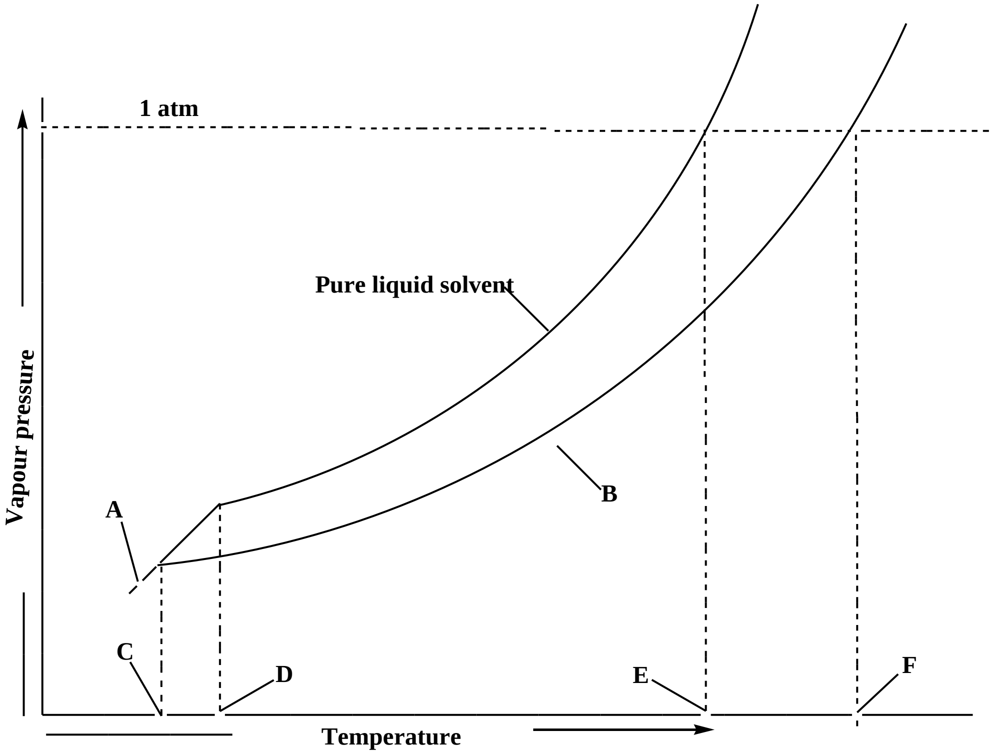
iv) Heat of sublimation: Is heat change when one mole of a substance in its solid state converted into its corresponding gaseous state under a given conditions of temperature and pressure.

v) Endothermic reaction: Is the type of reaction which absorb energy from the surrounding for it to proceed foward or to ~~rea~~ take place.

Extract 6.2 shows that the candidate correctly defined the terms heat of solution, spontaneous reaction, enthalpy change, heat of sublimation and endothermic reaction.

2.1.7 Question 7: Relative Molecular Masses in Solution

This question had three parts; (a), (b) and (c). In part (a), the candidates were asked to state four colligative properties which are useful for determination of molecular masses while in part (b), the candidates were required to study the following diagram:



They were then required to give: (i) the titles of the locations labeled **A**, **B**, **C**, **D**, **E**, **F** and (ii) the names for the difference given by **F** - **E** (i.e **F** minus **E**) and **D** - **C** (i.e **D** minus **C**). Finally in part (c), the candidates were provided with the information that "Ammonium chloride solution was dissolved in pure water to make a 25% solution" and were required to calculate freezing point of the solution given that the molal boiling point constant for NH_4Cl = -1.86 $^{\circ}$C kg mol^{-1}.

This question was attempted by 19,226 candidates (57.8 %) out of which 92.4 percent scored 0 - 3.0 marks, 5.6 percent scored 3.5 - 5.5 marks and only 2.0 percent scored 6.0 - 10 marks. Performance in this question is summarized in Figure 7.

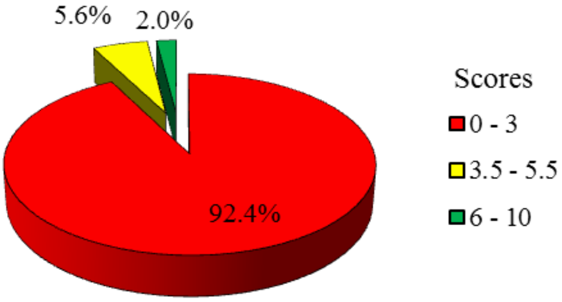
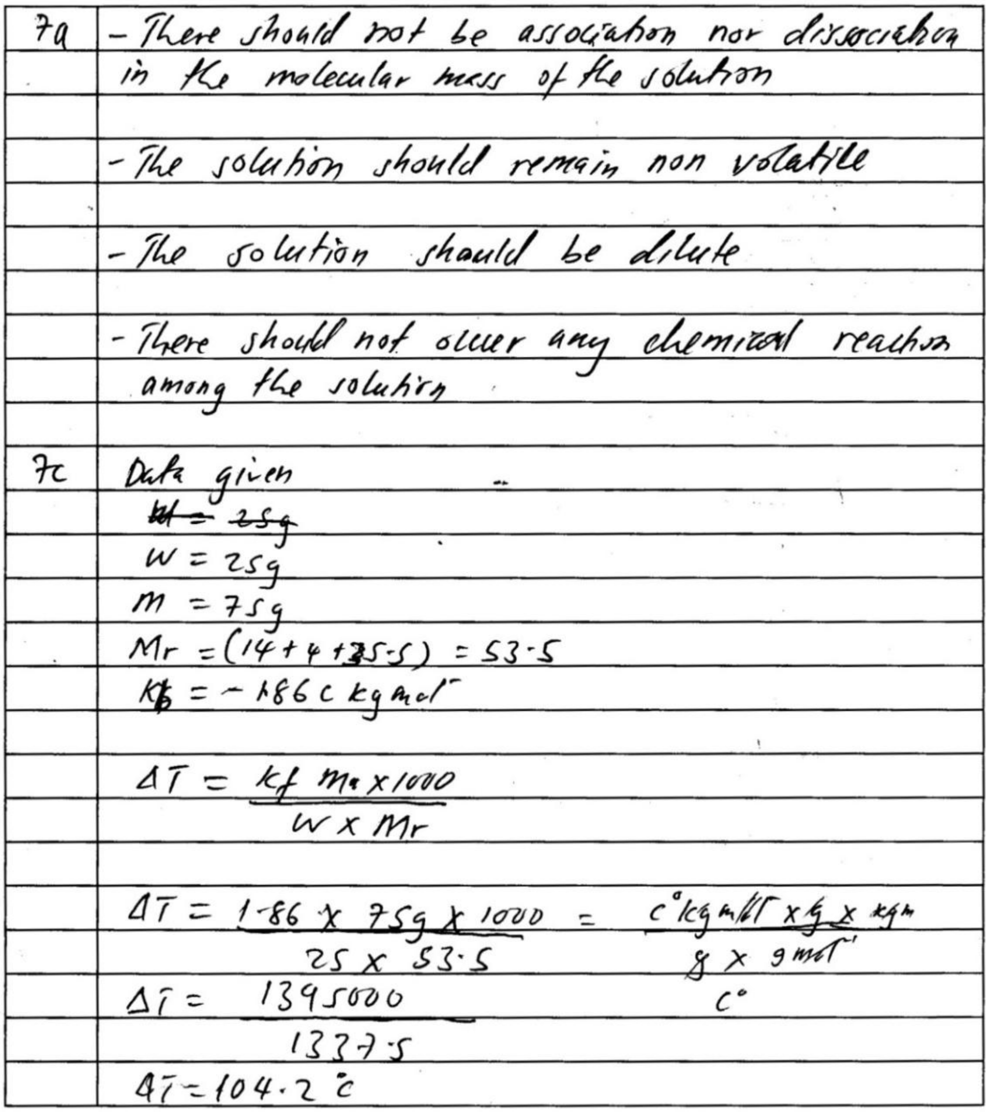


Figure 7: *Performance of the candidates in question 7.*

Figure 7 portrays that the general performance in this question was poor as 92.4 percent of the candidates scored below 3.5 marks. Further analysis showed that, 1,032 candidates, equivalent to 3.1 percent scored zero mark.

Candidates with poor performance in this question hardly stated the colligative properties and most of them failed to interpret the diagram given in part (b). Most of the candidates in this category applied an inappropriate approach to calculate the freezing temperature of the solution. Some candidates wrote the data without further attempt to calculate the freezing point, an indication that they could not establish the relationship between the data. Generally, the candidates lacked interpretational ability on how to describe vapour pressure diagrams. The low performance is also attributed to lack of competence in interpreting curves/graphs containing experimental information. Extract 7.1 shows sample response for part (a) and (b) from a candidate whose performance was poor.

Extract 7.1



7a - There should not be association nor dissociation in the molecular mass of the solution

- The solution should remain non volatile

- The solution should be dilute

- There should not occur any chemical reaction among the solution

7c Data given

~~W = 25g~~

$W = 25g$

$m = 75g$

$Mr = (14 + 4 + 35.5) = 53.5$

$K_f = -1.86\ c\ kg\ mol^{-1}$

$$\Delta T = \frac{K_f\ m \times 1000}{W \times Mr}$$

$$\Delta T = \frac{1.86 \times 75g \times 1000}{25 \times 53.5} = \frac{c^{\circ}kg\ mol^{-1} \times g \times kg}{g \times g\ mol^{-1}}$$

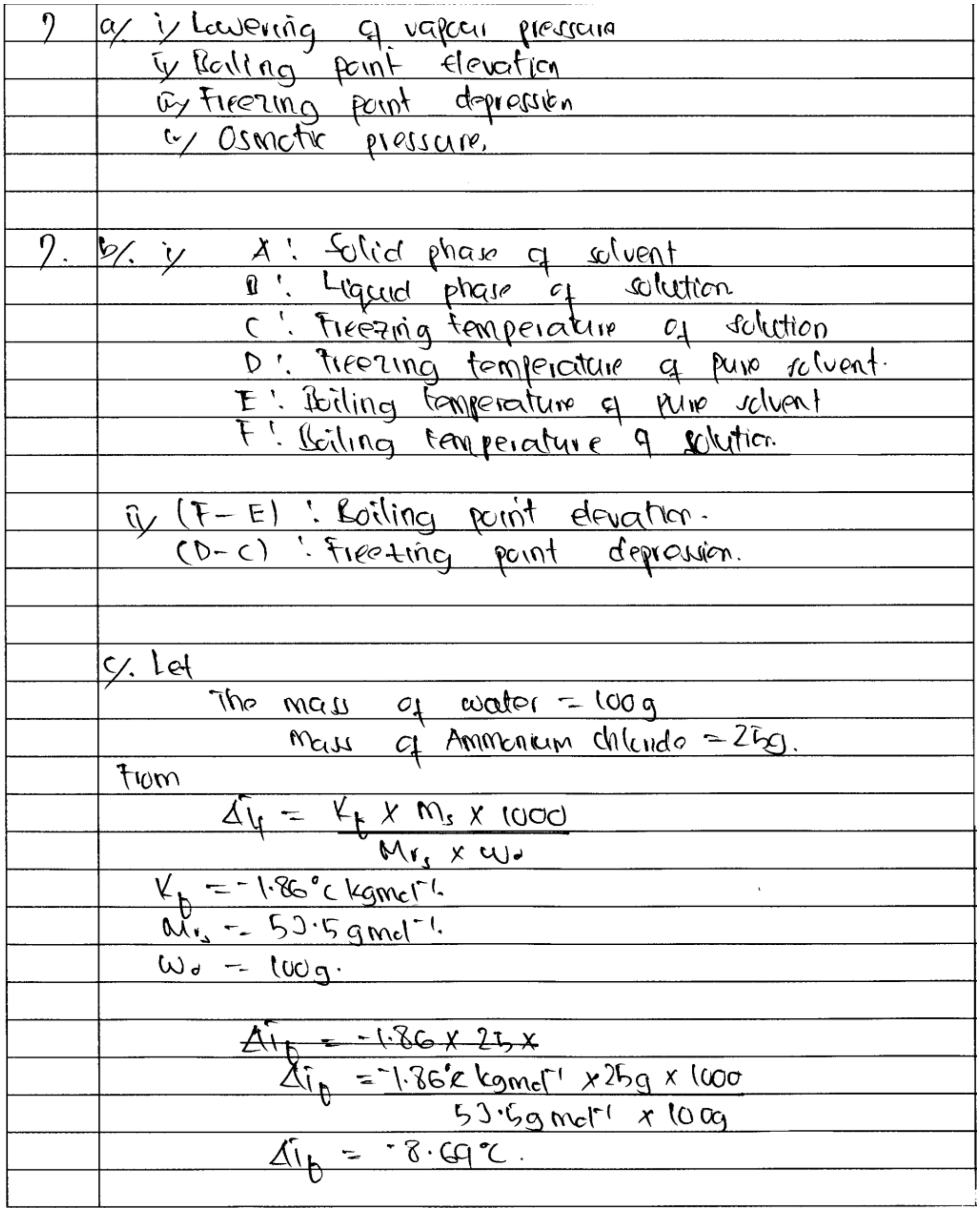
$$\Delta T = \frac{1395000}{1337.5} \qquad c^{\circ}$$

$\Delta T = 104.2\ ^{\circ}c$

In Extract 7.1 the candidate stated the limitations of Raoult's law instead of stating the four colligative properties. He/she used incorrect formula and manipulated the units incorrectly hence getting a wrong value for temperature change.

On the other hand, some few candidates responded correctly to most parts of the question. Most of them managed to state correctly the colligative properties and made realistic interpretation of the diagram in part (b). Moreover, most of candidates in this group utilized appropriate mathematical expression, inserted data correctly and obtained the required value of freezing temperature of the solution. Good performance in this question is a manifestation of the candidates being acquainted with abilities of interpreting graphs. It is absolute fact that the candidates had good understanding of concepts and ability to logically integrate physical constants. However, some items of the question were attempted incorrectly by several candidates in this category. Extract 7.2 shows an example of a good response, although the candidate failed to identify the locations of letters A and B in the curve provided.

Extract 7.2



7 a/ i/ Lowering of vapour pressure
ii/ Boiling point elevation
iii/ Freezing point depression
iv/ Osmotic pressure.

7. b/. i/ A: Solid phase of solvent
B: Liquid phase of solution
C: Freezing temperature of solution
D: Freezing temperature of pure solvent.
E: Boiling temperature of pure solvent
F: Boiling temperature of solution.

ii/ (F − E): Boiling point elevation.
(D − C): Freezing point depression.

c/. Let
The mass of water = 100g
Mass of Ammonium chloride = 25g.

From

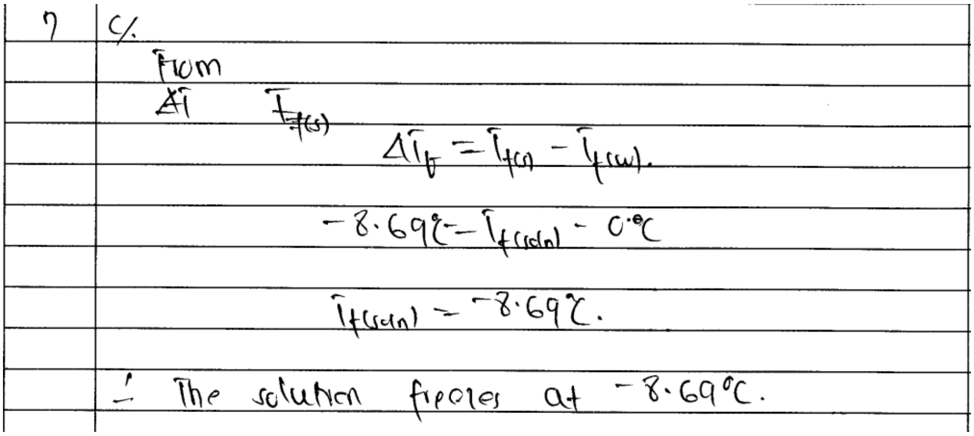
$$\Delta T_f = \frac{K_f \times m_s \times 1000}{Mr_s \times W_o}$$

$K_f = -1.86°C\,kg\,mol^{-1}$.
$Mr_s = 53.5\,g\,mol^{-1}$.
$W_o = 100g$.

~~$\Delta T_f = -1.86 \times 25 \times$~~

$$\Delta T_f = \frac{-1.86°C\,kg\,mol^{-1} \times 25g \times 1000}{53.5g\,mol^{-1} \times 100g}$$

$\Delta T_f = -8.69°C$.



7 c/.

From

ΔT $T_{f(s)}$

$\Delta T_f = T_{f(s)} - T_{f(w)}$.

$-8.69^{\circ}C = T_{f(soln)} - 0^{\circ}C$

$T_{f(soln)} = -8.69^{\circ}C$.

∴ The solution freezes at $-8.69^{\circ}C$.

In Extract 7.2 the candidate mentioned correctly the colligative properties, labeled the diagram appropriately in part (b) and demonstrated a good approach in calculating the value of temperature change in part (c).

2.1.8 Question 8: Two Components Liquid System

This question had four parts; (a), (b), (c) and (d). In part (a), the candidates were provided with the information that, "Nitrobenzene ($C_6H_5NO_2$) and water form a mixture of immiscible liquids which boils at 99 °C. The mixture was distilled at 1.013×10^5 Pa, the vapour pressure of water at 99 °C was 9.749×10^{-4} Pa". The molar masses of nitrobenzene and water to be used in their calculations were given as 123 g mol^{-1} and 18 g mol^{-1} respectively. The candidates were required to calculate the percentage by mass of nitrobenzene in the distillate. In part (b), they were provided with the information that "Water (b.p = 100 °C) and phenyl amine (b.p 184 °C) form a mixture of immiscible liquids that boils at 98 °C". The candidates were required to explain with the aid of a diagram how the mixture could be separated by steam distillation. In part (c), the candidates were required to frame representations of the equation of partition law when solute "x" dissolved in two immiscible solvents A and B under the following conditions:

(i) when solute "x" associated in solvent A and remained normal in solvent B (ii) when solute "x" dissociated in solvent A and associated in solvent B and

(iii) when solute "x" dissociated in solvent B and remained normal in solvent A.

In part (d), the candidates were given the information that

Fifty (50) grams of the acid are dissolved in one litre (1000 cm^3) of water. The distribution coefficient of the acid between ether and water is 3. A *volume 1000 cm^3 of ether is available for use in the extraction process. Two experiments were performed to extract acid from water. In the first experiment, 1000 cm^3 of ether were used once, i.e. single extraction. In the second experiment, two extractions were performed, each using 500 cm^3 of ether.*

The candidates were required to compare the amounts of the acid left in aqueous solution in each case and recommend the best method to extract the acid from water.

This question was attempted by 16,132 candidates equivalent to 48.5 percent. The candidates who scored 0 – 3.0 marks were 78 percent among which 7.4 percent scored zero mark. Candidates who scored 3.5 – 5.5 and 6.0 – 10 marks were 21.2 and 0.8 percent respectively. Summary of analysis in this question is shown in Figure 8.

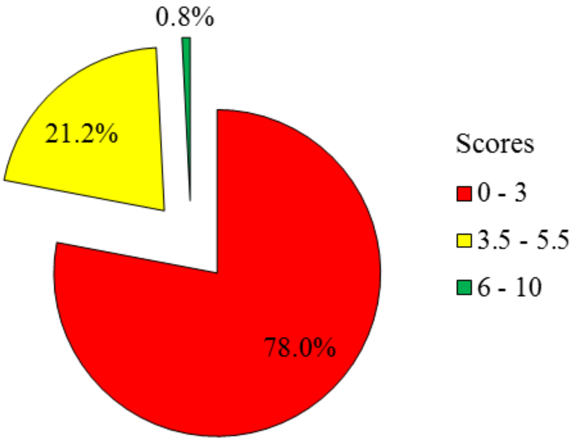
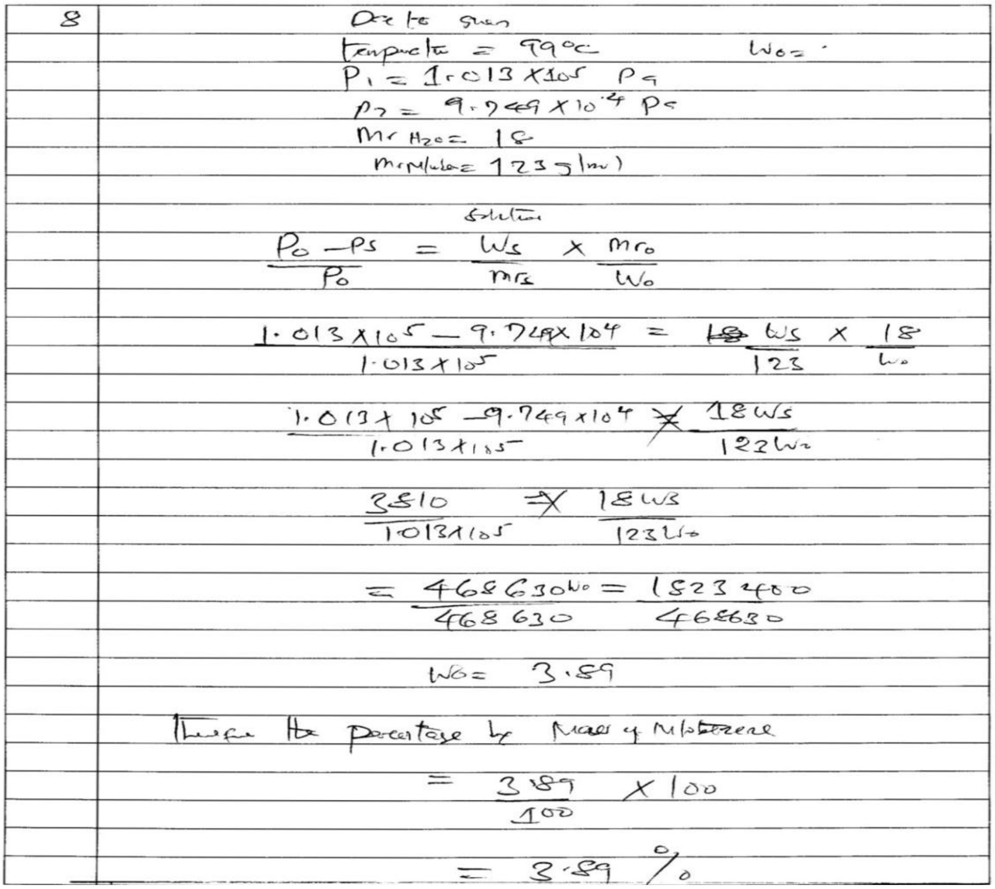


Figure 8: *Performance of the candidates in question 8.*

The general performance in this question was poor where by 78 percent of the candidates scored below the average marks. The candidates who scored low marks faced difficulties in calculation of the percentage by mass of nitrobenzene in the distillate at the stated conditions. This shows that the candidates had insufficient knowledge on the application of Raoult's law and Dalton's law of partial pressure. There was a significant number of candidates who interchanged steam distillation formulae for determination of molar mass of compounds with Raoult's law of lowering of vapour pressure. Further analysis shows that in part (b), many candidates could not draw appropriate diagram to show the process of steam distillation although they seemed to have some ideas on the apparatii required. This portrayed that, the candidates had insufficient practical knowledge regarding apparatii set - up as far as the process of steam distillation is concerned. Part (c) of the question was the most poorly attempted in this question.

Majority of the candidates were unable to show the proper equations of extracting solute "x" in part (i) to (iii). This showed that the candidates had insufficient understanding regarding modification of partition law. In part (d), some of the candidates were unable to calculate the amount of the acid left in aqueous solution in each of the two approaches stated. They had inadequate knowledge of applying the distribution law in solvent extraction. Conversely, few candidates in this category were able to recommend appropriately the best method of extracting the acid from water. However, they failed to calculate correctly the amount of the solute extracted in each case. Generally, low performance in this question seemed to be caused by inadequate knowledge on the principles of separation of mixtures. Extract 8.1 is a sample of poor responses to this question.

Extract 8.1



8

Data given

Temperature = 99°C Wo =

$P_1 = 1{\cdot}013 \times 10^5$ Pa

$P_2 = 9{\cdot}749 \times 10^4$ Pa

$Mr_{H_2O} = 18$

Mr Nitrobenzene = 123 g/mol

Solution

$$\frac{P_o - P_s}{P_o} = \frac{W_s}{mr_s} \times \frac{mr_o}{W_o}$$

$$\frac{1{\cdot}013 \times 10^5 - 9{\cdot}749 \times 10^4}{1{\cdot}013 \times 10^5} = \frac{\cancel{18}\,W_s}{123} \times \frac{18}{W_o}$$

$$\frac{1{\cdot}013 \times 10^5 - 9{\cdot}749 \times 10^4}{1{\cdot}013 \times 10^5} \cancel{=} \frac{18W_s}{123W_o}$$

$$\frac{3810}{1{\cdot}013 \times 10^5} \cancel{=} \frac{18W_s}{123W_o}$$

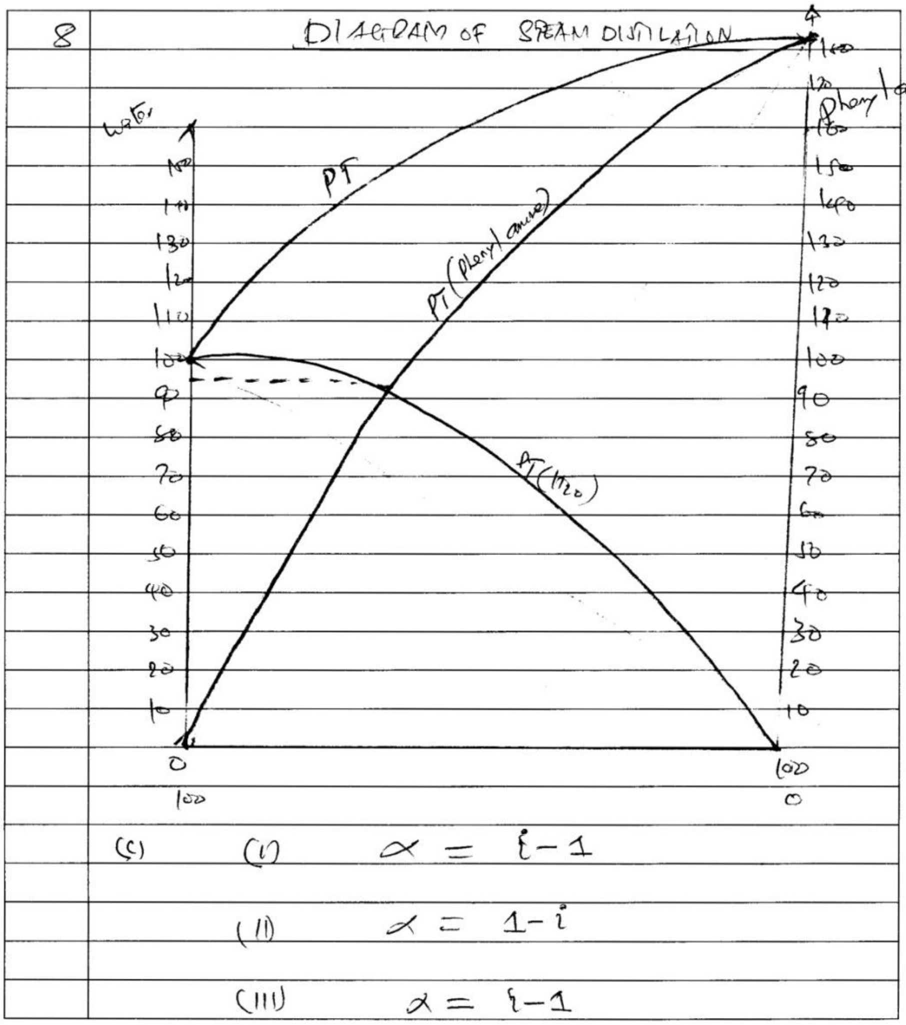
$$= \frac{468630W_o}{468630} = \frac{1823400}{468630}$$

$W_o = 3{\cdot}89$

Therefore the percentage by mass of Nitrobenzene

$$= \frac{3{\cdot}89}{100} \times 100$$

$= 3{\cdot}89\%$



8

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

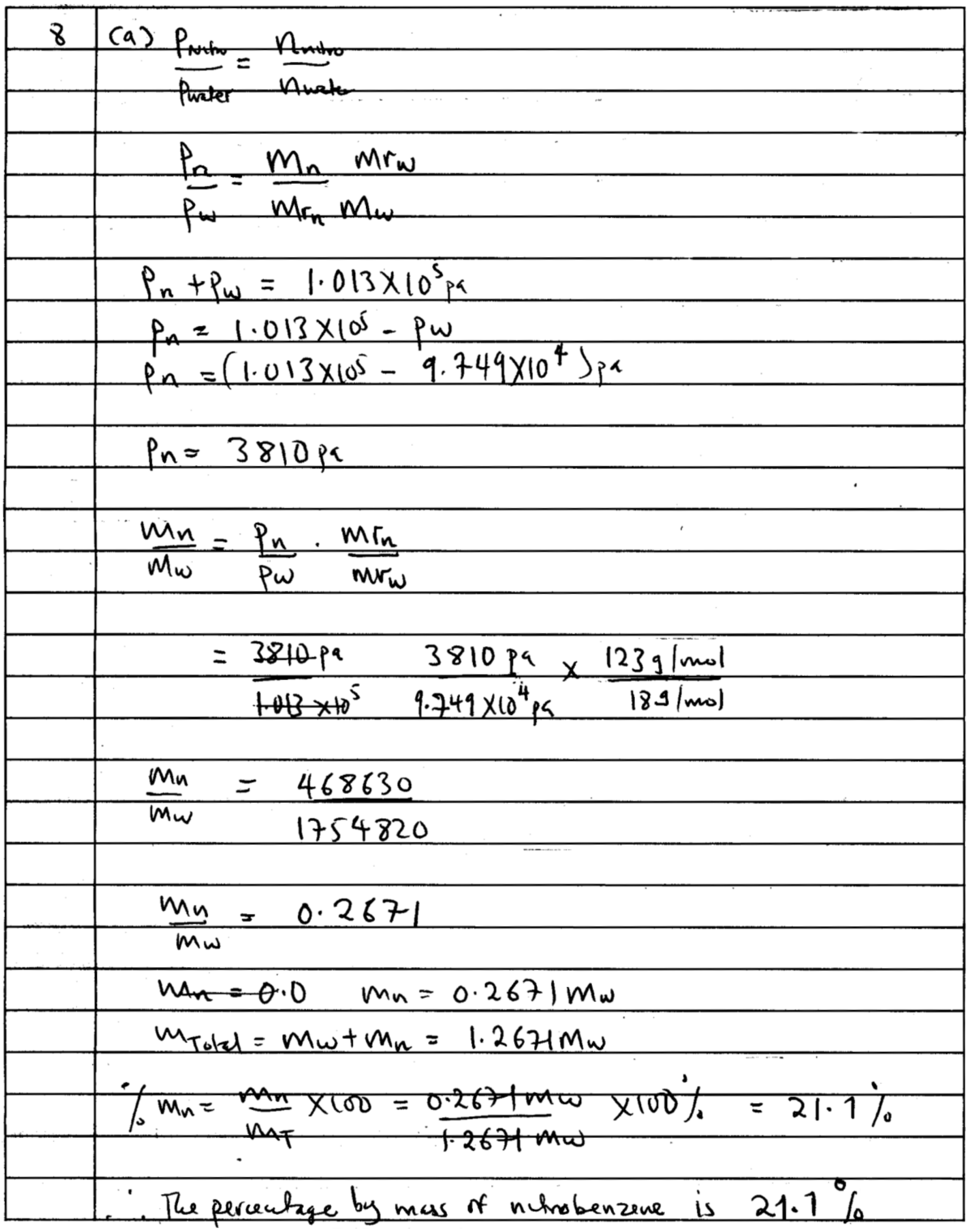
(ii) $\alpha = 1 - i$

(iii) $\alpha = i - 1$

In Extract 8.1, the candidate used inappropriate formula to calculate the percentage by mass of nitrobenzene, sketched a vapour pressure composition diagram instead of steam a distillation set up for separating liquid mixtures. Furthermore, he/she wrote van't Hoff's factor notation instead of equations related to the law of partition.

Some of the candidates who scored high marks in this question managed to give correct responses to most parts of the question. However, there were those who failed to do calculations specifically in part (c). They applied either incorrect or irrelevant mathematical expressions. Part (b) was attempted correctly by many candidates in this category. In general, the candidates who scored high marks in this question were knowledgeable enough in applying relevant mathematical formula, substituting data and clear manipulation of units. Extract 8.2 gives a sample of good responses to this question.

Extract 8.2



8 (a) $\frac{P_{nitro}}{P_{water}} = \frac{n_{nitro}}{n_{water}}$

$\frac{P_n}{P_w} = \frac{M_n}{Mr_n} \frac{Mr_w}{M_w}$

$P_n + P_w = 1.013 \times 10^5 pa$

$P_n = 1.013 \times 10^5 - P_w$

$P_n = (1.013 \times 10^5 - 9.749 \times 10^4) pa$

$P_n = 3810 pa$

$\frac{m_n}{M_w} = \frac{P_n}{P_w} \cdot \frac{Mr_n}{Mr_w}$

$= \frac{\cancel{3810} pa}{\cancel{1.013 \times 10^5}} \quad \frac{3810 pa}{9.749 \times 10^4 pa} \times \frac{123 g/mol}{18 g/mol}$

$\frac{m_n}{M_w} = \frac{468630}{1754820}$

$\frac{m_n}{M_w} = 0.2671$

~~$m_n = 0.0$~~ $\quad m_n = 0.2671 M_w$

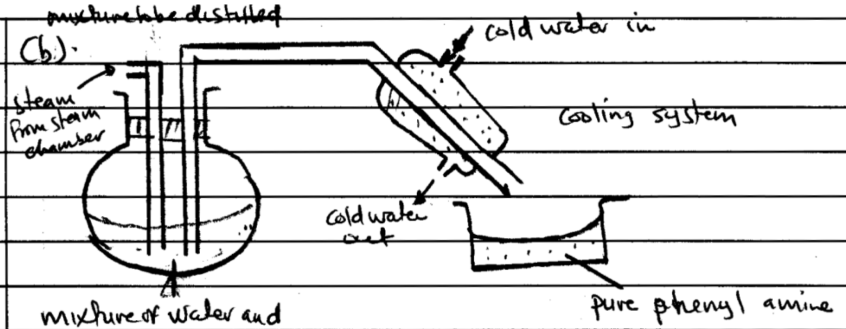
$m_{Total} = M_w + m_n = 1.2671 M_w$

$\% m_n = \frac{m_n}{m_T} \times 100 = \frac{0.2671 M_w}{1.2671 M_w} \times 100\% = 21.1\%$

∴ The percentage by mass of nitrobenzene is 21.1 %

~~mixture to be distilled~~

8 (b).



A steam from steam chamber is allowed to enter into vessel containing water and phenyly amine where as it leave with phenylamine. on passing a cooling system phenylamine cools and liquidify into the collecting vessel.

(b).(i) $K_d = \dfrac{[X] \text{ in solvent } B}{\sqrt[n]{[X] \text{ in solvent } A}}$

n - is degree of association

(ii)

(iii) $K_d = \dfrac{[x] \text{ in Solvent } A}{[x] \text{ in solvent } B \, (1-\alpha)}$

α - is the degree of dissociation

(d) $W_r = W_o \left(\dfrac{V_b}{V_b + V_a K_d} \right)^n$

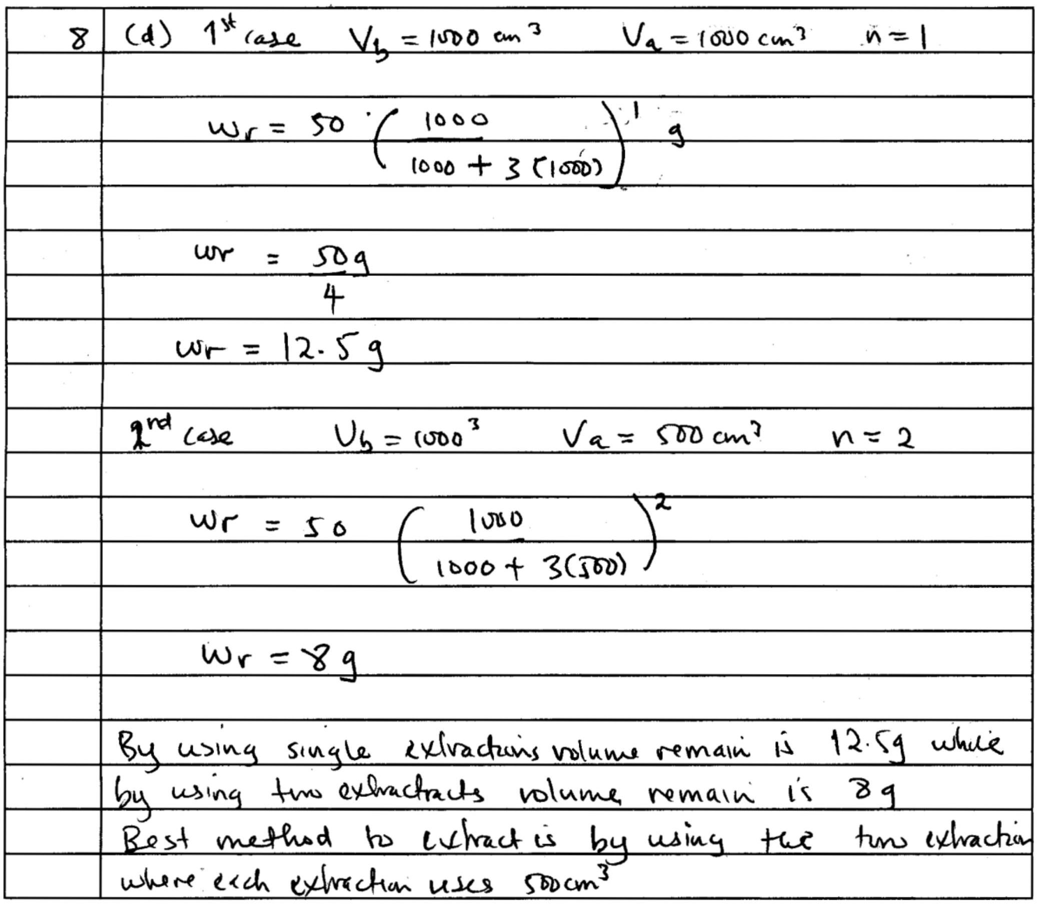
where W_r - remamed solute in residue solvent

W_o - is the initial amount of solute in extractive solute

V_b and V_a - are volumes of residue and extractive solvent respectively

n - number of extraction

Kd - partition coefficient



8 (d) 1st case $V_b = 1000\ cm^3$ $V_a = 1000\ cm^3$ $n = 1$

$$w_r = 50\left(\frac{1000}{1000 + 3(1000)}\right)^1 g$$

$$w_r = \frac{50g}{4}$$

$$w_r = 12.5g$$

2nd case $V_b = 1000^3$ $V_a = 500\ cm^3$ $n = 2$

$$w_r = 50\left(\frac{1000}{1000 + 3(500)}\right)^2$$

$$w_r = 8g$$

By using single extractions volume remain is 12.5g while by using two extractacts volume remain is 8g Best method to extract is by using the two extraction where each extraction uses $500 cm^3$

In Extract 8.2, the candidate carried out the calculations in parts (a), (c), and (d) in the appropriate manner and gave the required description of the process of steam distillation in part (b).

2.1.9 Question 9: Chemical Equilibrium

This question consisted of three parts; (a), (b) and (c). Part (a) required the candidates to state the law of mass action, Le Chatelier's principle, factors that change the position of the chemical equilibrium and to give definition of dynamic equilibrium. In part (b), the candidates were given the information that: *The equilibrium constant for the reaction $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$ at $986\ ^{\circ}C$ is 0.63. A mixture of 1.0 mole of water vapour and 3.0 moles of CO were allowed to come to equilibrium. The equilibrium pressure is 2.0 atmosphere.*

They were required to calculate the number of moles of hydrogen present at equilibrium, and the partial pressure of the gases at equilibrium mixture. Finally, in part (c) the candidates were provided with the chief reaction used in the contact process; $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) + 4200$ kJ and were required to explain three conditions necessary for the maximum yield of $SO_3(g)$ based on the Le Chatelier's principle.

The question was attempted by 30,806 candidates, equivalent to 92.7 percent with 63.3 percent scoring 3.5 marks and above as shown in Figure 9.

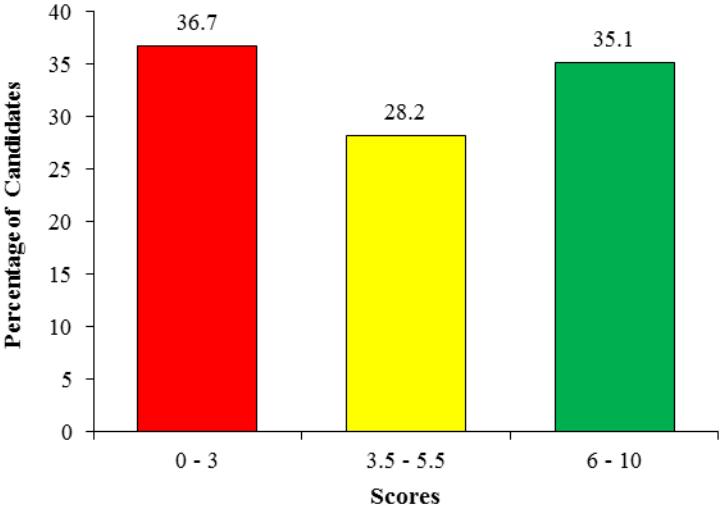
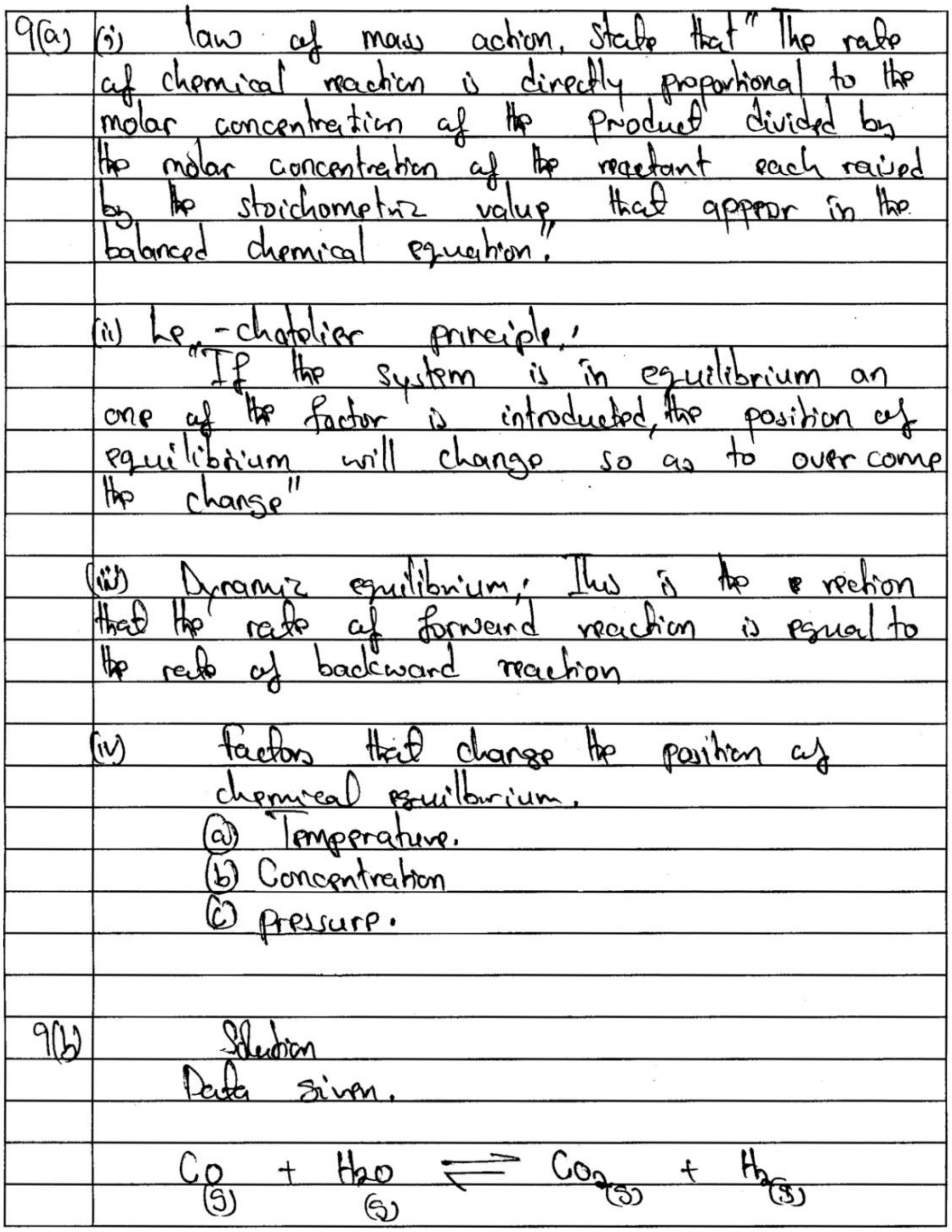


Figure 9: *Performance of the candidates in question 9.*

Figure 9 shows that the candidates who scored marks ranging from of 6.0 - 10, 3.5 – 5.5 and 0 – 3.0 were 35.1, 28.2 and 36.7 percent, respectively. The overall performance in this question was good. Candidates who scored high marks in this question responded correctly to most of the items. Majority of the candidates were able to state the two laws in part (a)(i) and (ii) correctly,. and gave appropriate definition of dynamic equilibrium. Most of them carried out the calculation in part (b) by applying correct equilibrium expression (Kc). However, there were few candidates in this category who failed to compute partial pressure of the gases at equilibrium. Furthermore, the candidates were able to attempt part (c) of the question with exception of some candidates who assumed the reaction being an endothermic instead of an exothermic process. Other candidates in this group incorrectly stated surface area and catalyst as the factors that can change the position of chemical equilibrium. Extract 9.1 shows an example of good responses in this question.

Extract 9.1



9(a) (i) law of mass action, State that "The rate of chemical reaction is directly proportional to the molar concentration of the product divided by the molar concentration of the reactant each raised by the stoichometric value, that appear in the balanced chemical equation".

(ii) Le-chatolier principle.
"If the system is in equilibrium an one of the factor is introducted, the position of equilibrium will change so as to over come the change"

(iii) Dynamic equilibrium; This is the rection that the rate of forward reaction is equal to the rate of backward reaction

(iv) factors that change the position of chemical equilibrium.
(a) Temperature.
(b) Concentration
(c) pressure.

9(b) Solution
Data given.

$CO_{(g)} + H_2O_{(g)} \rightleftharpoons CO_{2(g)} + H_{2(g)}$

9(b) $CO_{(g)} + H_2O_{(g)} \rightleftharpoons CO_{2(g)} + H_{2(g)}$

(i)

$K_c = 0.63$

$P_T = 2.0$ atm.

$$\begin{array}{cccc} CO & + H_2O & \rightleftharpoons CO_2 & + H_2 \\ 3-x & 1-x & x & x \end{array}$$

From

$$K_c = \frac{[CO_2][H_2]}{[CO][H_2O]}$$

$$0.63 = \frac{x^2}{(3-x)(1-x)}$$

$$0.63 = \frac{x^2}{3-4x+x^2}$$

$$1.89 - 2.52x + 0.63x^2 = 1x^2.$$

$$0.37x^2 + 2.52x - 1.89 = 0.$$

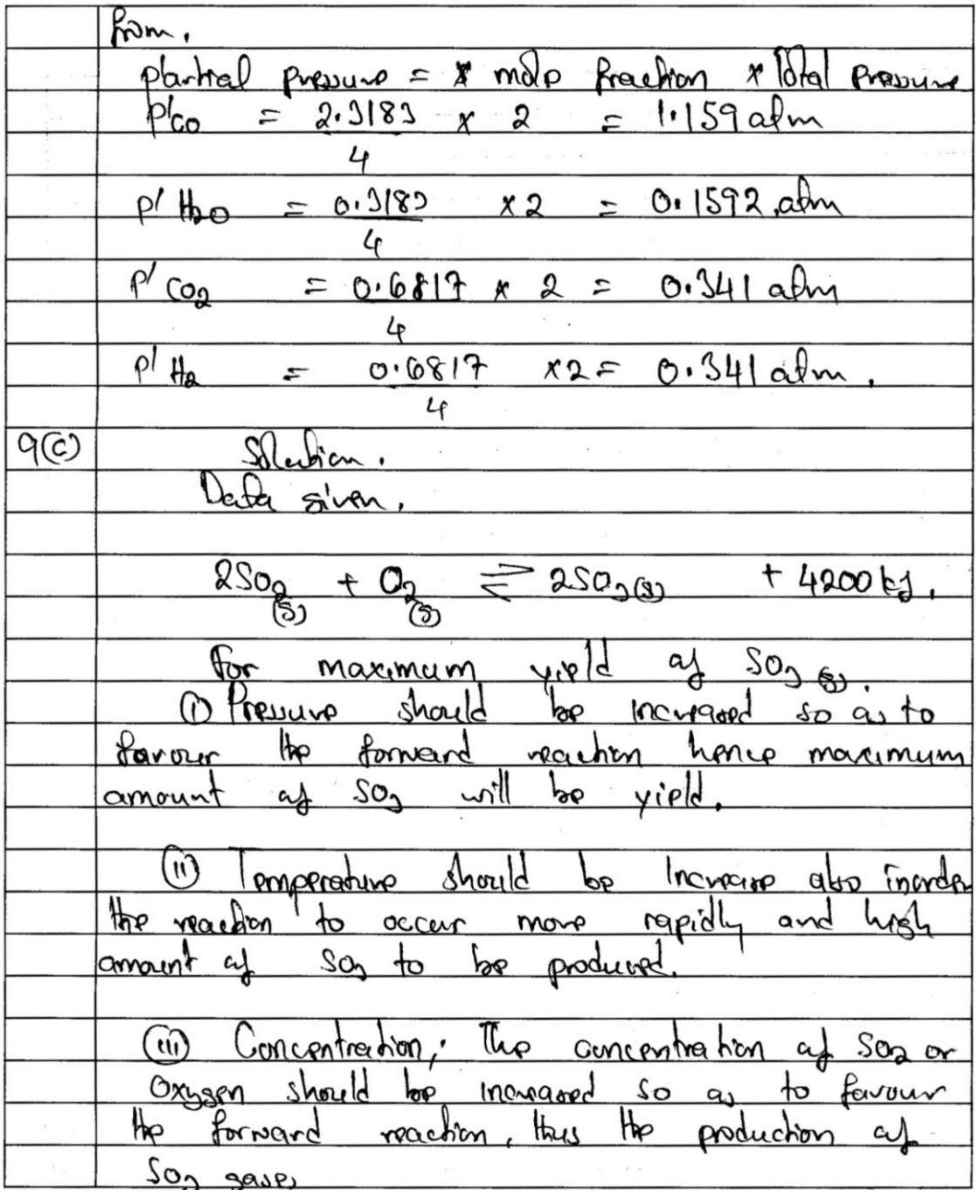
$$x = 0.6817.$$

∴ The number of moles of H_2 at equilibrium is 0.6817 moles.

(ii) Required partial pressure of each.

$$\begin{array}{cccc} CO & + H_2O & \rightleftharpoons CO_2 & + H_2 \\ 2.3183. & 0.3183 & 0.6817 & 0.6817 \end{array}$$

$n_T = 4.$



from,

partial pressure = $\times$ mole fraction $\times$ Total Pressure

$P'_{CO} = \frac{2.3183}{4} \times 2 = 1.159$ atm

$P'_{H_2O} = \frac{0.3183}{4} \times 2 = 0.1592$ atm

$P'_{CO_2} = \frac{0.6817}{4} \times 2 = 0.341$ atm

$P'_{H_2} = \frac{0.6817}{4} \times 2 = 0.341$ atm.

9(c) Solution.

Data given,

$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)} + 4200\ kJ.$

For maximum yield of $SO_{3(g)}$.

(i) Pressure should be increased so as to favour the forward reaction hence maximum amount of SO_3 will be yield.

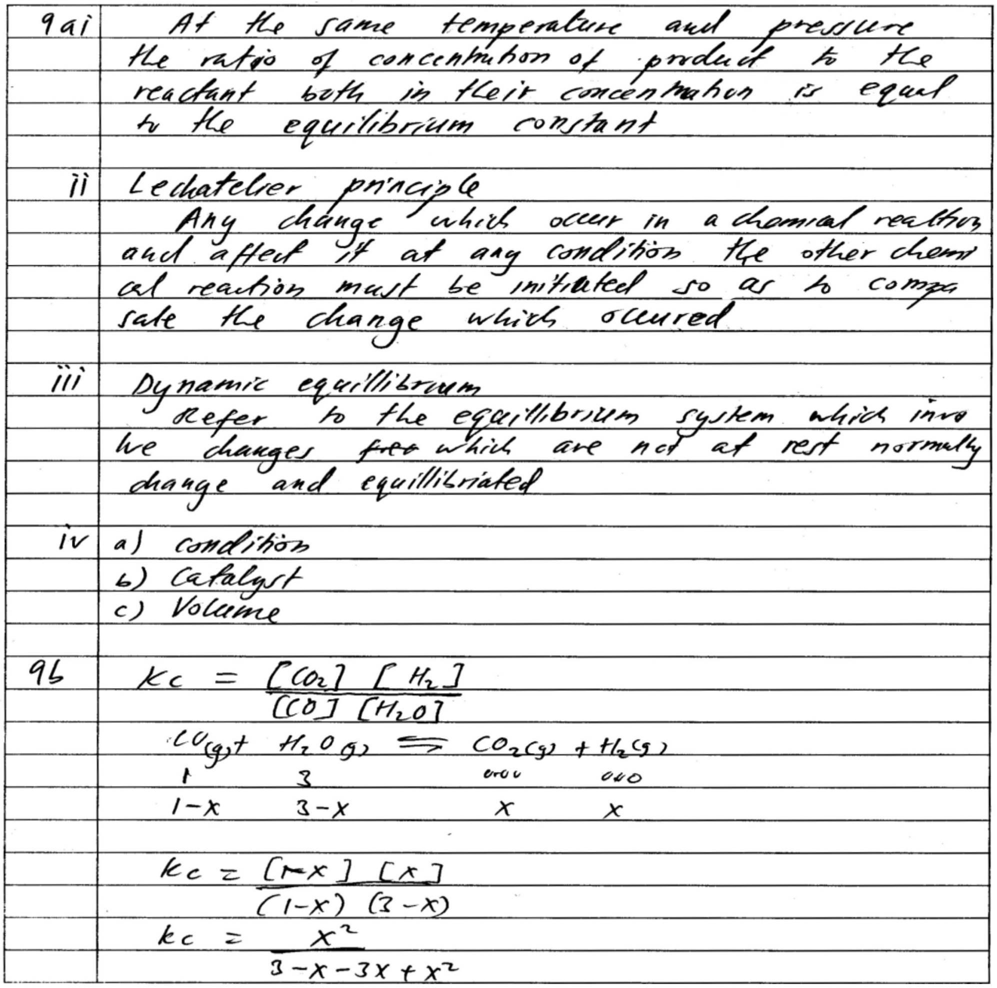
(ii) Temperature should be increase also inorder the reaction to occur more rapidly and high amount of SO_3 to be produced.

(iii) Concentration; The concentration of SO_2 or Oxygen should be increased so as to favour the forward reaction, thus the production of SO_3 gases

Extract 9.1 shows correct responses (most of them) by a candidate who scored high marks. However, he/she failed to explain correctly how temperature can be adjusted to maximize the yield of SO_3(g).

The candidates who scored low marks failed to attempt most parts of the question. Some of them could hardly attempt correctly the items which required them to define or state concepts and eventually earned low marks. Part (b) was poorly attempted by candidates in this category as they failed to write and apply Kc expressions correctly. This implied that the candidates had insufficient understanding of concepts, specifically the law of mass action. A significant number of the candidates demonstrated poor competence in language and could not write meaningful sentences. For example, one of the candidates stated the law of mass action as "*The rate equal of foward reaction is to rate reaction backward of "*. In part (b), most of the candidates used incorrect formulae and failed to obtain the required values. Furthermore, in part (c), the candidates could not explain correctly the three reasons that were required. This was due to inability to predict observations based on the application of Le Chatelier's principle. Principally, poor performance of candidates in this question was attributed by inadequate knowledge about applying Le Chatelier's principle and expressions for chemical reactions at equilibrium. The candidates also were inefficient in carrying out calculations. Extract 9.2 shows a sample poor responses for question 9 part (a) and (b).

Extract 9.2



9ai At the same temperature and pressure the ratio of concentration of product to the reactant both in their concentration is equal to the equilibrium constant

ii Lechatelier principle
Any change which occur in a chemical reaction and affect it at any condition the other chemical reaction must be initiated so as to compensate the change which occured

iii Dynamic equillibrium
Refer to the equillibrium system which involve changes ~~free~~ which are not at rest normally change and equillibriated

iv a) condition
b) Catalyst
c) Volume

9b $Kc = \frac{[CO_2]\ [H_2]}{[CO]\ [H_2O]}$

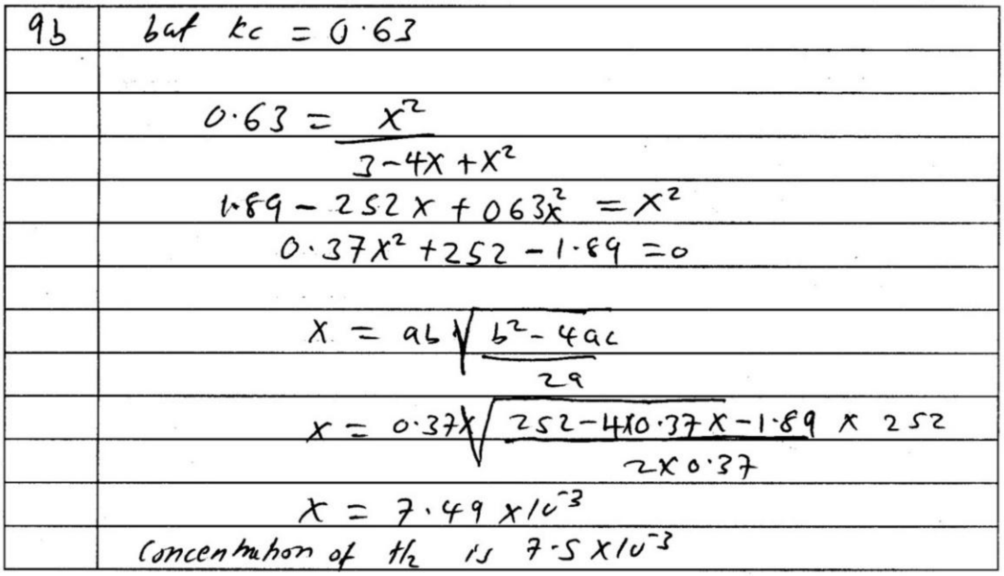
$CO_{(g)} + H_2O_{(g)} \rightleftharpoons CO_{2(g)} + H_{2(g)}$

$1 \qquad 3 \qquad 0.0 \qquad 0.0$

$1-x \qquad 3-x \qquad x \qquad x$

$Kc = \frac{[1-x]\ [x]}{(1-x)\ (3-x)}$

$kc = \frac{x^2}{3-x-3x+x^2}$



9b but kc = 0·63

$$0{\cdot}63 = \frac{x^2}{3-4x+x^2}$$

$$1{\cdot}89 - 252x + 063x^2 = x^2$$

$$0{\cdot}37x^2 + 252 - 1{\cdot}89 = 0$$

$$x = ab\sqrt{\frac{b^2-4ac}{2a}}$$

$$x = 0{\cdot}37x\sqrt{\frac{252-4\times0{\cdot}37\times-1{\cdot}89 \times 252}{2\times0{\cdot}37}}$$

$$x = 7{\cdot}49\times10^{-3}$$

Concentration of H_2 is $7{\cdot}5\times10^{-3}$

In Extract 9.2 the candidate gave incorrect responses in part (a) and the calculations in part (b) was incorrect as well.

2.1.10 Question 10: Chemical Bonding

Part (a) required the candidates to differentiate between dative and covalent bond by using appropriate examples. In part (b), the candidates were required to explain briefly the following concepts with the help of sketches:

(i) Two types of hydrogen bonding, giving one example for each.
(ii) The boiling point of ortho-nitrophenol being lower than that of para-isomer.
(iii) Ethene being planar in shape.
(iv) Methane being tetrahedron geometry.

In part (c), the candidates were asked to state, two conditions that are necessary for formation of hydrogen bond, two effects of hydrogen bonding and show how many *s*-and *p*-bonds are formed between C-C in ethyne.

The question was attempted by 21,611 candidates equivalent to 65 percent. Performance in this question is shown in Figure 10.

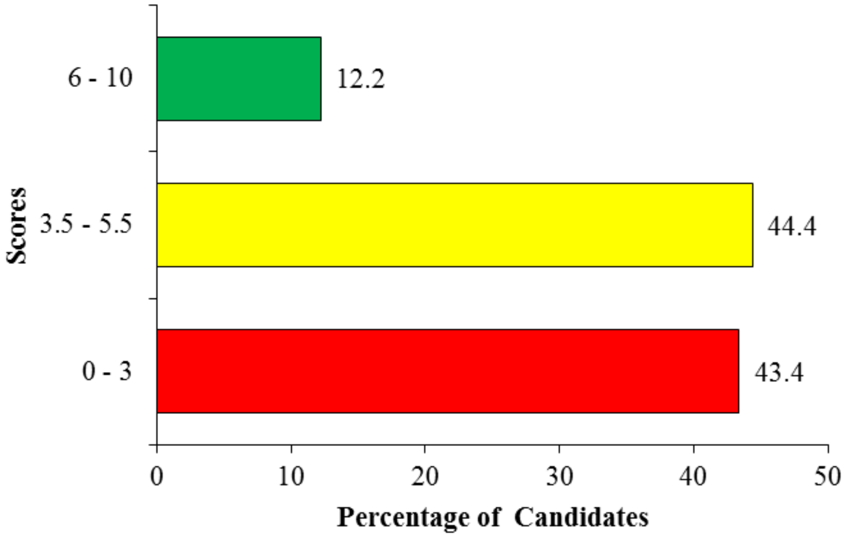


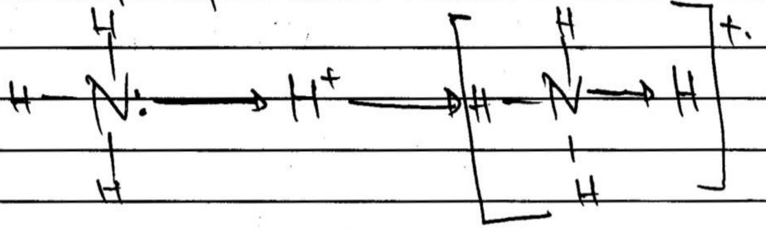
Figure 10: *Performance of the candidates in question 10.*

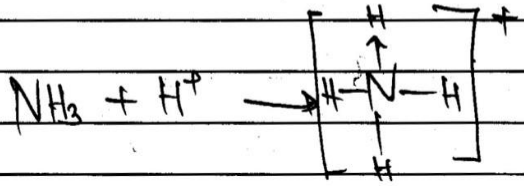
Figure 10 shows that 12.2 percent of the candidates scored 6.0 - 10 marks, 44.4 percent scored 3.5 - 5.5 marks while 43.4 percent scored 0 - 3.0 marks. The general performance in this question was average as 56.6 percent of the candidates scored 3.5 marks and above. Most of the candidates who scored high marks were able to differentiate between dative and covalent bonds appropriately. Furthermore, the candidates supported their answers with relevant examples. Few of the candidates attempted part (b) appropriately, and in most cases, they gave irrelevant sketches. Part (c) was moderately performed by most candidates in this category while only few candidates responded correctly to part (d). High scores of the candidates in this question implied that, the candidates had sufficient knowledge on types of bonds and hybridization of atomic orbitals. Extract 10.1 is an example of good responses in this question.

Extract 10.1

16. a) Dative bond are the forces of attraction formed when the ~~bondi~~ bonding shared electrons are contributed by one atom (lewis base). while ~~coordinate~~ covalent bonds are the forces of attraction formed when the shared electrons are contributed by both bonding atoms.

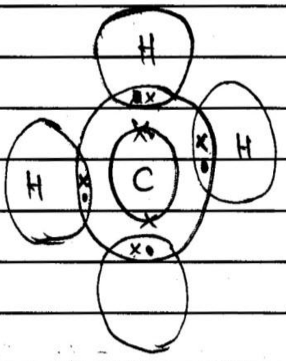
Example of dative bond.





• Example of covalent bond.

CH_4.

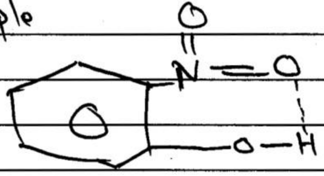


16. b) i) There are two types of hydrogen bonding.

a) Intramolecular hydrogen bond.

– This is the type of hydron bond that is formed between the same molecule. The molecular normal have more than one functional group.

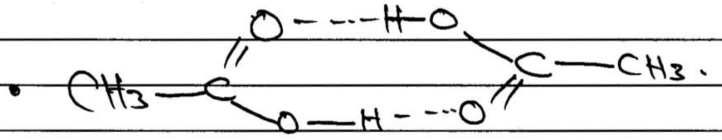
Example

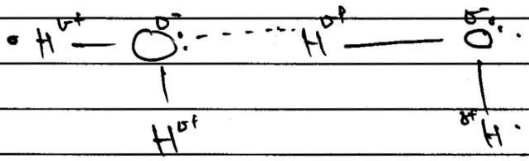


b) Intermolecular (~~Forces~~) hydrogen bond.

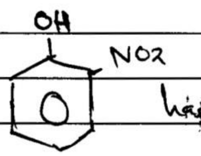
– Is the type of hydrogen bond formed between the two different molecules–

Example.





16. b) ii)

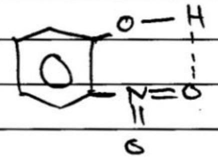


has ~~lower~~ lower boiling point than para isomer because, ~~the~~ ortho-nitrophenol

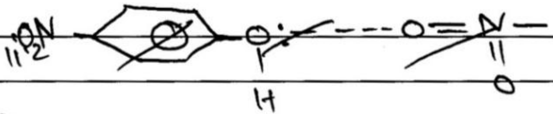
10. (b)(ii) forms intramolecular forces of attraction which are weak compared to ~~or~~ para-isomer which forms intermolecular forces of attraction. ~~and they~~ of hydrogen and thus determine high boiling point because intermolecular for hydrogen bond are strong than intramolecular hydrogen bond. Also Steric hindrance plays a part on determining boiling point

Example.

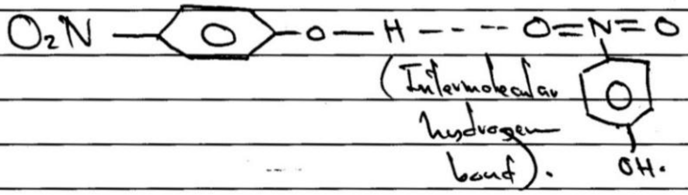
i)



(Intramolecular forces).

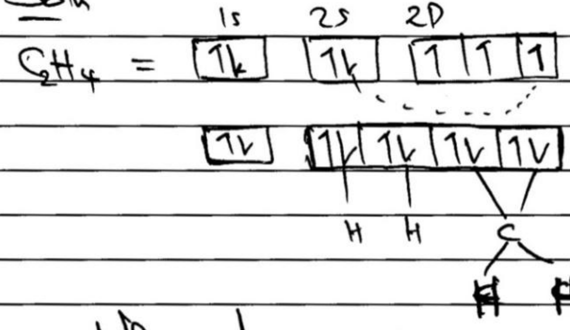


ii)



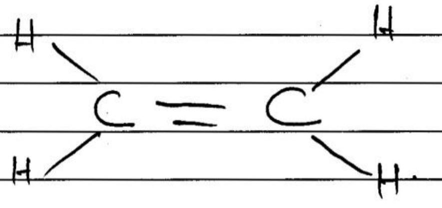
(Intermolecular hydrogen bond).

10a)(iii) Soln

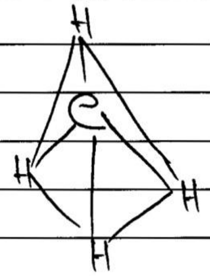


Ethene has a planar geometry because

10 b)ii) it forms sp^2 hybridization, which have planal geometry.



10 b) iv) Methane has tetrahedral geometry. This is because Methane has four bonded atoms and thus forms sp^3 hybridization in which also there are no lone pair.



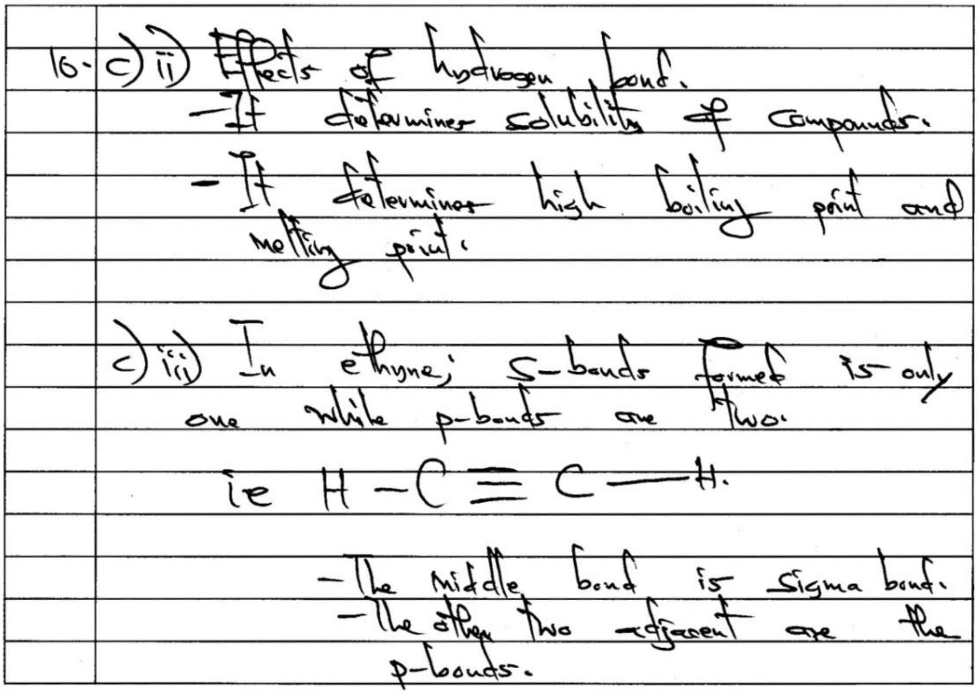
Tetrahydral geometry

10 c). Conditions for formation of hydrogen bond.

→ Hydrogen atom should be bonded to the most electronegative atom.

→ The most electronegative atom must have atleast one lone pair.

Example, Oxygen, nitrogen.



16. c) ii) Effects of hydrogen bond.
- It determines solubility of compounds.
- It determines high boiling point and melting point.

c) iii) In ethyne; S-bonds formed is only one while p-bonds are two.

ie $H - C \equiv C - H$.

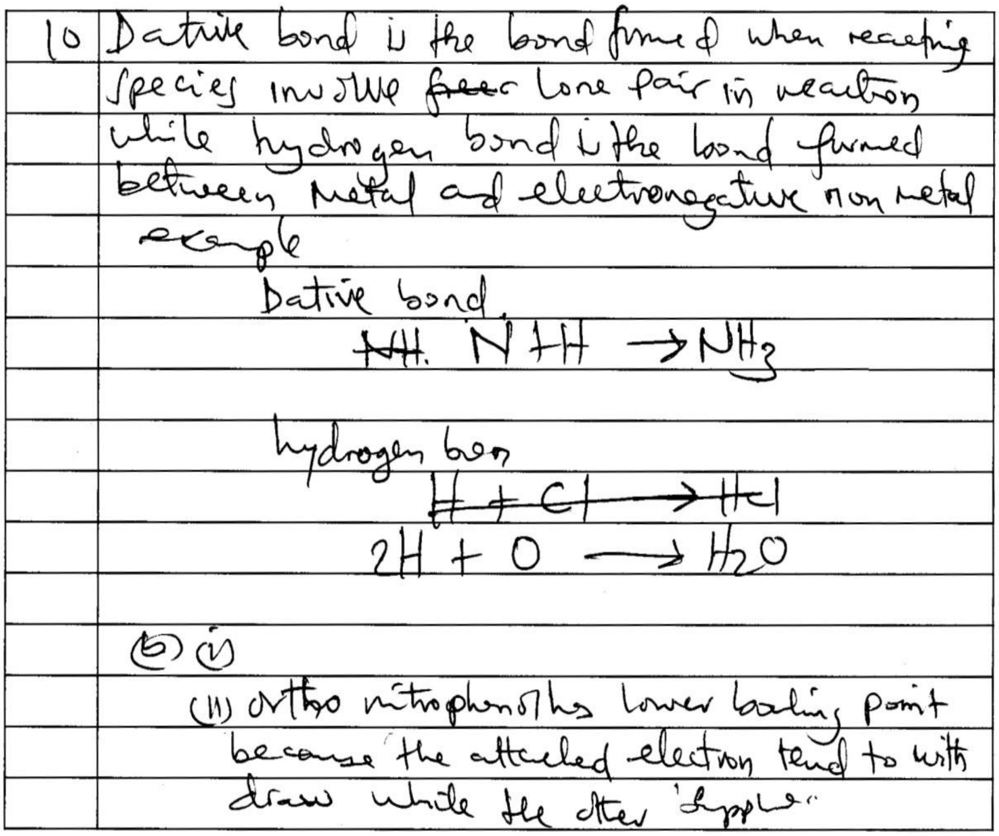
- The middle bond is sigma bond.
- The other two adjacent are the p-bonds.

In Extract 10.1 the candidate responded correctly to the items in part (a) and (c). However, he/she failed to justify the tetrahedron geometry of methane in part (b)(iv).

On the other hand in part (a) most of the candidates who scored low marks were incapable of differentiating between dative and covalent bonds. This indicated that the candidates lacked sufficient knowledge on the concept of bond formation as far as the sharing of electrons between atoms is concerned. For example one of the candidates wrote that "*Covalent bonds are bonds which formed between combination of metallic and non-metallic elements, e.g,* $H_2 + O_2 \rightarrow H_2O$ *where's dative bonds are bond which does not consider formation of covalent bond."*

In part (b), some of the candidates failed to give sketches relevant to hydrogen bonding, *ortho*-nitrophenol and para-nitrophenol structures, the planar geometry of ethene and tetrahedron geometry of methane. This implies that the candidates failed to inter-link the concepts of hybridization with the shapes of covalent molecules as well as effect of hydrogen bonding on physical properties such as boiling points of compounds. In part (c) it was observed that some of the candidates failed to state both the conditions necessary for the formation of hydrogen bond and the effects of hydrogen bonding. This indicated that the candidates had little knowledge on hydrogen bonding and the associated dipole-dipole attraction between covalent molecules. Extract 10.2 is a sample of poor responses from a candidate who attempted only part (a) and (b) of this question.

Extract 10.2



10 Dative bond is the bond formed when receping species involve ~~free~~ Lone pair in reaction while hydrogen bond is the bond formed between metal and electronegative non metal

example

Dative bond.

~~NH.~~ N + H → NH_3

hydrogen bon

~~H + Cl → HCl~~

2H + O → H_2O

(b) (i)

(ii) ortho nitrophenol has lower boiling point because the attached electron tend to with draw while the other 'supplie'

In Extract 10.2 the candidate gave incorrect differences between dative and covalent bond. Similarly, he/she gave irrelevant explanation in part (b)(ii) and did not attempt the remaining parts of the question.

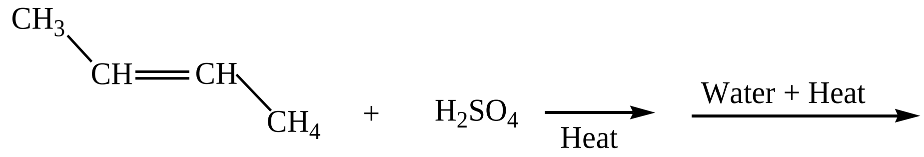
2.1.11 Question 11: Aliphatic and Aromatic Hydrocarbons

In part (a), the candidates were required to explain why, $CH_3CH_2CH_2CH_3$ has a boiling point of -1 °C while $CH_3CH(CH_3)CH_3$ has a boiling point of -12 °C. In part (b)(i), the candidates were required to state with one example, the meaning of 'Friedel-Crafts acylation'. In part (b)(ii), they were required to show the reaction mechanism between benzene and nitric acid in the presence of sulphuric acid with the aid of illustration. In part (b)(iii), they were required to draw the chemical structure of the product formed from oxidation of 1,3-dimethylbenzene by potassium dichromate VI solution.

In part (c), the candidates were required to write the product of each of the following reactions:

(i) $CH_4 + Cl_2 \xrightarrow{Uv}$

(ii)



(iii) $CH_3-C\equiv CH + CuCl\,(aq) \xrightarrow{NH_3}$

(iv) $CaC_2 + H_2O \longrightarrow$

The question was attempted by 28,036 candidates constituting 84.3 percent. The candidates performance is as shown in Figure 11.

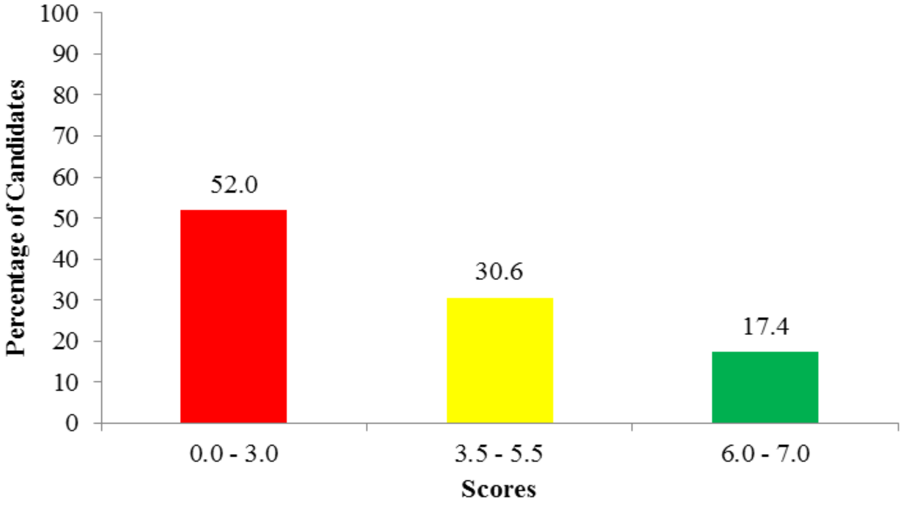
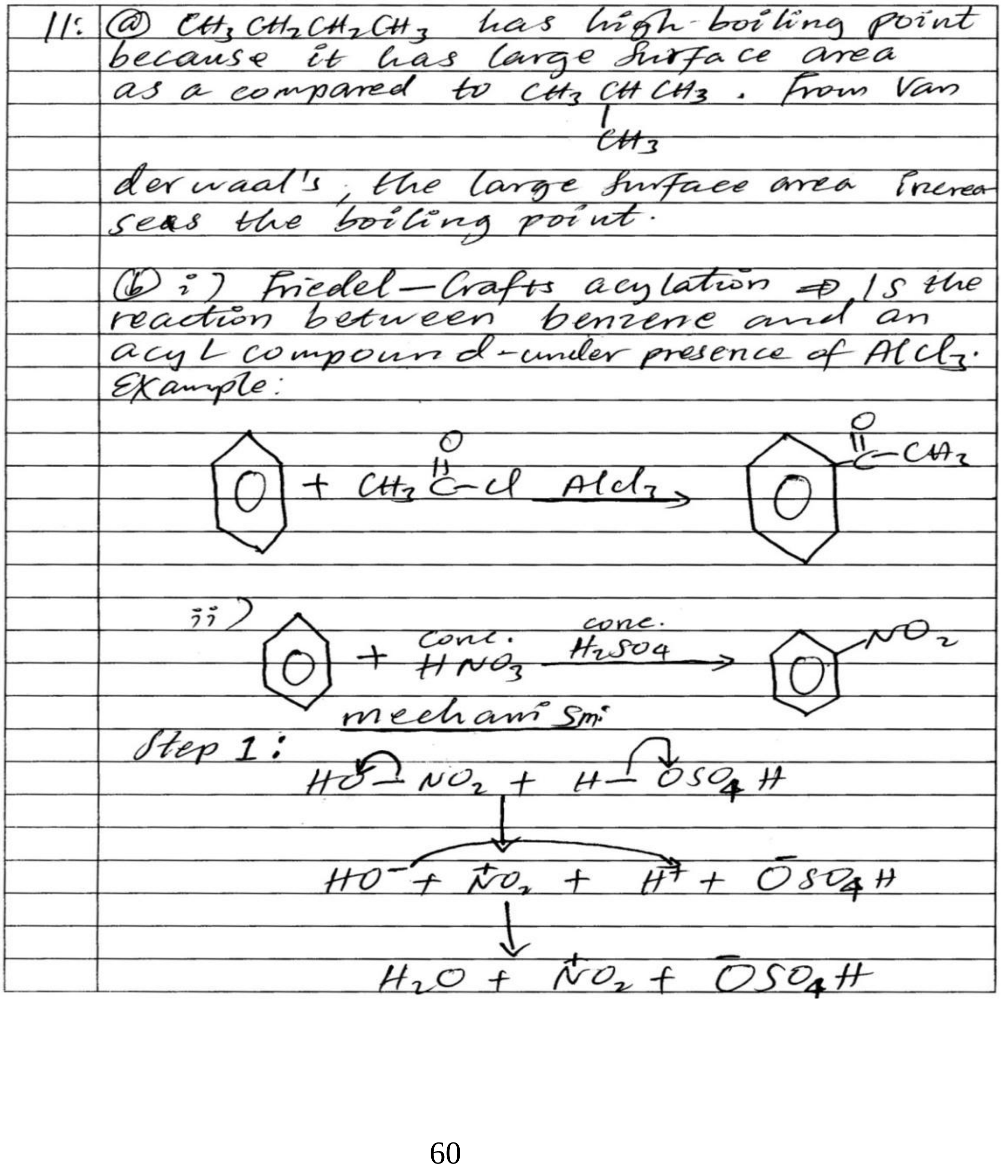


Figure 11: *Performance of the candidates in question 11.*

Figure 11 shows that among the candidates who attempted this question, 52.0 percent scored 0 – 3.0 marks, 30.6 percent scored 3.5 – 5.5 marks while 17.4 percent scored 6.0 – 10 marks. Generally, the performance was average with 48 percent of the candidates scoring 3.5 marks and above. Most of the candidates in this category were able to answer correctly part (a) of this question by focusing on differences in surface area between *n*-butane and 2-methylpropane. This indicated that most of the candidates had good understanding of the effect of surface area and van der Waals' forces on boiling point. Majority of the candidates attempted the three items in part (b) correctly by defining Friedel-Crafts acylation and giving examples and they managed to show the appropriate reaction mechanism in (b)(ii). Most of them were also capable of drawing the correct structure of the product in (b)(iii). In addition, some of these candidates, even included the name of the product which was benzene-1,3-dioic acid. In part (d), most of the candidates in this group were able to give products of the reactions (i) to (iv) correctly. High scores achieved by candidates in this category indicated that they had sufficient knowledge both in writing chemical equations by using appropriate symbols and applying rules governing reaction mechanisms. Extract 11.1 is a sample of good responses in part (a), (b) and (c) in question 11.

Extract 11.1



11: (a) $CH_3CH_2CH_2CH_3$ has high boiling point because it has large surface area as a compared to $CH_3CH(CH_3)CH_3$. From Van derwaal's, the large surface area increases the boiling point.

(b) i) Friedel—Crafts acylation ⇒ Is the reaction between benzene and an acyl compound - under presence of $AlCl_3$.
Example:

ii)

mechanism:

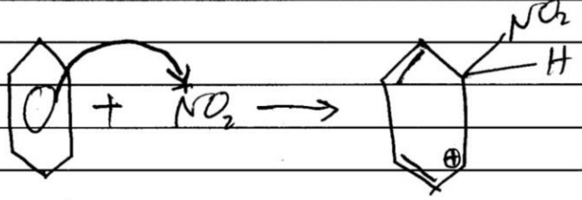
Step 1:

$HO-NO_2 + H-OSO_4H$

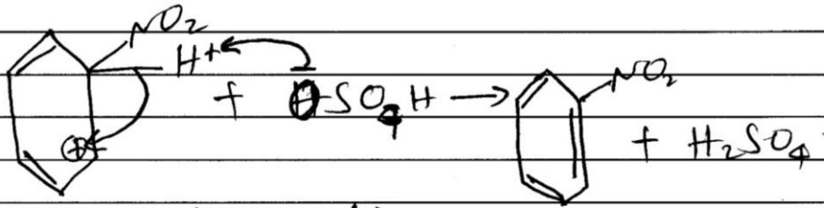
$HO^- + \overset{+}{N}O_2 + H^+ + \bar{O}SO_4H$

$H_2O + \overset{+}{N}O_2 + \bar{O}SO_4H$

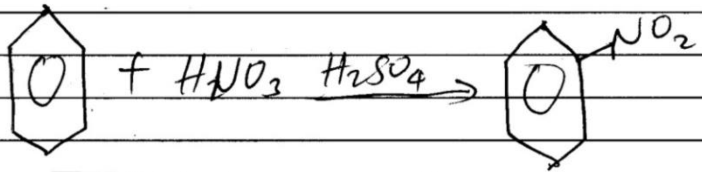
11: ⓑ ii) Step 2:



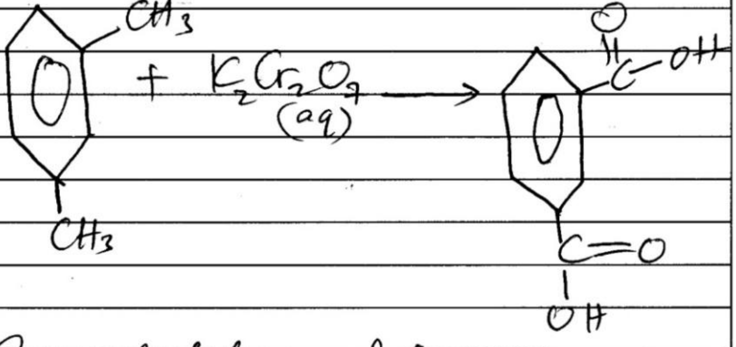
Step 3:



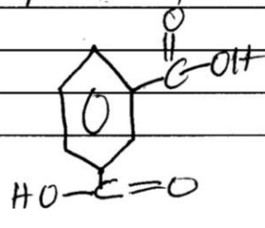
→ overall reaction

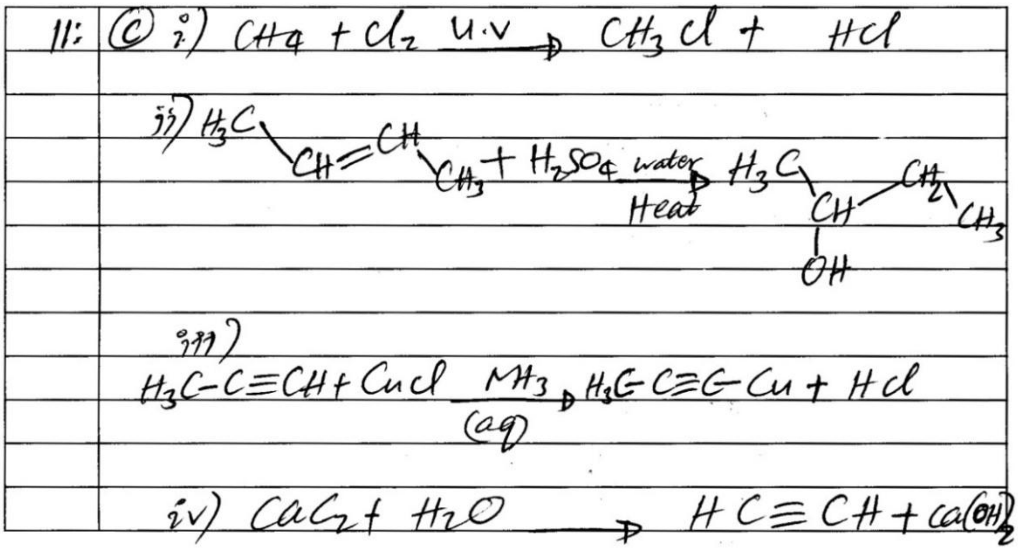


iii)



∴ The product formed is:





11: (c) i) $CH_4 + Cl_2 \xrightarrow{U.V} CH_3Cl + HCl$

ii) $H_3C-CH=CH-CH_3 + H_2SO_4 \xrightarrow[Heat]{water} H_3C-CH(OH)-CH_2-CH_3$

iii) $H_3C-C\equiv CH + CuCl \xrightarrow[(aq)]{NH_3} H_3C-C\equiv C-Cu + HCl$

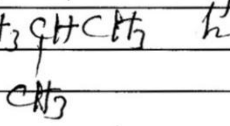
iv) $CaC_2 + H_2O \rightarrow HC\equiv CH + Ca(OH)_2$

In Extract 11.1 the candidate gave correct explanations and products as well as plausible reaction mechanism depending on the demand of each item.

On the other hand, most of the candidates who scored 0 - 3.0 marks failed to account for the differences in boiling points of the compounds in part (a). This shows that they had inadequate ability to relate boiling points with surface area of the molecules. In part (b), most of them failed to show the steps involved in the reaction mechanism of benzene reacting with nitric acid in presence of fuming sulfuric acid. Majority of the candidates in this group failed to draw the chemical structure of the product formed when 1,3-dimethylbenzene was oxidized by potassium dichromate (vi) solution. This showed that the candidates were incompetent in interpreting the factors affecting reaction mechanism such as inductive effect, mesomerism and reactivity of lone pairs. In part (c), most of the candidates gave an incorrect product, a case suggesting that they were not conversant with the concept of functional group interconversions. The poor performance of candidates in this group is attributed to insufficient understanding of principles that determine the type of products to be formed in chemical reactions. Extract 11.2 shows responses of a candidate who gave incorrect answers.

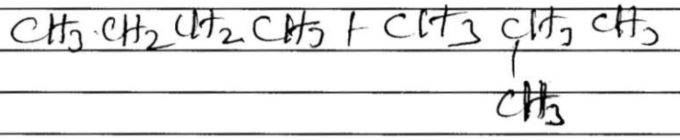
Extract 11.2

11 a) $CH_3CH_2CH_2CH_3$ has a boiling point of -1 2 while



$CH_3\underset{\displaystyle CH_3}{\underset{|}{C}}HCH_3$

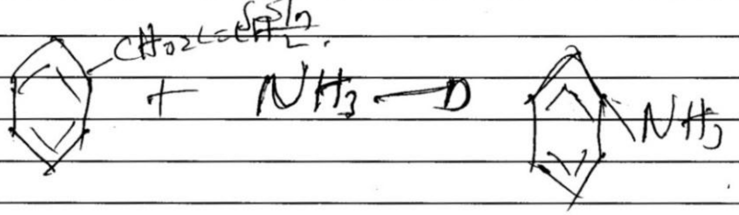
has a boiling point of -12 C

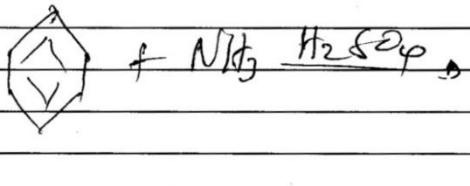


$CH_3 \cdot CH_2CH_2CH_3 + CH_3\underset{\displaystyle CH_3}{\underset{|}{C}}H_2CH_3$

b) i) With one example, state the Meaning of Friedel-crafts acylation

ii) With the aid of illustration, show the reaction mechanism of between benzene and nitric acid,

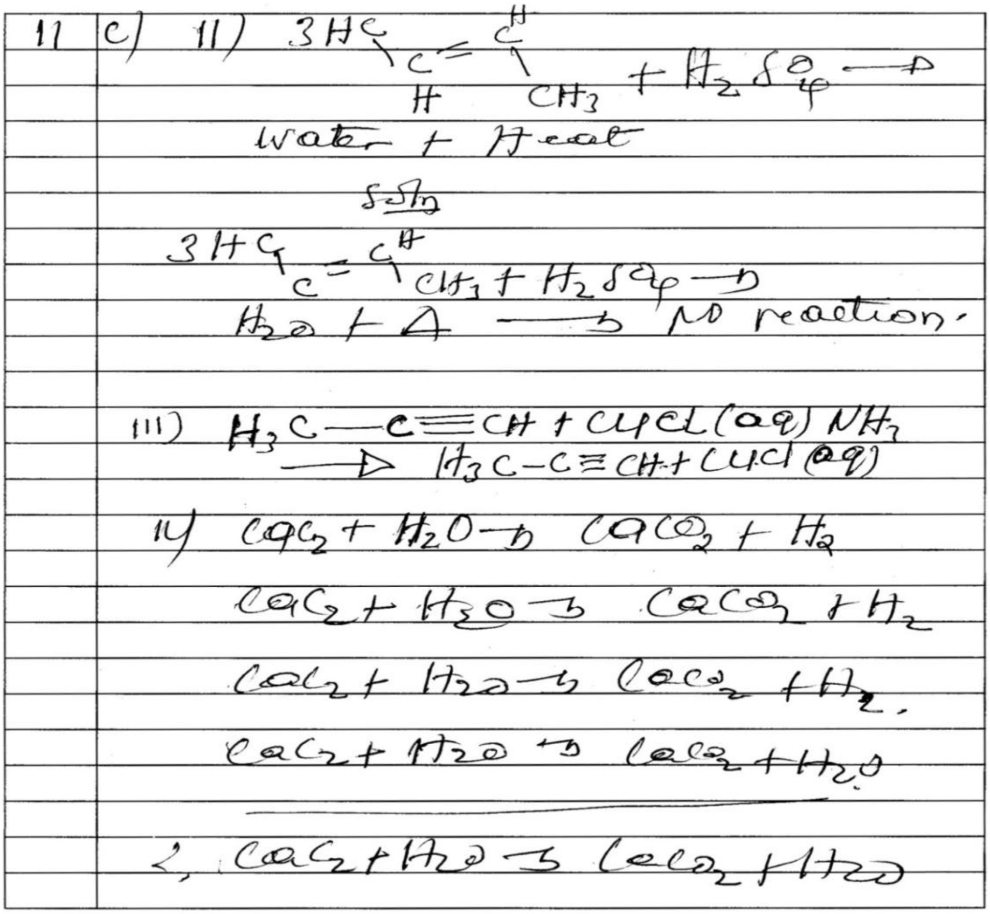




NO reaction taking plales

c) i) write the product of each the following.

i) $CH_{4} + Cl_2 \xrightarrow{UV} CH_4 Cl_2$



11 c) 11) 3HC C= C H H CH$_3$ + H_2SO_4 →

Water + Heat

Soln

3HC C= C H CH$_3$ + H_2SO_4 →

H_2O + Δ → no reaction.

III) $H_3C—C≡CH$ + CuCl(aq) NH_3

→ $H_3C–C≡CH$ + CuCl (aq)

IV) $CaC_2 + H_2O$ → $CaCO_2 + H_2$

$CaC_2 + H_2O$ → $CaCO_2 + H_2$

$CaC_2 + H_2O$ → $CaCO_2 + H_2$.

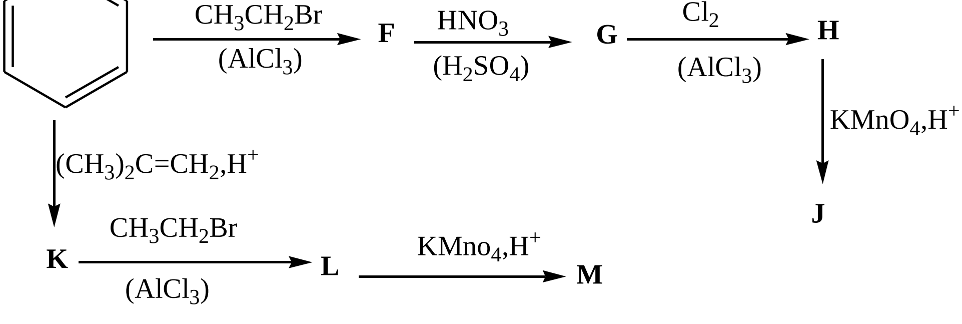
$CaC_2 + H_2O$ → $CaCO_2 + H_2O$

2, $CaC_2 + H_2O$ → $CaCO_2 + H_2O$

In Extract 11.2, the candidate copied some items from the question paper, used irrelevant formula equations and failed to show the reaction mechanism for benzene when reacting with nitric acid in presence of sulfuric acid.

2.1.12 Question 12: Aromatic Hydrocarbons

Part (a) of this question required candidates to give the structural formula of the aromatic compounds **F** to **M** which were formed from the following reaction scheme:



In part (b), the candidates were asked to give the product of chlorination of benzene and methylbenzene in the presence of: (i) a halogen carrier catalyst and (ii) ultra-violet light.

The question was attempted by 21,755 candidates corresponding to 65.4 percent. The scores in this question were as follows: 43.3 percent of the candidates scored marks ranging from 0 - 3.0, 28 percent scored from 3.5 - 5.5 marks while 28.7 of the candidates scored marks ranging from 6.0 - 10. The candidates performance in this question is summarized in Figure 12.

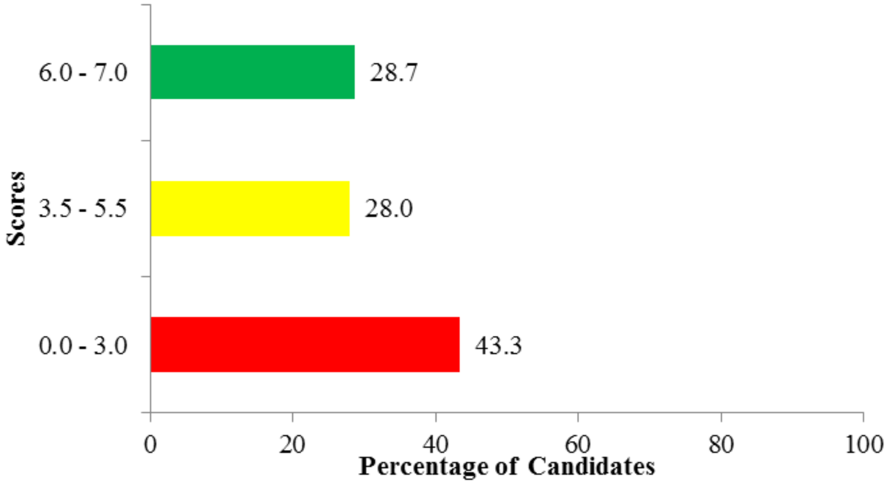
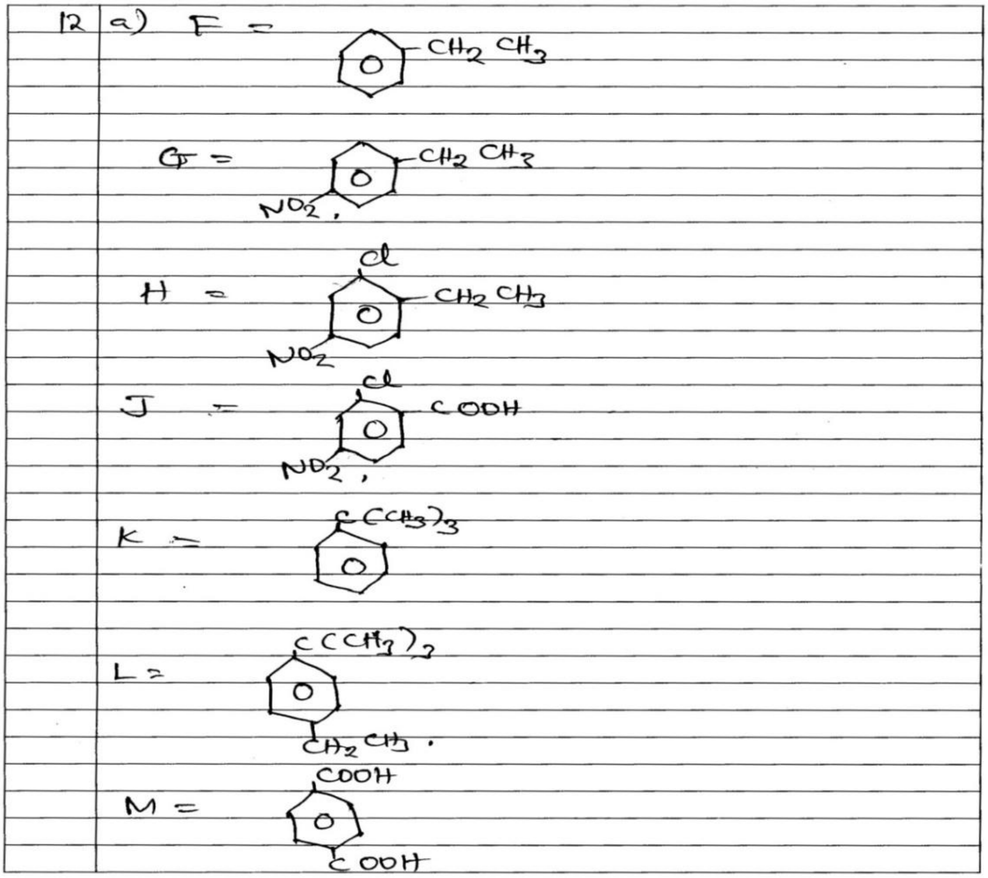


Figure 12: *Performance of the candidates in question 12.*

Data summarized in Figure 12 shows that 56.7 percent of the candidates passed the question. This signified that the overall performance in this question was average. Few candidates who managed to score high marks had mastered properly the concepts of aromatic hydrocarbons particularly the types of reactions which benzene undergoes at different reaction conditions. Hence, they were able to give appropriate products for alkylation, nitration, and chlorination of benzene. Furthermore, they were able to recall the basic concepts regarding the directive influences of substituent groups on benzene ring, which in turn enabled them to attempt part (b) correctly. Extract 12.1 displays a sample of good responses from one of the candidates in part (a).

Extract 12.1

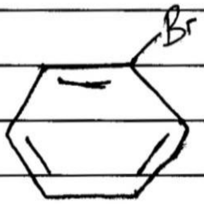


Extract 12.1 shows that the candidates gave correct products **F**, **G**, **H**, **J**, **K**, **L** and **M** by drawing the structures.

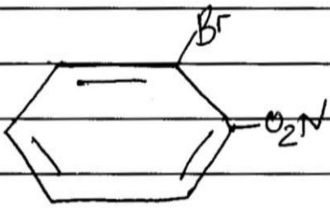
Further analysis of the candidates responses in this question, indicated that most of the candidates who scored low marks (0 - 3.0) were not knowledgeable enough regarding the basic types of reactions undertaken by aromatic hydrocarbons (benzene). Therefore, the candidates in this category failed to supply appropriate structures for the products in part (b). Extract 12.2 illustrates a poor response from one of the candidates for part (a) and (b).

Extract 12.2

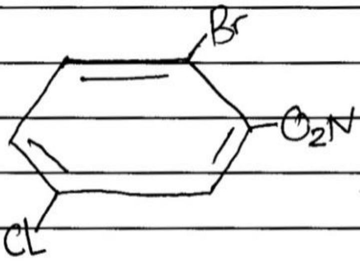
12. F =



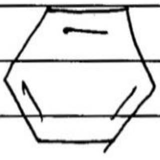
G =



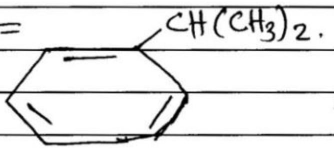
H =



J =

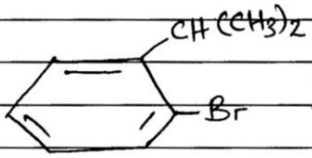


12 a/ K =



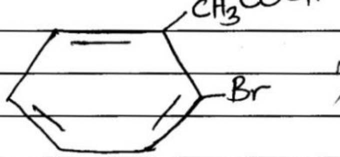
✗

L =

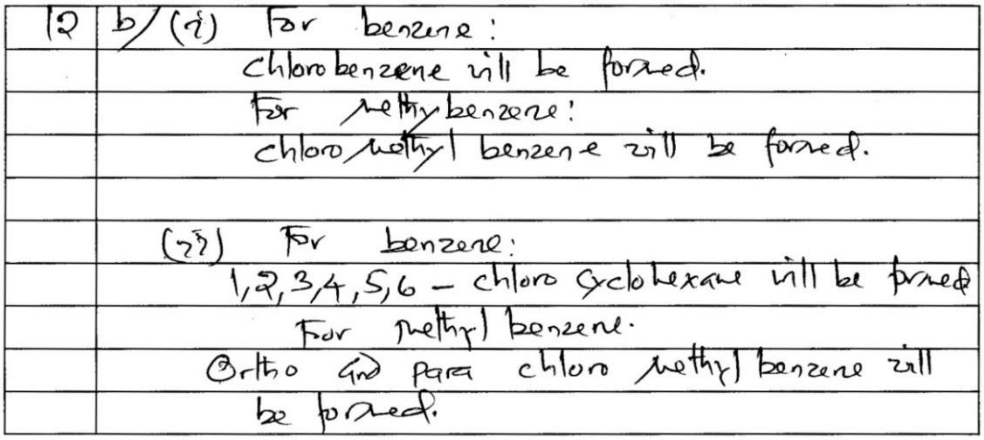


✗

M =



✗



12 b/ (i) For benzene:

Chlorobenzene will be formed.

For methylbenzene:

chloro methyl benzene will be formed.

(ii) For benzene:

1,2,3,4,5,6 – chloro cyclohexane will be formed

For methyl benzene.

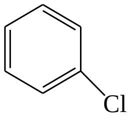
Ortho and para chloro methyl benzene will be formed.

In Extract 12.2 the candidate gave incorrect structural formula for compounds F to M in part (a) as well as irrelevant products in part (b).

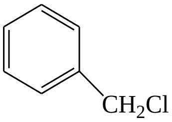
2.1.13 Question 13: Halogen Derivatives of Hydrocarbons

Part (a) required the candidates to outline with the aid of reaction equations, six different applications of haloalkanes in the process of organic synthesis. In part (b), the candidates were required to provide the chemical test used to distinguish each of the given pairs of organic compounds:

(i)



and



(ii) H_3C-CH_2Br and $H_2C=CHCH_3$

Part (c) required the candidates to give a reason why silver nitrate solution does not precipitate the chloride in 1-chloropropene, but it does so in 1-chloropropane.

The candidates who attempted this question were 11,026 corresponding to 33.2 percent. Distribution of scores in this question was as follows: 56.7 percent scored marks ranging from 0 - 3.0, 24.1 percent scored from 3.5 - 5.5 while 19.2 percent scored marks in the range of 6.0 - 10. Performance in this question is summarized in Figure 13.

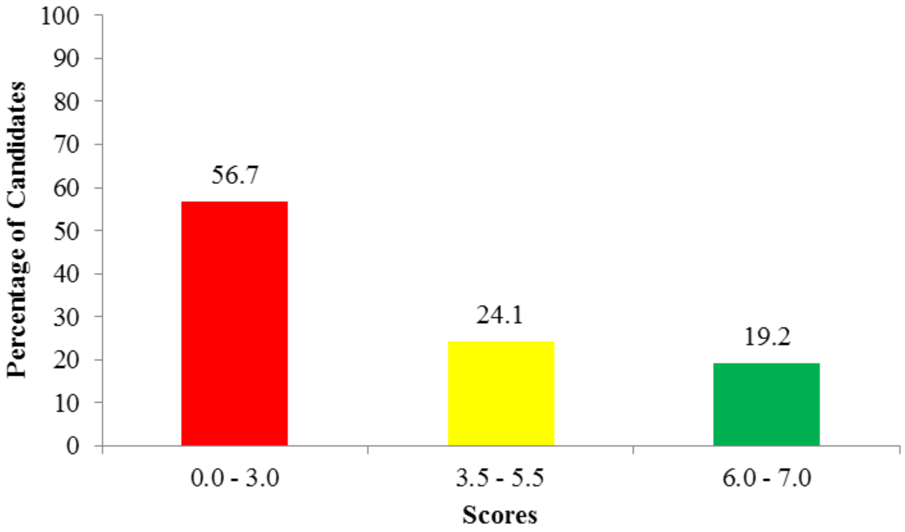
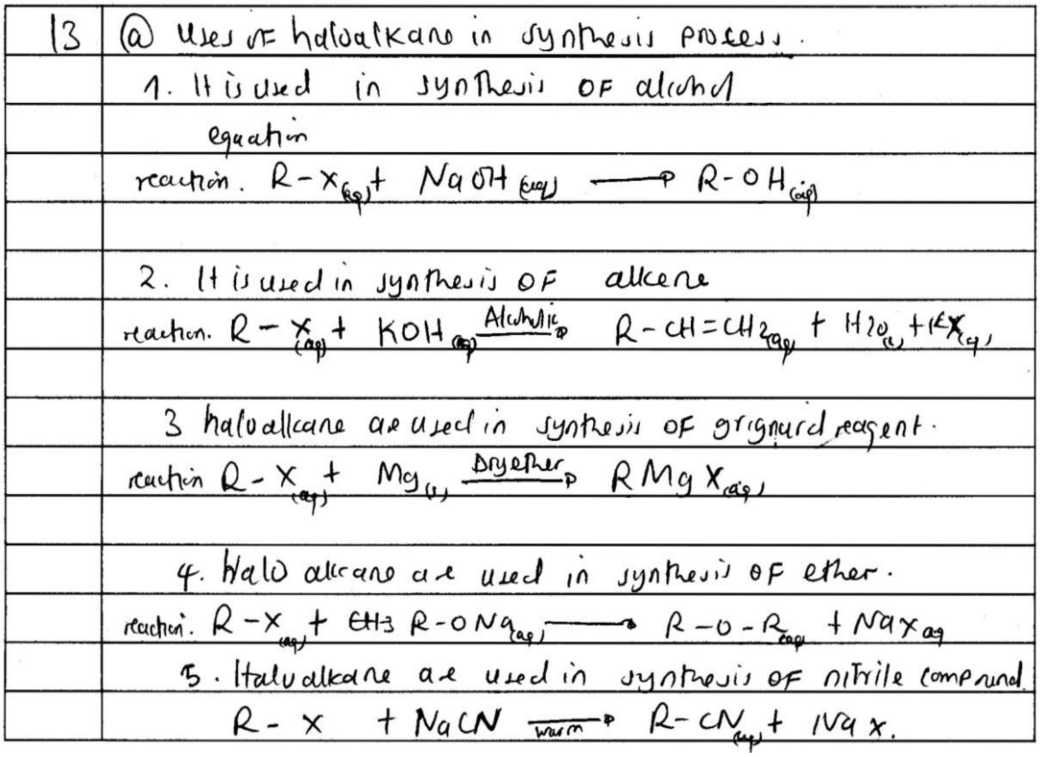


Figure 13: *Performance of the candidates in question 13.*

Figure 13 shows that 56.7 percent of the candidates scored below the average mark from 0 - 3.0. Further analysis showed that 43.3 percent of the candidates were able to score 3.5 marks and above. This signifies that the overall performance in this question was average, but leaning towards the lower margin. Some candidates among those with high marks managed to respond appropriately to most parts of the question. They demonstrated satisfactory competence on the topic of halogen derivatives of hydrocarbons. Hence, most of them were able to account for the applications of haloalkanes in organic synthesis aided by supplying suitable reaction equations. Some of them were able to differentiate correctly between the given pairs of organic compounds. Furthermore, some few candidates managed to apply correctly the concept of inductive effects in part (c) and established the bond strength between carbon and chlorine. Eventually, they were able to provide an appropriate account on the reactivity of 1-chloropropane and 1-chloropropene against silver nitrate on the basis of their bond strength. Extract 13.1 is a sample of good responses in question 13.

Extract 13.1



13 @ Uses of haloalkane in synthesis process.

1. It is used in synthesis OF alcohol

equation

reaction. $R-X_{(aq)} + NaOH_{(aq)} \longrightarrow R-OH_{(aq)}$

2. It is used in synthesis OF alkene

reaction. $R-X_{(aq)} + KOH_{(aq)} \xrightarrow{Alcoholic} R-CH=CH2_{(aq)} + H2O_{(l)} + KX_{(aq)}$

3 haloalkane are used in synthesis OF grignard reagent.

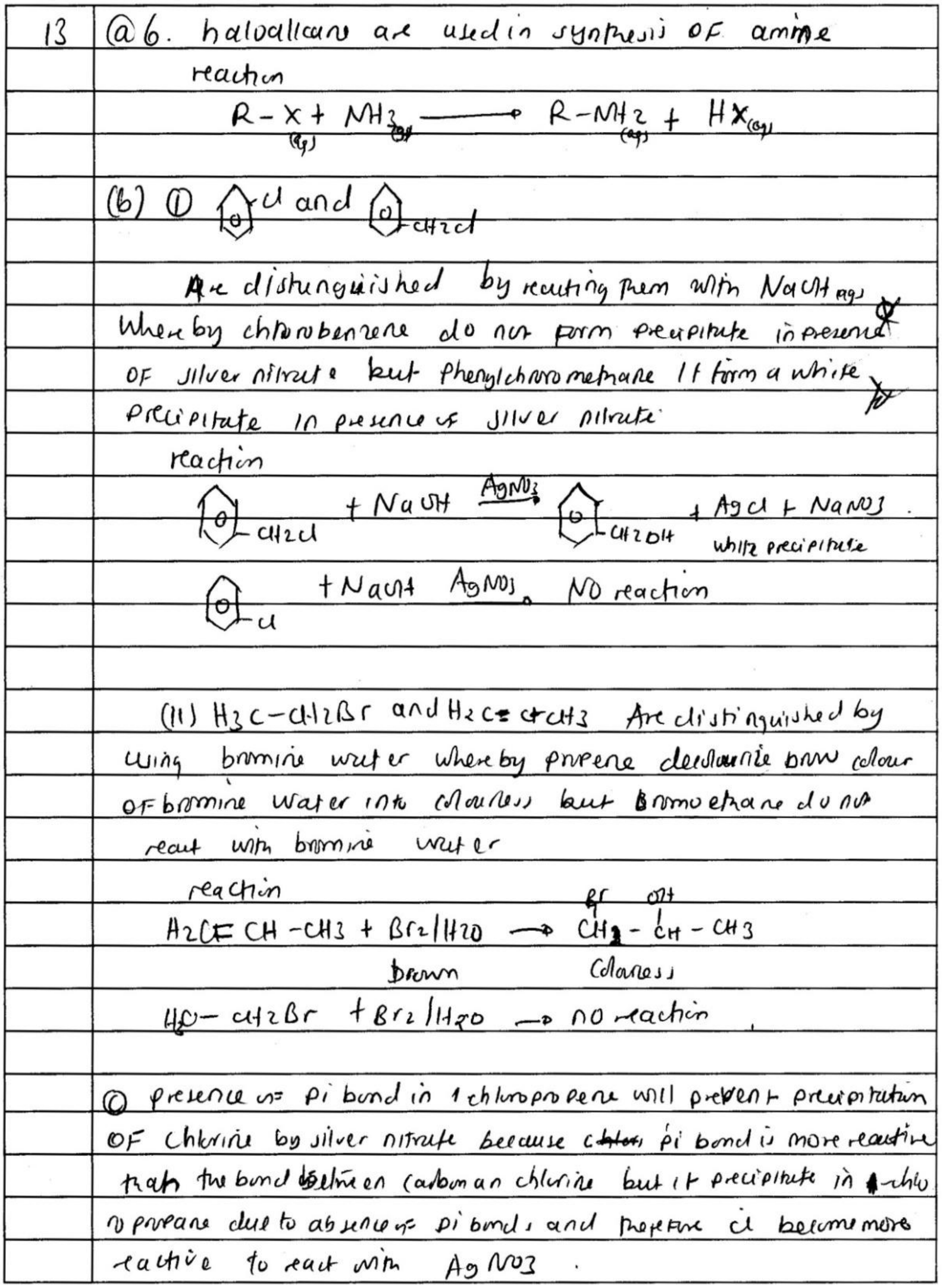
reaction $R-X_{(aq)} + Mg_{(s)} \xrightarrow{Dry ether} RMgX_{(aq)}$

4. Halo alkane are used in synthesis OF ether.

reaction. $R-X_{(aq)} +$ ~~CH3~~ $R-ONa_{(aq)} \longrightarrow R-O-R_{(aq)} + NaX_{aq}$

5. Haloalkane are used in synthesis OF nitrile compound.

$R-X + NaCN \xrightarrow[warm]{} R-CN_{(aq)} + NaX.$



13 (a) 6. haloalkane are used in synthesis OF amine

reaction

$$R-X_{(aq)} + NH_{3(aq)} \longrightarrow R-NH_{2(aq)} + HX_{(aq)}$$

(b) (i) $\bigcirc$-Cl and $\bigcirc$-CH2Cl

Are distinguished by reacting them with $NaOH_{(aq)}$ Whereby chlorobenzene do not form precipitate in presence OF silver nitrate but Phenylchloromethane It form a white precipitate in presence of silver nitrate

reaction

$$\bigcirc\!-CH_2Cl + NaOH \xrightarrow{AgNO_3} \bigcirc\!-CH_2OH + \underset{\text{white precipitate}}{AgCl} + NaNO_3.$$

$$\bigcirc\!-Cl + NaOH \xrightarrow{AgNO_3} \text{NO reaction}$$

(ii) H_3C-CH_2Br and $H_2C=CHCH_3$ Are distinguished by using bromine water whereby propene decolourize brown colour OF bromine water into colourless but Bromoethane do not react with bromine water

reaction

$$H_2C=CH-CH_3 + \underset{\text{brown}}{Br_2/H_2O} \longrightarrow \underset{\text{colourless}}{\overset{Br}{CH_2}-\overset{OH}{CH}-CH_3}$$

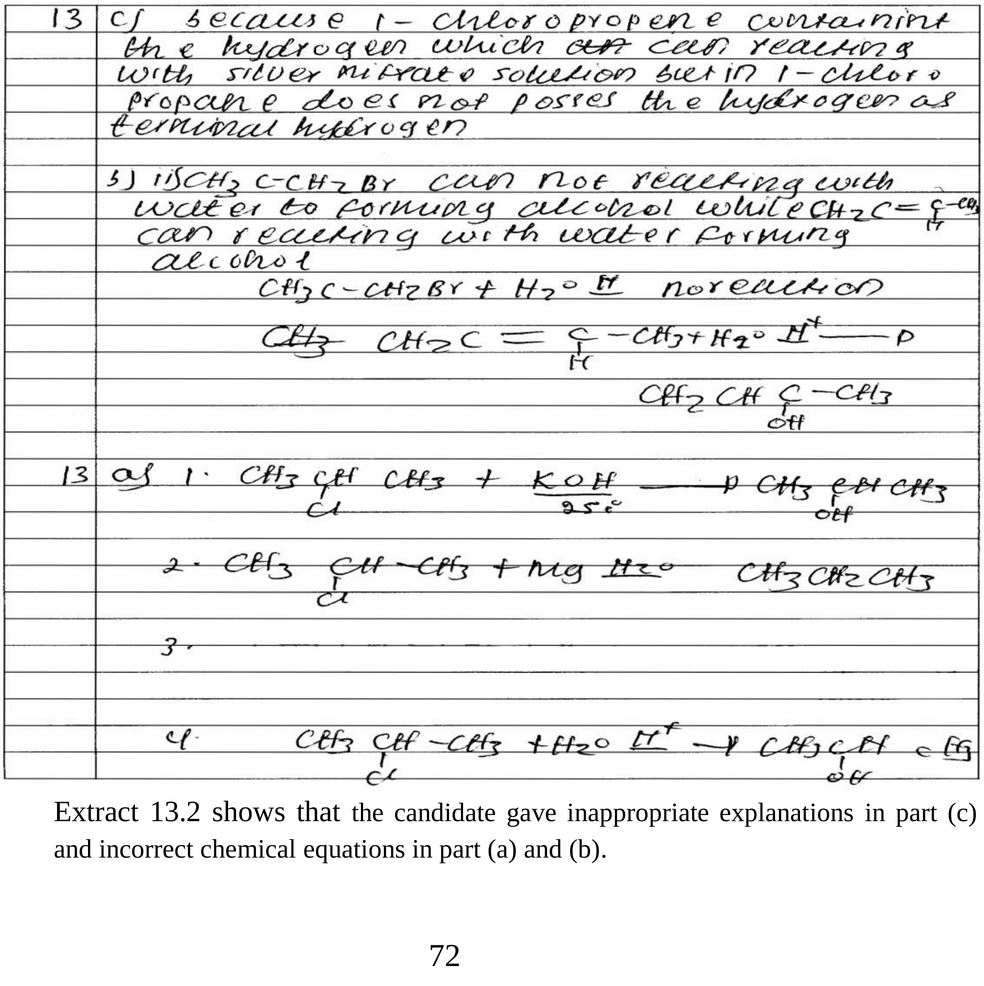
$$H_3C-CH_2Br + Br_2/H_2O \longrightarrow \text{no reaction}$$

(c) presence of pi bond in 1 chloropropene will prevent precipitation OF chlorine by silver nitrate because c~~[illegible]~~ pi bond is more reactive than the bond between carbon an chlorine but it precipitate in 1-chloropropane due to absence of pi bond, and therefore cl become more reactive to react with $AgNO_3$.

Extract 13.1 is an illustration of good responses from one of the candidates who managed to answer all the parts of the question correctly and scored full marks.

However, majority of the candidates (56.7 percent) scored low marks in this question. Most of them failed to understand the requirements of the question. For example, one of the candidates mentioned the applications of haloalkanes in organic synthesis with the aid of reaction equations as "*used in production of manure, used in production of fertilizer, used in manufacture of salt when react with base and used in manufacture of medicines*". This showed that, those candidates had insufficient competencies on the topic of Halogen Derivatives of Hydrocarbons, particularly its central application in the synthesis of other organic compounds. In part (b), some of the candidates failed to provide the chemical tests used to distinguish between the given pairs of organic compounds. This indicated that the candidates were not familiar with the properties of the functional groups in the given pairs of compounds and their specific reactions. Hence, the candidates in this category failed to account for the physical changes which could be observed to distinguish the given pairs of organic molecules. Extract 13.2 illustrates an example of the poor responses in question 13.

Extract 13.2



13 c) because 1- chloropropene containint the hydrogen which ~~can~~ can reacting with silver nitrate solution but in 1-chloro propane does not posses the hydrogen as terminal hydrogen

b) i) CH_3C-CH_2Br can not reacting with water to forming alcohol while $CH_2C=\underset{H}{\underset{|}{C}}-CH_3$ can reacting with water forming alcohol

$CH_3C-CH_2Br + H_2O \xrightarrow{H}$ noreaction

$\cancel{CH_3}\ CH_2C=\underset{H}{\underset{|}{C}}-CH_3+H_2O \xrightarrow{H^+}$

$CH_2CH\underset{OH}{\underset{|}{C}}-CH_3$

13 a) 1. $CH_3\underset{Cl}{\underset{|}{CH}}CH_3 + \frac{KOH}{25°c} \longrightarrow CH_3\underset{OH}{\underset{|}{CH}}CH_3$

2. $CH_3\underset{Cl}{\underset{|}{CH}}-CH_3 + Mg\ \underline{H_2O}\quad CH_3CH_2CH_3$

3.

4. $CH_3\underset{Cl}{\underset{|}{CH}}-CH_3 + H_2O \xrightarrow{H^+} CH_3\underset{OH}{\underset{|}{C}}H$ c [illegible]

Extract 13.2 shows that the candidate gave inappropriate explanations in part (c) and incorrect chemical equations in part (a) and (b).

2.1.14 Question 14: Halogen Derivatives of Hydrocarbons

Part (a) of the question required the candidates to arrange the following alkyl bromides in order of decreasing reactivity towards an S_N1 type of attack: (i) CH_3Br, (ii) $C(CH_3)_3Br$, (iii) $CH(CH_3)_2Br$ and (iv) $CH_3CH_2CH_2Br$. Part (b) required the candidates to write the mechanism for each of the following substitution reactions:

(i) $CH_3CH_2OH + HBr \longrightarrow CH_3CH_2Br + H_2O$

(ii) $CH_3SCH_3 + CH_3I \longrightarrow (CH_3)_3S^+I^-$

In part (c), the candidates were provided with the information that: "When phenol is treated with Br_2, a mixture of monobromophenol, dibromophenol and tribromophenol are obtained". The candidates were required to write a synthesis mechanism to convert phenol to: (i) 2-bromophenol and (ii) 4-bromophenol.

A total of 17,110 candidates corresponding to 51.5 percent attempted this question. The scores in this question were as follows: 98.3, 1.3 and 0.4 percent of the candidates scored 0 - 3.0, 3.5 - 5.5 and 6.0 - 10 marks respectively. Table 1 summarizes performance of the candidates in this question.

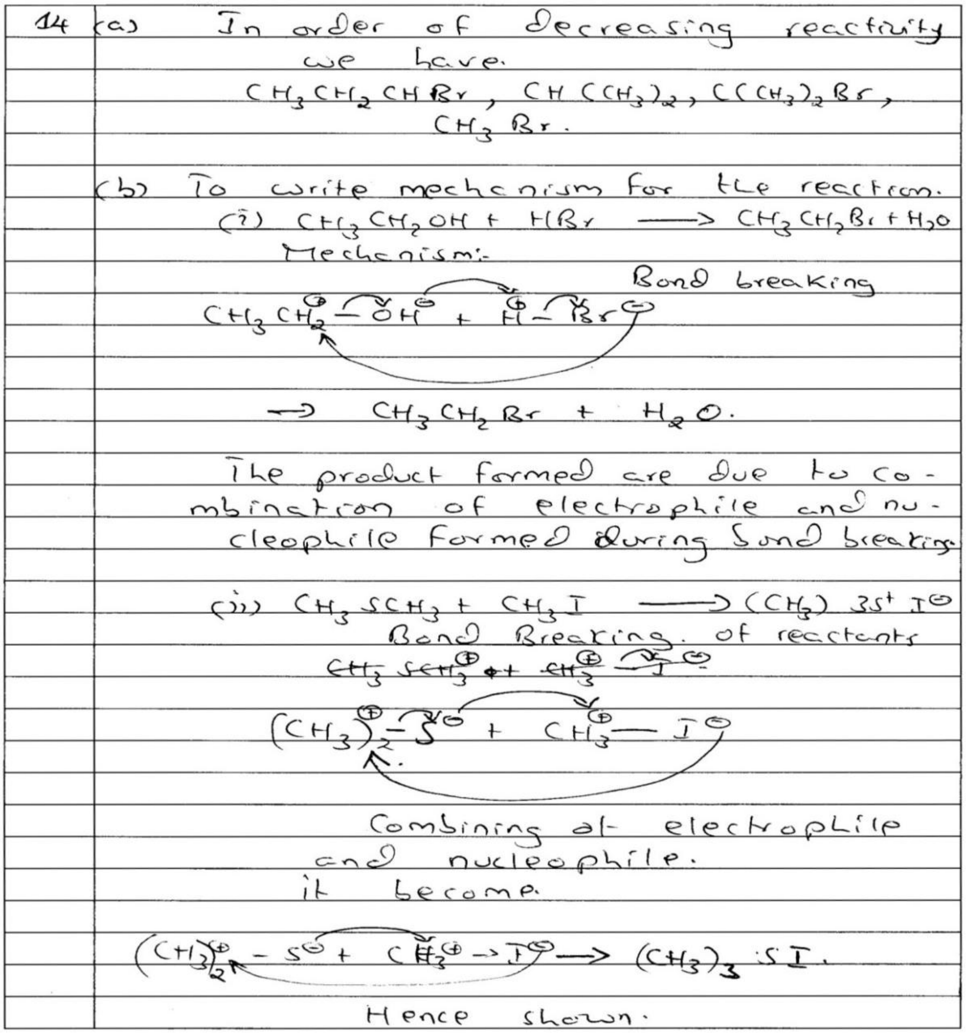
Table 1: Scores, Number of Candidates and Percentage of Candidates in question 14

Scores	Number of Candidates	Percentage of Candidates
0.0 - 3.0	16819	98.3
3.5 - 5.5	221	1.3
6.0 - 7.0	70	0.4

Statistical data in Table 1 shows that majority of the candidates summing up to 98.3 percent scored poor marks out of which 88.0 percent equivalent to 15,060 candidates scored zero mark. Data analysis indicated that only 1.7 percent of the candidates who attempted the question scored 3.5 marks and above. This signifies that the overall performance in this question was poor. In addition, the overall analysis across different questions in paper 1 showed that the candidates performed the least in this question.

Majority of the candidates scored poorly in nearly all parts of the question. They were not knowledgeable enough regarding types of organic reaction and reaction mechanisms. Hence, they failed to establish the trend in stability of the carbocations formed in part (a), and could not deduce the order of decrease in reactivity towards S_N1 type of attack. Consequently, the candidates failed to propose plausible reaction mechanism in subsequent sections (b) and (c). Most of them failed to devise a mechanism which would avoid formation of the mixture of phenolic products. As a result, most of the candidates lost all marks in this part which weighed nearly half of the total marks allocated to the question. Extract 14.1 is a sample of poor responses in this question.

Extract 14.1



14 (a) In order of Decreasing reactivity we have.

CH_3CH_2CHBr, $CH(CH_3)_2$, $C(CH_3)_2Br$, CH_3Br.

(b) To write mechanism for the reaction.

(i) $CH_3CH_2OH + HBr \longrightarrow CH_3CH_2Br + H_2O$

Mechanism:-

Bond breaking

$CH_3CH_2^{\oplus} - OH^{\ominus} + H^{\oplus} - Br^{\ominus}$

$\longrightarrow CH_3CH_2Br + H_2O.$

The product formed are due to combination of electrophile and nucleophile formed during bond breaking

(ii) $CH_3SCH_3 + CH_3I \longrightarrow (CH_3)3S^+ I^{\ominus}$

Bond Breaking. of reactants

~~$CH_3SCH_3^{\oplus} + CH_3^{\oplus} - I^{\ominus}$~~

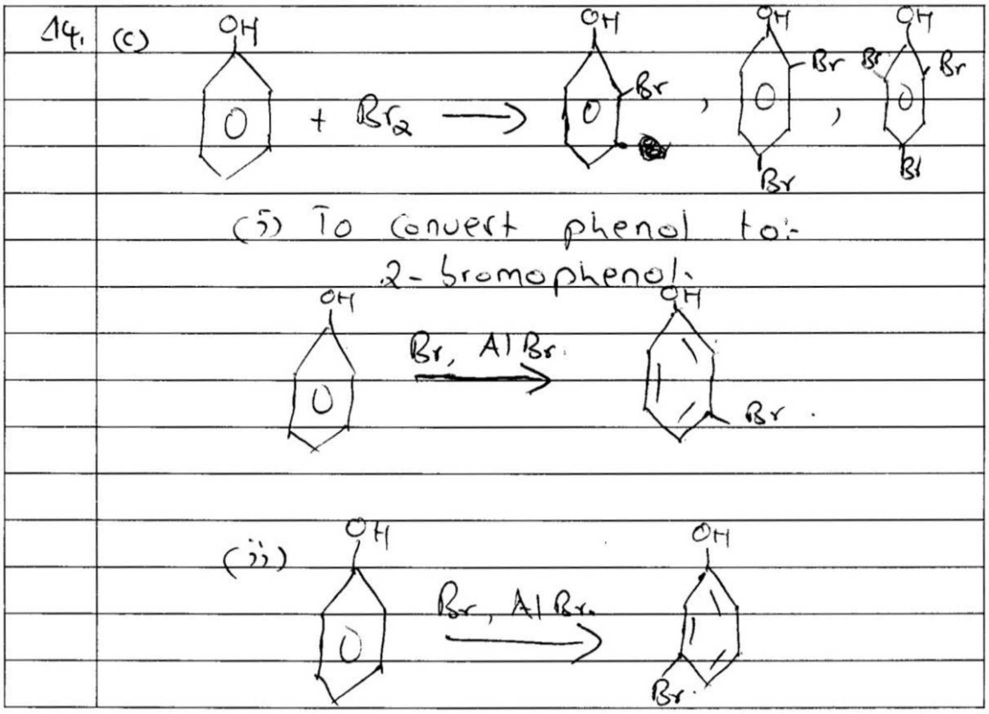
$(CH_3)_2^{\oplus} - S^{\ominus} + CH_3^{\oplus} - I^{\ominus}$

Combining of electrophile and nucleophile.

it become

$(CH_3)_2^{\oplus} - S^{\ominus} + CH_3^{\oplus} \to I^{\ominus} \longrightarrow (CH_3)_3SI.$

Hence shown.



14. (c)

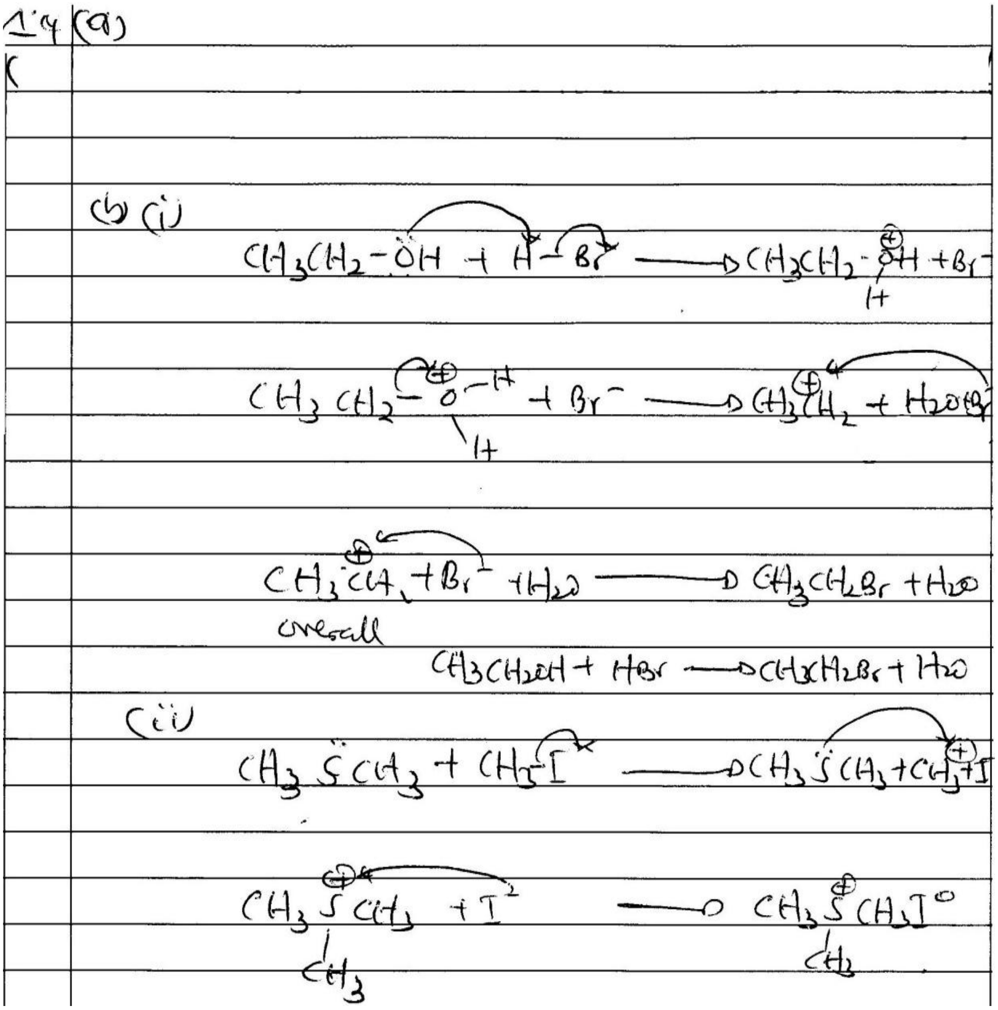
(i) To convert phenol to:-
2-bromophenol.

(ii)

Extract 14.1 shows that the candidate gave incorrect trend of reactivity of alkylbromides towards S_N1 reaction in part (a). He/she devised improper mechanisms in part (b) and gave an approach which results into a mixture of phenolic products in part (c) contrary to the requirement of the question.

On the other hand few candidates who managed to score high marks in this question were able to attempt most parts of the question correctly. These candidates showed good understanding of both the concept of reaction mechanisms and the rules of writing the reaction mechanism. As a result, some of the candidates managed to score all the marks allocated in part (b). Extract 14.2 represents responses from a candidate who provided appropriate responses in part (b).

Extract 14.2



1.4 (a)

(

(b) (i)

$CH_3CH_2-\ddot{O}H + H-Br \longrightarrow CH_3CH_2-\overset{\oplus}{\underset{H}{O}}H + Br^-$

$CH_3CH_2-\overset{\oplus}{\underset{H}{O}}-H + Br^- \longrightarrow CH_3\overset{\oplus}{C}H_2 + H_2O + Br^-$

$CH_3\overset{\oplus}{C}H_2 + Br^- + H_2O \longrightarrow CH_3CH_2Br + H_2O$

overall

$CH_3CH_2OH + HBr \longrightarrow CH_3CH_2Br + H_2O$

(ii)

$CH_3\ddot{S}CH_3 + CH_3-I \longrightarrow CH_3\ddot{S}CH_3 + \overset{+}{C}H_3 + I$

$CH_3\overset{\oplus}{\underset{CH_3}{S}}CH_3 + I^- \longrightarrow CH_3\overset{\oplus}{\underset{CH_3}{S}}CH_3I^{\circ}$

In Extract 14.2, the candidate gave correct reaction mechanisms for the two reactions in part (b)(i) and (ii).

2.2 132/2-CHEMISTRY 2

This paper had a total of ten (10) questions. Each question carried 20 marks. The pass mark in each question was 7 marks.

2.2.1 Question 1: Chemical Kinetics

This question had three parts; (a), (b), and (c). Part (a) of the question, required the candidates to define rate of reaction, reaction mechanism, rate constant, molecularity of reaction, zero order reaction and half life. In part (b), the candidates were provided with the initial concentrations of the reactants and initial rates of the reaction with regard to chemical equation:

$2NO(g) + 2H_2(g) \rightarrow N_2(g) + H_2O(g)$ as follows:

Experiment	**Initial [NO] (M)**	**Initial $[H_2]$(M)**	**Initial rate (M/s)**
1	5×10^{-3}	2×10^{-3}	1.3×10^{-5}
2	10×10^{-3}	2×10^{-3}	5×10^{-5}
3	10×10^{-3}	4×10^{-3}	10×10^{-5}

The candidates were required to determine the order of reaction with respect to each reactant and the overall order of reaction, establish the rate law for the reaction, and calculate the rate constant. In part (c), the candidates were provided with the information that: "The conversion of cyclopropane to propene in gas phase is a first order reaction with a rate constant of 6.7×10^{-4} s^{-1} at 500 ^{o}C". From this information, the candidates were required in part (c)(i) to calculate the concentration of cyclopropane after 8.8 minutes if the initial concentration was 0.25 M. In part (c)(ii), the candidates were required to calculate the time taken for the concentration of cyclopropane to decrease from 0.25 M to 0.15 M. In the last part of the question, (c)(iii), the candidates were required to calculate the time taken to achieve the conversion of the starting material to reach 74%.

This question was attempted by 29,495 candidates corresponding to 88.7 percent. This was the question that was attempted by most of the candidates in both paper 1 and paper 2. The performance of the candidates is shown in Figure 14.

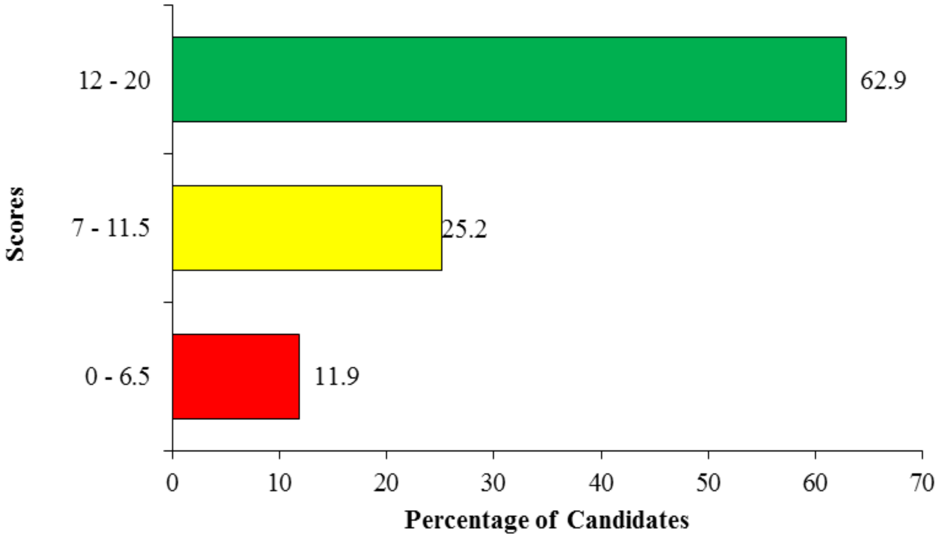
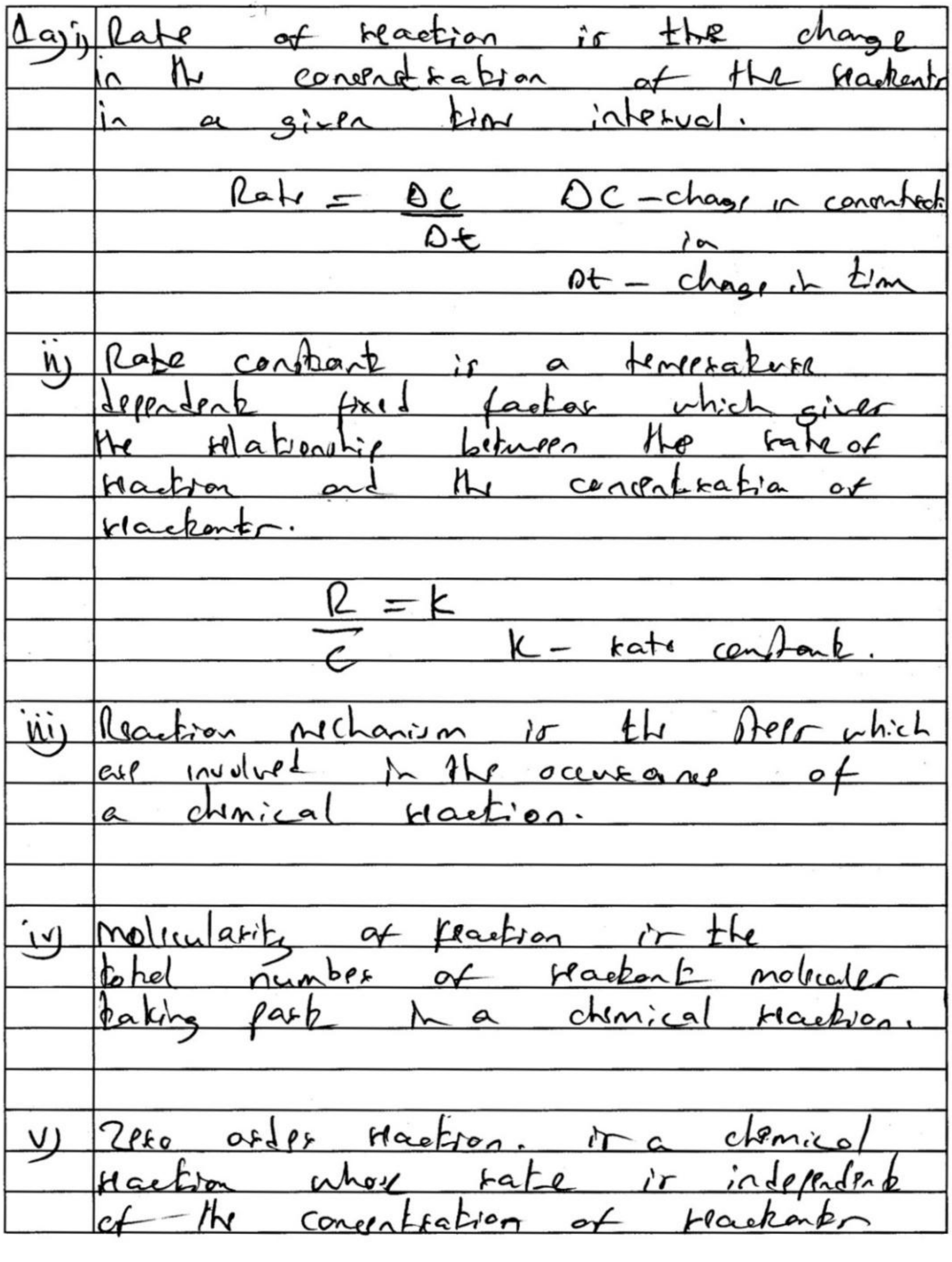


Figure 14: *Performance of the candidates in question 1.*

Figure 14 shows that 88.1 percent of the candidates passed the question, with the majority (62.9 %) scoring marks ranging from 12 - 20. The candidates who managed to score all the 20 marks were 1.5 percent. Most of the candidates who scored high marks demonstrated a good understanding on the concepts of Chemical Kinetics, hence they were able to state the meaning of the terms asked. Most of them were also able to show the relationship between the initial concentrations and the rate of the chemical reactions leading to the correct deduction of the order of the reaction. Extract 15.1 shows responses from one of the candidates who gave correct answers and scored full mark in question 1.

Extract 15.1



1 a) i) Rate of reaction is the change in the concentration of the reactants in a given time interval.

$$Rate = \frac{\Delta C}{\Delta t}$$

ΔC – change in concentrati

in

Δt – change in time

ii) Rate constant is a temperature dependent fixed factor which gives the relationship between the rate of reaction and the concentration of reactants.

$$\frac{R}{C} = K$$

K – rate constant.

iii) Reaction mechanism is the steps which are involved in the occurance of a chemical reaction.

iv) Molecularity of reaction is the total number of reactant molecules taking part in a chemical reaction.

v) Zero order reaction. is a chemical reaction whose rate is independent of the concentration of reactants

vi) Half life is the time taken half of the amount of reactant present to form products.

b) i) from; $R = k[NO]^x[H_2]^y$

1, $1.3\times10^{-5} = k(5\times10^{-3})^x(2\times10^{-3})^y$

2, $5\times10^{-5} = k(10\times10^{-3})^x(2\times10^{-3})^y$

3, $10\times10^{-5} = k(10\times10^{-3})^x(4\times10^{-3})^y$

for x; take 2 ÷ 1

$$\frac{5\times\cancel{10^{-5}}}{1.3\times\cancel{10^{-5}}} = \frac{\cancel{k}(10\times10^{-3})^x}{\cancel{k}(5\times10^{-3})^x}\frac{\cancel{(2\times10^{-3})^y}}{\cancel{(2\times10^{-3})^y}}$$

$$\frac{5}{1.3} = \left(\frac{10\times\cancel{10^{-3}}}{5\times\cancel{10^{-3}}}\right)^x$$

$$\frac{5}{1.3} = 2^x$$

$$\frac{\log \frac{5}{1.3}}{\log 2} = x \qquad \underline{x = 2}$$

for y; take 2 ÷ 3

$$\frac{5\times\cancel{10^{-8}}}{10\times\cancel{10^{-8}}} = \frac{\cancel{k}}{\cancel{k}}\cancel{\left(\frac{10\times10^{-3}}{10\times10^{-3}}\right)^{\alpha}}\times\left(\frac{2\times\cancel{10^{-3}}}{4\times\cancel{10^{-3}}}\right)^{y}$$

$$\frac{5}{10} = \left(\frac{2}{4}\right)^{y}$$

$$0.5 = 0.5^{y} \qquad y = 1$$

order of reaction with respect to [NO] was 2

order of reaction with respect to [H$_2$] was 1

overall order = 2 + 1 = 3

The overall order of reaction was 3

ii) $R = k[NO]^{x}[H_2]^{y}$

$\alpha = 2$

$y = 1$

Then rate law

$R = k[NO]^{2}[H_2]$

iii)

$R = K[NO]^2[H_2]$

considers experiment 3

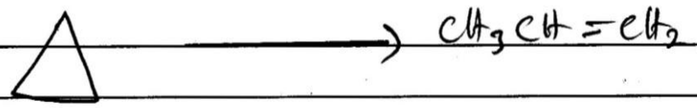
$10\times10^{-5} = K(10\times10^{-3})^2 \times (4\times10^{-3})$

$$K = \frac{10\times10^{-5}\ M/s}{(10\times10^{-3})^2\times(4\times10^{-3})\ M^2}$$

$\underline{K = 250\ M^{-2}s^{-1}}$

The rate constant is $250\ M^{-2}s^{-1}$

c) $k = 6.7\times10^{-4}\ s^{-1}$



i)

$a = 0.25M$

$t = 8.8\times60 = 528s$

$a-x = ?$

$$\log\left(\frac{a}{a-x}\right) = \frac{kt}{2.303}$$

$$\log\left(\frac{0.25}{a-x}\right) = \frac{6.7\times10^{-4}\times 528}{2.303}$$

$$\cancel{\log}\left(\frac{0.25}{a-x}\right) = \log^{-1}\left(\frac{6.7\times10^{-4}\times 528}{2.303}\right)$$

$$\frac{0.25}{a-x} = 1.424$$

$$a-x = \frac{0.25}{1.424}$$

$$a-x = 0.1756\,M$$

The concentration of Cyclopeclar after 8.8 minutes is 0.1756M

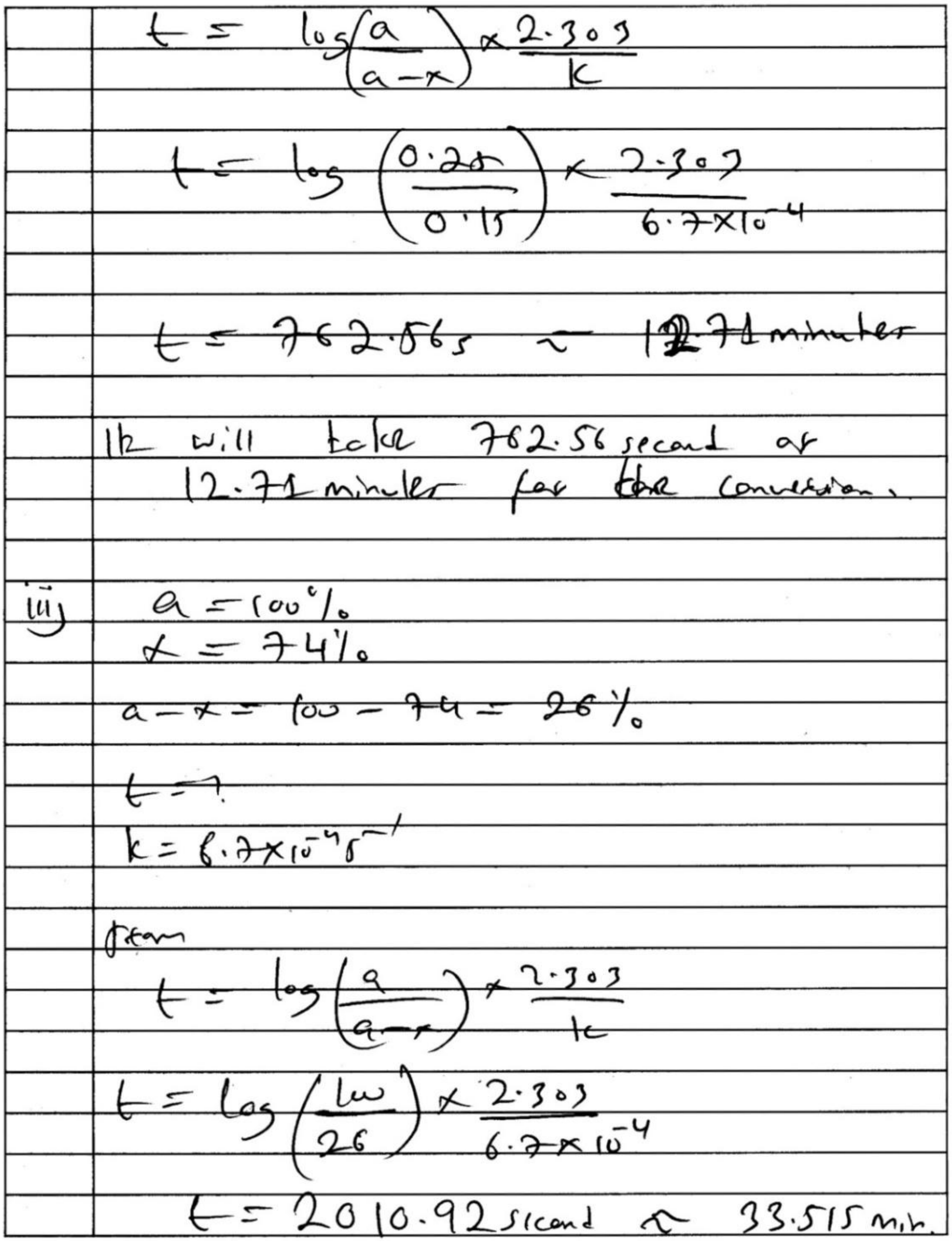
iii) $a = 0.25M$

$a-x = 0.15M$

$t = ?$

$k = 6.7\times10^{-4}\ s^{-1}$

$$\log\left(\frac{a}{a-x}\right) = \frac{kt}{2.303}$$



$t = \log\left(\frac{a}{a-x}\right) \times \frac{2.303}{k}$

$t = \log\left(\frac{0.25}{0.15}\right) \times \frac{2.303}{6.7\times10^{-4}}$

$t = 762.56s \approx 12.71$ minutes

It will take 762.56 second or 12.71 minutes for the conversion.

iii) $a = 100\%$

$x = 74\%$

$a - x = 100 - 74 = 26\%$

$t = ?$

$k = 6.7\times10^{-4}s^{-1}$

from

$t = \log\left(\frac{a}{a-x}\right) \times \frac{2.303}{k}$

$t = \log\left(\frac{100}{26}\right) \times \frac{2.303}{6.7\times10^{-4}}$

$t = 2010.92$ second ≈ 33.515 min.

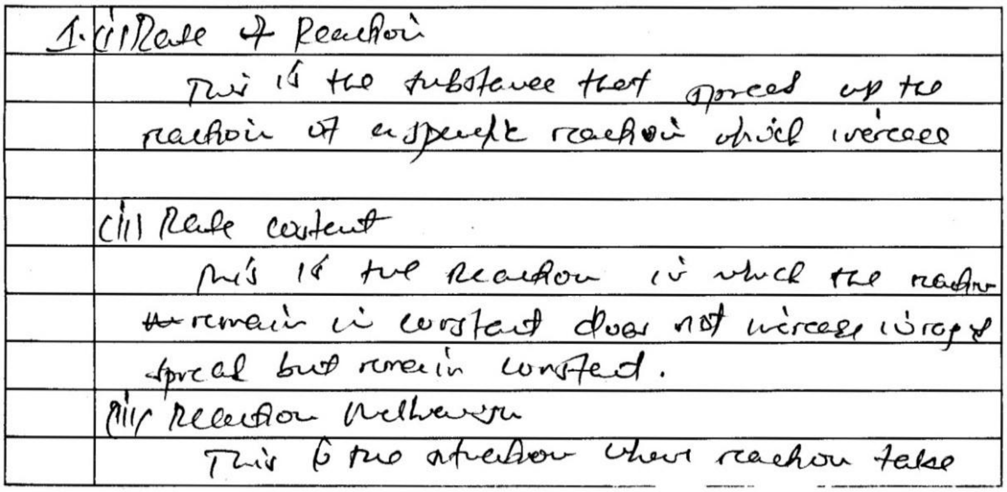
Extract 15.1 is a set of responses from a candidate who correctly defined the terms and related the initial concentrations to the reaction rates. He/she correctly deduced the orders of the reactions given and finally used correct formulae to perform the required calculations.

On the other hand some of the candidates with low scores in part (a) failed to use the necessary key words in the definitions of the terms and some gave irrelevant responses at all. One of the candidates for example, defined the term half life as "*This is the reaction where the reaction take place on short* *then stop to producers on the reaction!*". Further analysis showed that some candidates interchanged the definitions of terminologies. For example one of the candidates defined rate of reaction instead of rate constant.

In part (b), some of the candidates did not figure out how to determine the order of reaction with respect to each reactant hence, they failed to deduce the overall order of the reaction and were unable to perform the associated calculations using the data provided. Some candidates failed to apply and manipulate the chemical formulae while others generally lacked sufficient knowledge on Chemical Kinetics.

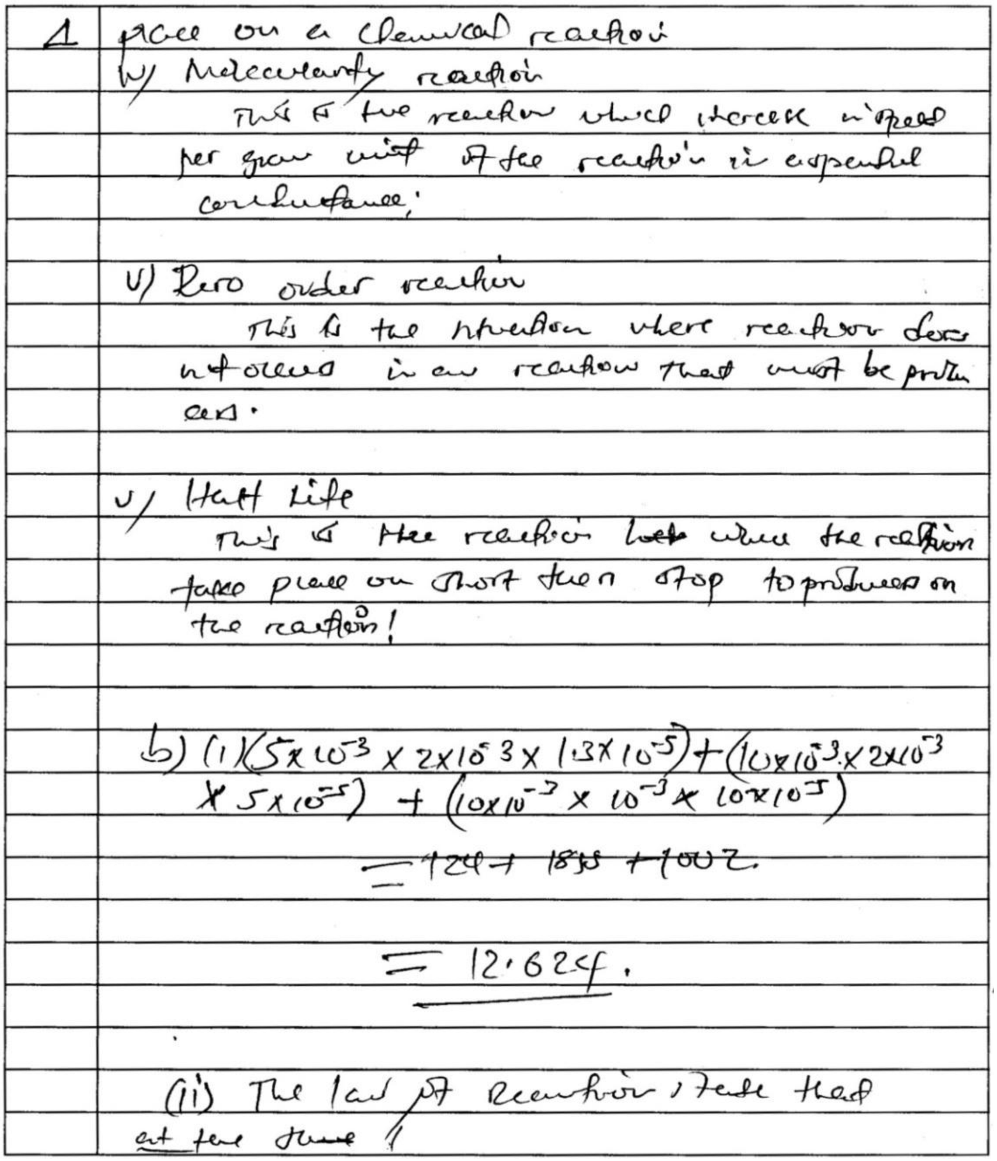
In part (c)(i), some of the candidates failed to manipulate the data provided to calculate the time taken to convert 74% of the starting material. The analysis revealed that some candidates had little knowledge on the topic while others encountered problems in mathematical computations. For part (c)(ii) and (iii) of the question, some candidates failed to calculate time taken for the concentration of cyclopropane to decrease from 0.25 M to 0.15 M. Most of them failed due to inadequate knowledge on derivation of formulae and data processing. Some candidates had insuffitient knowledge of Chemical Kinetics to the extent of scoring zero mark out of 10 marks. Extract 15.2 shows responses from a candidate who attempted part (a) and (b) poorly.

Extract 15.2



1. (i) Rate of Reaction
This is the substance that speed up the
reaction of a specific reaction which increase

(ii) Rate content
This is the reaction in which the reaction
~~th~~ remain in constant does not increase or drop of
speed but remain constant.
(iii) Reaction Mechanism
This is the situation where reaction take



1 place on a chemical reaction

iv) Molecularity reaction

This is the reaction which increase in speed per given unit of the reaction in experimental conductance;

v) Zero order reaction

This is the situation where reaction does not occurs in an reaction that must be products.

v) Half Life

This is the reaction ~~took~~ when the reaction take place on short then stop to produces on the reaction!

b) (i) $(5\times10^{-3}\times2\times10^{-3}\times1.3\times10^{-5})+(10\times10^{-3}\times2\times10^{-3}\times5\times10^{-5})+(10\times10^{-3}\times10^{-3}\times10\times10^{-5})$

$= 124 + 1855 + 1002.$

$= 12.625.$

(ii) The law of Reaction state that at the time

Extract 15.2 shows responses from a candidate who knew some chemical kinetics terms, but failed to arrange them properly to give a meaningful statement. This was attributed to not only lack of enough knowledge but also poor language skills.

2.2.2 Question 2: Electrochemistry

This question had parts; (a), (b), (c) and (d). In part (a)(i), the candidates were required to explain the term oxidation-reduction reaction. In part (a)(ii), they were provided with the following chemical equation of the reaction between dichromate (VI) ion and chloride ion in acidic solution:

$CrO_7^{2-}(aq) + Cl^-(aq) \longrightarrow Cr^{3+}(aq) + Cl_2(aq)$

Then they were required to derive balanced half-reaction equations and overall net equation. Part (b) required the candidates to state which among the given chemical equations represented oxidation-reduction reactions. The chemical equations given were:

(i) $CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(g)$

(ii) $Zn(s) + 2HCl(aq) \longrightarrow ZnCl_2(aq) + H_2(g)$

(iii) $Cr_2O_7^{2-}(aq) + 2OH^-(aq) \longrightarrow 2CrO_4^{2-}(aq) + H_2O(l)$

(iv) $O_3(g) + NO(g) \longrightarrow O_2(g) + NO_2(g)$

Part (c) required the candidates to identify the oxidizing agent, the reducing agent, the substance being oxidized and the one being reduced in (b) (i - iv). Lastly, part part (d) required the candidates to calculate e.m.f of the cell: $Pb(s)/Pb^{2+}(aq)(1\times10^{-3}M)//Cu^{2+}(aq)(1\times10^{-2}M)/Cu(s)$ using standard electrode potentials which were Pb^{2+}/Pb, $E^o = -0.126V$ and Cu^{2+}/Cu, $E^o = 0.34V$.

The question was attempted by 16,671 candidates equivalent to 50.2 percent. Majority of the candidates summing up to 62.5 percent passed the question out of which 39.9 percent scored 7.0 - 11.5 marks while 22.6 percent scored 12 - 20 marks. The rest constituting 39.9 percent scored marks ranging from 0 - 6.5. Figure 15 summarizes the candidates' performance in question 2.

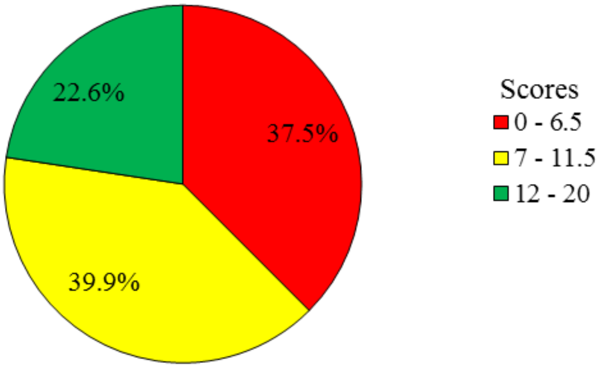
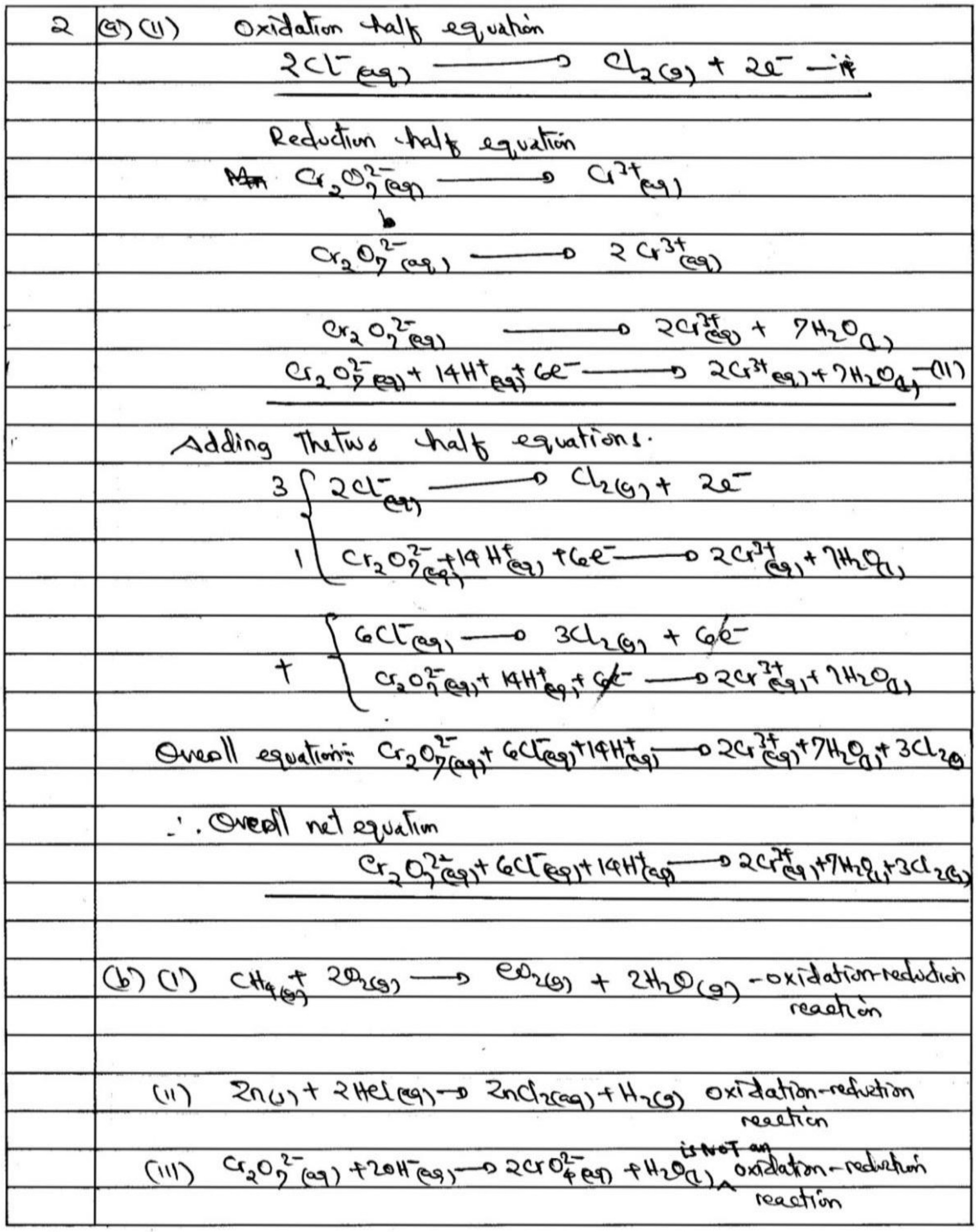


Figure 15: *Performance of the candidates in question 2.*

Figure 15 shows that 62.5 percent of the candidates scored 7 marks and above, an indication that the general performance in this question was good. Moreover statistical data (not displayed here) shows that 0.1 percent of the candidates who attempted the question scored full 20 marks. The candidates who scored high marks demonstrated understanding of the oxidation-reduction concept and therefore they were competent enough to write the half cell reactions and the correct overall net equation. In addition, most of the candidates who got high marks were able to apply the established oxidation-reaction concept in part (a) to correctly point out the oxidants and reductants. Furthermore, the candidates were competent in applying the Ernst equation to calculate the e.m.f of the given cell. Extract 16.1 displays an example of good responses from one of the candidates who scored 20 marks in this question.

Extract 16.1



2 (a) (ii) Oxidation half equation

$2Cl^-_{(aq)} \longrightarrow Cl_{2(g)} + 2e^-$ — (i)

Reduction half equation

~~Mn~~ $Cr_2O_7^{2-}{}_{(aq)} \longrightarrow Cr^{7+}{}_{(aq)}$

$Cr_2O_7^{2-}{}_{(aq)} \longrightarrow 2Cr^{3+}{}_{(aq)}$

$Cr_2O_7^{2-}{}_{(aq)} \longrightarrow 2Cr^{7+}{}_{(aq)} + 7H_2O_{(l)}$

$Cr_2O_7^{2-}{}_{(aq)} + 14H^+{}_{(aq)} + 6e^- \longrightarrow 2Cr^{3+}{}_{(aq)} + 7H_2O_{(l)}$ — (ii)

Adding The two half equations.

$3 \{ 2Cl^-_{(aq)} \longrightarrow Cl_{2(g)} + 2e^-$

$1 \{ Cr_2O_7^{2-}{}_{(aq)} + 14H^+{}_{(aq)} + 6e^- \longrightarrow 2Cr^{3+}{}_{(aq)} + 7H_2O_{(l)}$

$6Cl^-_{(aq)} \longrightarrow 3Cl_{2(g)} + \cancel{6e^-}$

$+ \; Cr_2O_7^{2-}{}_{(aq)} + 14H^+{}_{(aq)} + \cancel{6e^-} \longrightarrow 2Cr^{3+}{}_{(aq)} + 7H_2O_{(l)}$

Overall equation: $Cr_2O_7^{2-}{}_{(aq)} + 6Cl^-_{(aq)} + 14H^+_{(aq)} \longrightarrow 2Cr^{3+}{}_{(aq)} + 7H_2O_{(l)} + 3Cl_{2(g)}$

∴ Overall net equation

$Cr_2O_7^{2-}{}_{(aq)} + 6Cl^-_{(aq)} + 14H^+_{(aq)} \longrightarrow 2Cr^{7+}{}_{(aq)} + 7H_2O_{(l)} + 3Cl_{2(g)}$

(b) (i) $CH_{4(g)} + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(g)}$ - oxidation-reduction reaction

(ii) $Zn_{(s)} + 2HCl_{(aq)} \longrightarrow ZnCl_{2(aq)} + H_{2(g)}$ oxidation-reduction reaction

(iii) $Cr_2O_7^{2-}{}_{(aq)} + 2OH^-_{(aq)} \longrightarrow 2CrO_4^{2-}{}_{(aq)} + H_2O_{(l)}$ is NOT an oxidation-reduction reaction

2 (b)(iv) $O_{3(g)} + NO_{(g)} \longrightarrow O_{2(g)} + NO_{2(g)}$

an oxidation reduction reaction.

(c)

(i) Oxidizing agent : $O_{2(g)}$

Reducing agent : $CH_{4(g)}$

Substance oxidized : $CH_{4(g)}$ to $CO_{2(g)}$

Substance reduced : $O_{2(g)}$ to $H_2O_{(g)}$

(ii) Oxidizing agent : $HCl_{(aq)}$

Reducing agent : ~~HCl~~ $Zn_{(s)}$

Substance oxidized : $Zn_{(s)}$ to $ZnCl_{2(aq)}$

Substance reduced : $HCl_{(aq)}$ to $H_{2(g)}$

(iv) Oxidizing agent : $O_{3(g)}$

Reducing agent : $NO_{(g)}$

Substance oxidized : $NO_{(g)}$ to $NO_{2(g)}$

Substance reduced : $O_{3(g)}$ to $O_{2(g)}$

(d) Given.

$Pb_{(s)} / Pb^{2+}_{(aq)}(1 \times 10^{-2}M) // Cu^{2+}_{(aq)}(1 \times 10^{-2}M) / Cu_{(s)}$

$Pb^{2+}/Pb \; E^\ominus = -0.126V \qquad Cu^{2+}/Cu \; E^\ominus = 0.34V.$

$E_{cell} = E_{cathode} - E_{anode}$

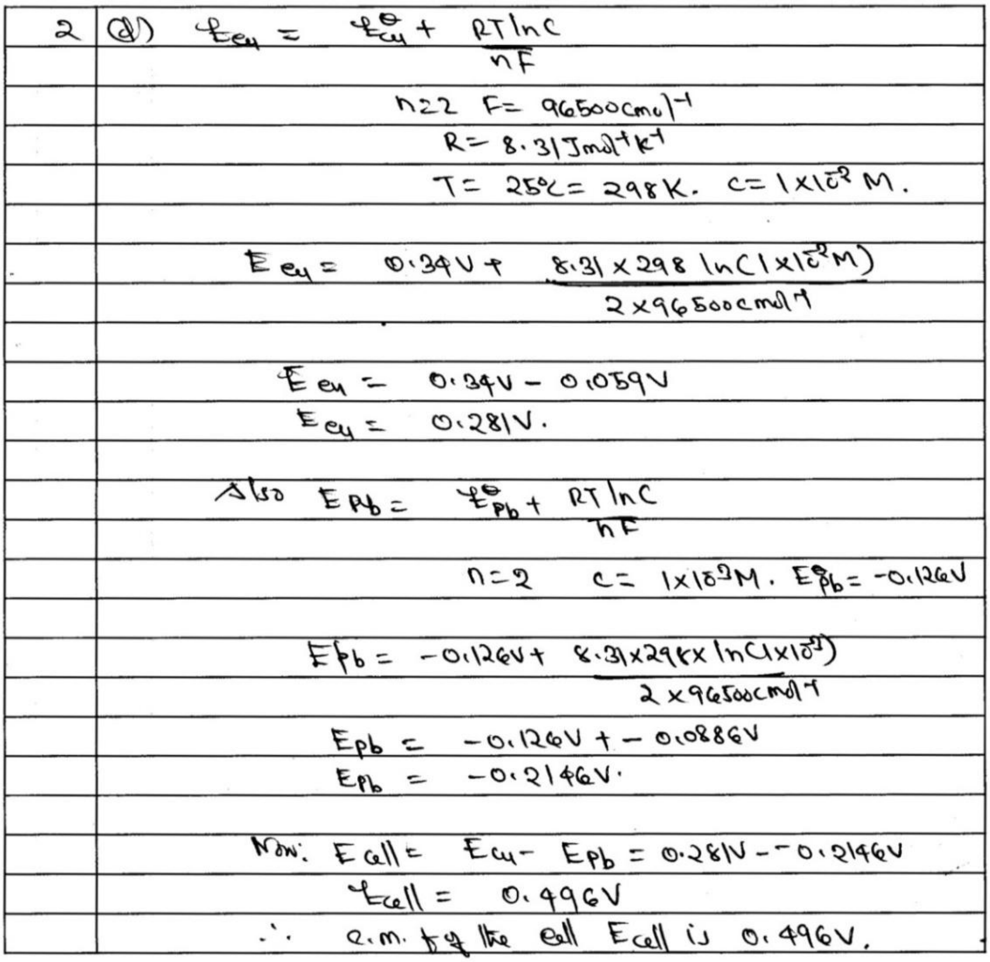
Cathode — Cu^{2+}/Cu.

Anode Pb^{2+}/Pb.

$E_{cell} = E_{Cu^{2+}} - E_{Pb^{2+}}.$

but

$$E = E^\ominus \pm \frac{RT\ln C}{nF}$$



2 (d) $E_{cu} = E^{\ominus}_{cu} + \frac{RT\ln C}{nF}$

$n = 2$ $F = 96500 C mol^{-1}$

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

$T = 25°C = 298K.$ $C = 1 \times 10^{-2} M.$

$E_{cu} = 0.34V + \frac{8.31 \times 298 \ln(1 \times 10^{-2} M)}{2 \times 96500 C mol^{-1}}$

$E_{cu} = 0.34V - 0.059V$

$E_{cu} = 0.281V.$

Also $E_{Pb} = E^{\ominus}_{Pb} + \frac{RT\ln C}{nF}$

$n = 2$ $C = 1 \times 10^{-2} M.$ $E^{\ominus}_{Pb} = -0.126V$

$E_{Pb} = -0.126V + \frac{8.31 \times 298 \times \ln(1 \times 10^{-2})}{2 \times 96500 C mol^{-1}}$

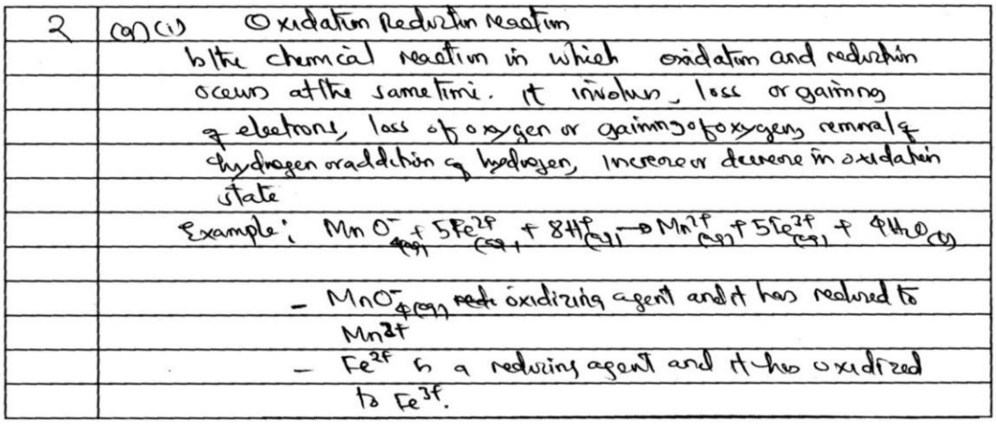
$E_{pb} = -0.126V + -0.0886V$

$E_{Pb} = -0.2146V.$

Now: $E_{cell} = E_{cu} - E_{Pb} = 0.281V - -0.2146V$

$E_{cell} = 0.496V$

$\therefore$ e.m.f of the cell E_{cell} is $0.496V.$



2 (a)(i) Oxidation Reduction reaction

Is the chemical reaction in which oxidation and reduction occurs at the same time. it involves, loss or gaining of electrons, loss of oxygen or gaining of oxygen, removal of hydrogen or addition of hydrogen, increase or decrease in oxidation state

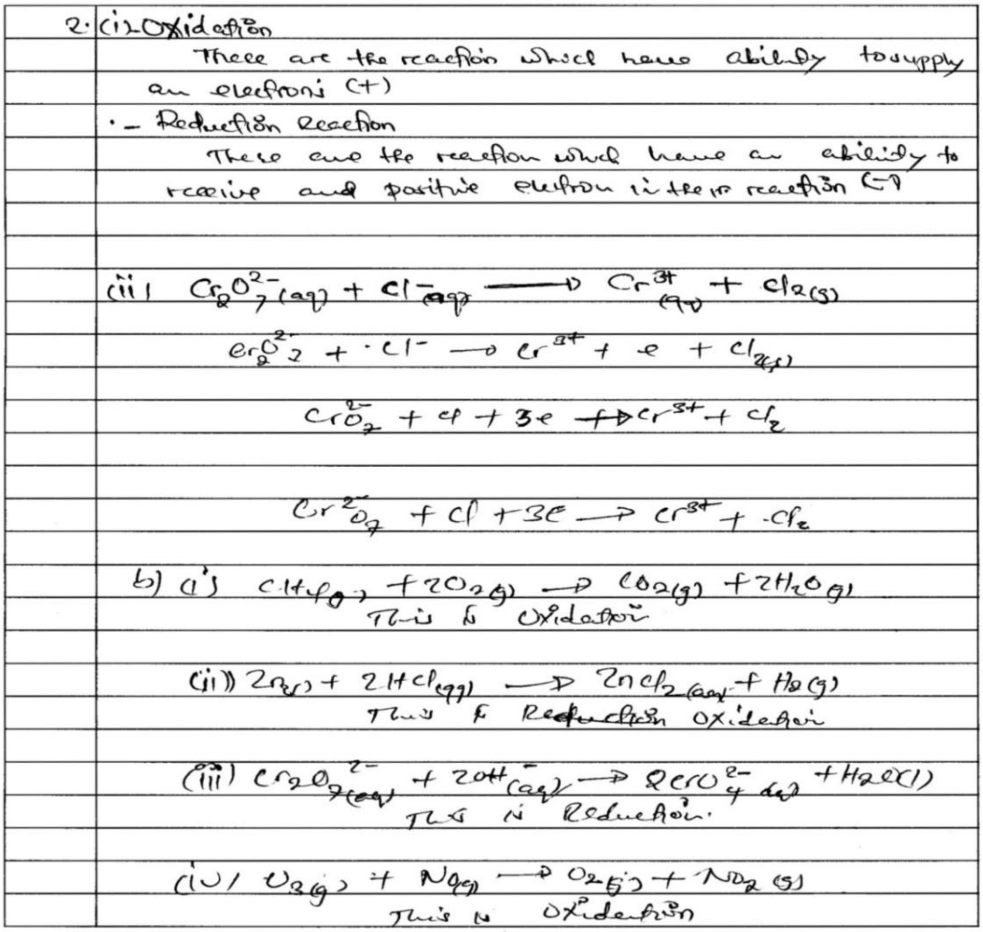
Example: $MnO^{-}_{4(aq)} + 5Fe^{2+}_{(aq)} + 8H^{+}_{(aq)} \rightarrow Mn^{2+}_{(aq)} + 5Fe^{3+}_{(aq)} + 4H_2O_{(l)}$

- $MnO^{-}_{4(aq)}$ ~~re~~ oxidizing agent and it has reduced to Mn^{2+}
- Fe^{2+} is a reducing agent and it has oxidized to Fe^{3+}.

Extract 16.1 shows that the candidate correctly applied the concept of oxidation-reduction to derive the overall net equation and succeed to point out both the oxidizing agents and reducing agents as required. Furthermore, he/she calculated the exact value of e.m.f of the cell which was 0.4955 V.

However, some few candidates got unsatisfactory marks. In part (a)(i), most of them defined oxidation-reduction as two independent terms (Oxidation and Reduction) contrary to the fact. This was attributed to insufficient understanding regarding the requirements of the question. This group was unfamiliar with the basic rules of balancing redox reactions and lacked enough exercises on the subtopic. Further analysis showed that some of the candidates failed to identify the oxidation-reduction reactions, oxidizing agent and the reducing agent. Similarly, they failed to point out the substance being oxidized and the one being reduced in the respective equation. This was due to lack of enough knowledge on electron transfers accompanying redox-reactions. Therefore, most of them lost most of the points in the subsequent section of the question as they failed to apply the Ernst Equation to calculate the e.m.f of the given cell. Extract 16.2 shows responses given by a candidate who scored low marks in this question.

Extract 16.2



2. (i) Oxidation

These are the reaction which have ability to supply an electrons (+)

·– Reduction Reaction

These are the reaction which have an ability to receive and positive electron in their reaction (–)

(ii) $Cr_2O_7^{2-}(aq) + Cl^-(aq) \longrightarrow Cr^{3+}(aq) + Cl_2(g)$

$Cr_2O_2^{2-} + Cl^- \longrightarrow Cr^{3+} + e + Cl_2(g)$

$CrO_7^{2-} + Cl + 3e \longrightarrow Cr^{3+} + Cl_2$

$Cr^{2-}O_7 + Cl + 3e \longrightarrow Cr^{3+} + Cl_2$

b) (i) $CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(g)$

This is Oxidation

(ii) $Zn(s) + 2HCl(aq) \longrightarrow ZnCl_2(aq) + H_2(g)$

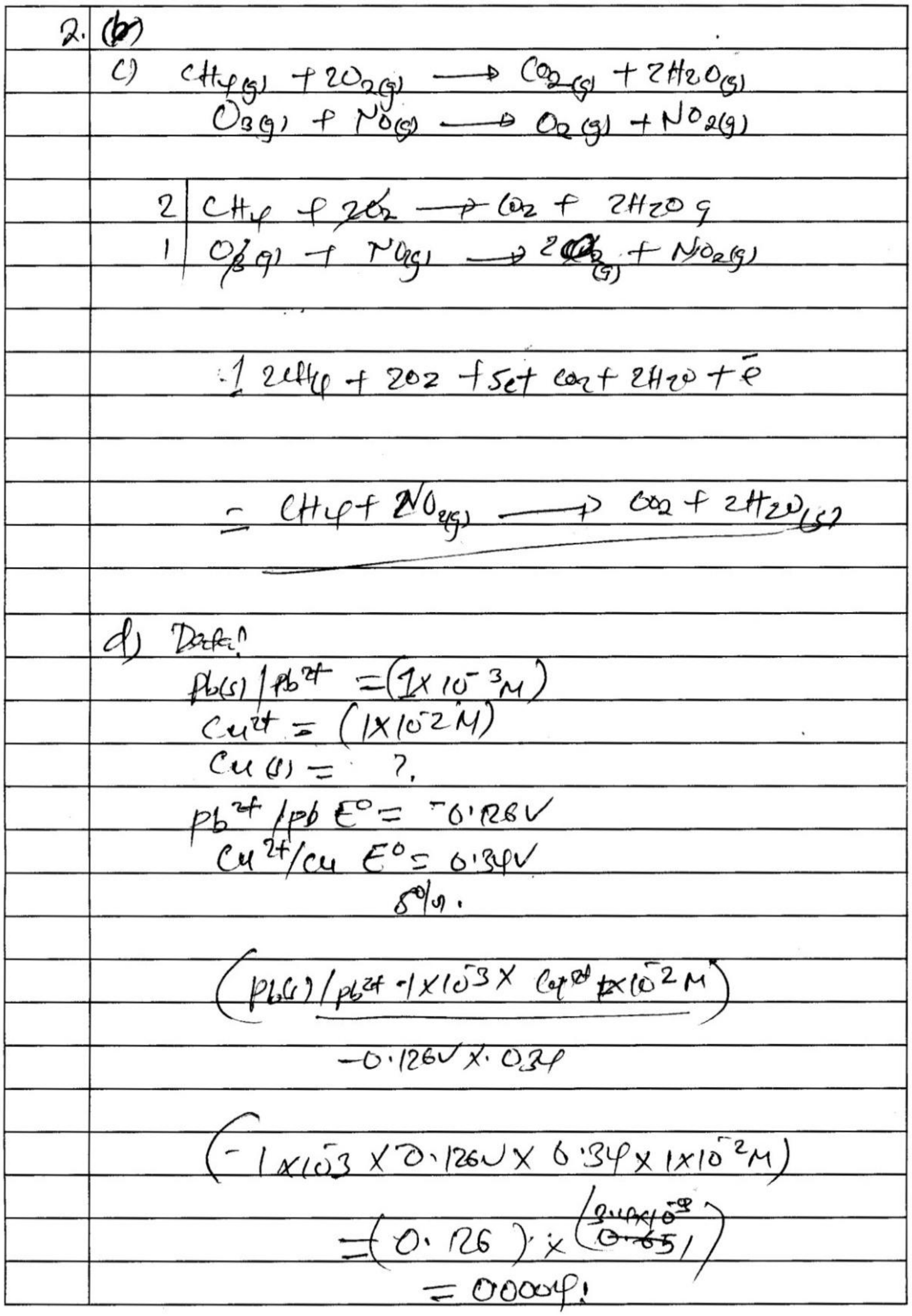
This is Reduction Oxidation

(iii) $Cr_2O_7^{2-}(aq) + 2OH^-(aq) \longrightarrow 2CrO_4^{2-}(aq) + H_2O(l)$

This is Reduction.

(iv) $O_3(g) + NO(g) \longrightarrow O_2(g) + NO_2(g)$

This is Oxidation



2. (b)

c) $CH_{4(g)} + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(g)}$

$O_{3(g)} + NO_{(g)} \longrightarrow O_{2(g)} + NO_{2(g)}$

2 | $CH_4 + \cancel{2O_2} \longrightarrow CO_2 + 2H_2O\ g$

1 | $O_{3(g)} + NO_{(g)} \longrightarrow 2\cancel{O_2}_{(g)} + NO_{2(g)}$

$1\ 2CH_4 + 2O_2 + 5e + CO_2 + 2H_2O + \bar{e}$

$= CH_4 + 2NO_{2(g)} \longrightarrow CO_2 + 2H_2O_{(s)}$

d) Data!

$Pb_{(s)} / Pb^{2+} = (1 \times 10^{-3} M)$

$Cu^{2+} = (1 \times 10^{-2} M)$

$Cu_{(s)} = ?.$

$Pb^{2+}/Pb\ E^\circ = -0.126V$

$Cu^{2+}/Cu\ E^\circ = 0.34V$

Soln.

$\left(\frac{Pb_{(s)}/Pb^{2+}\ 1 \times 10^{-3} \times Cu^{2+}\ 1 \times 10^{-2} M}{-0.126V \times 0.34}\right)$

$(-1 \times 10^{-3} \times 0.126V \times 0.34 \times 1 \times 10^{-2} M)$

$= (0.126) \times \left(\frac{\cancel{3.4 \times 10^{-8}}}{\cancel{0.65}}\right)$

$= 0.0004!$

In Extract 16.2, the candidate incorrectly defined oxidation-reduction reactions, gave improper chemical equations and failed to apply the Earnst equation in an attempt to calculate the e.m.f of the cell.

2.2.3 Question 3: Acids, Bases and Salts

This question consisted of four parts; (a), (b), (c) and (d). Part (a) required the candidates to define conjugate base, conjugate acid and conjugate acid-base pair. Part (b) required the candidates to identify the acid, base and acid-base conjugates for each of the chemical equations provided:

(i) $H_2O + HCl \longrightarrow H_3O^+ + Cl^-$

(ii) $CH_3COOH + H_2O \rightleftharpoons H_3O^+ + CH_3COO^-$

(iii) $CH_3COOH + H_2SO_4 \rightleftharpoons CH_3COOH_2^+ + HSO_4^-$

(iv) $C_6H_5NH_2 + {}^-NH_2 \rightleftharpoons C_6H_5NH^- + NH_3$

In part (c), the candidates were required to calculate the concentration of sodium propanoate (CH_3CH_2COONa) that was required to be present in a 0.01 M solution of propanoic acid (CH_3CH_2COOH) to produce a pH of 4.30 using the given value of K_a of propanoic acid 1.3×10^{-5}. In part (d), the candidates were given the K_a of acetic acid 1.8×10^{-5} and asked to calculate the pH of the 0.02 M acetic acid (CH_3COOH).

The question was attempted by 27,012 candidates corresponding to 81.3 percent. The analysis shows that the question was one of the most opted questions by the candidates. The analysis revealed that 67.2 percent of the candidates were able to score 12.0 - 20.0 marks which indicated good performance while 21.0 percent scored 7.0 - 11.5 marks which indicates average performance. Moreover, 11.8 percent of the candidates scored 0 - 6.5 marks which are classified as weak scores. The bar graph (Figure 16) gives a graphical presentation of these data.

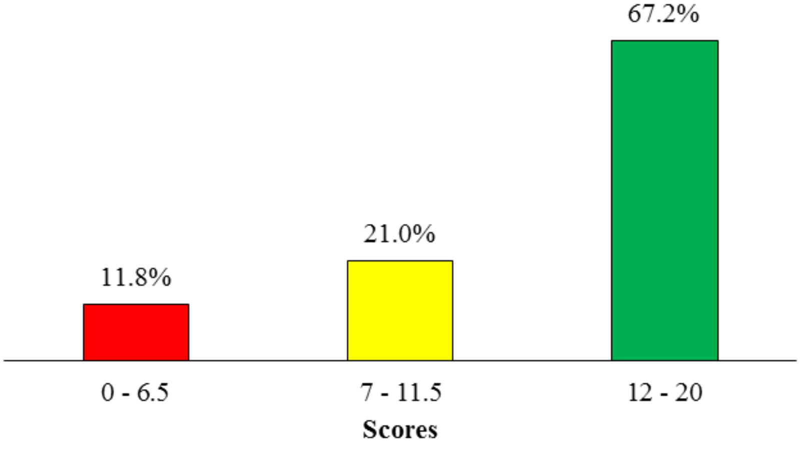
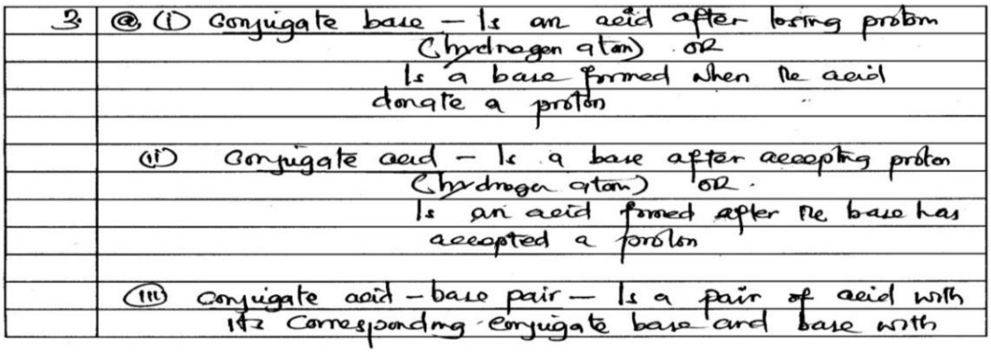


Figure 16: *Performance of the candidates in question 3.*

The information in Figure 16 shows that 88.2 percent of all the candidates passed the question. This signified that the overall performance was good. The candidates who managed to perform well in this question were able to utilize correctly the concept of acid-base conjugate pairs to define the given terms. Most of them identified the acids, bases and acid-base conjugates in each of the chemical equations. They were also able to recall and apply the Ostwald dilution law correctly to calculate the pH of 0.02 M acetic acid. Extract 17.1 illustrates an example of good responses from one of the candidates.

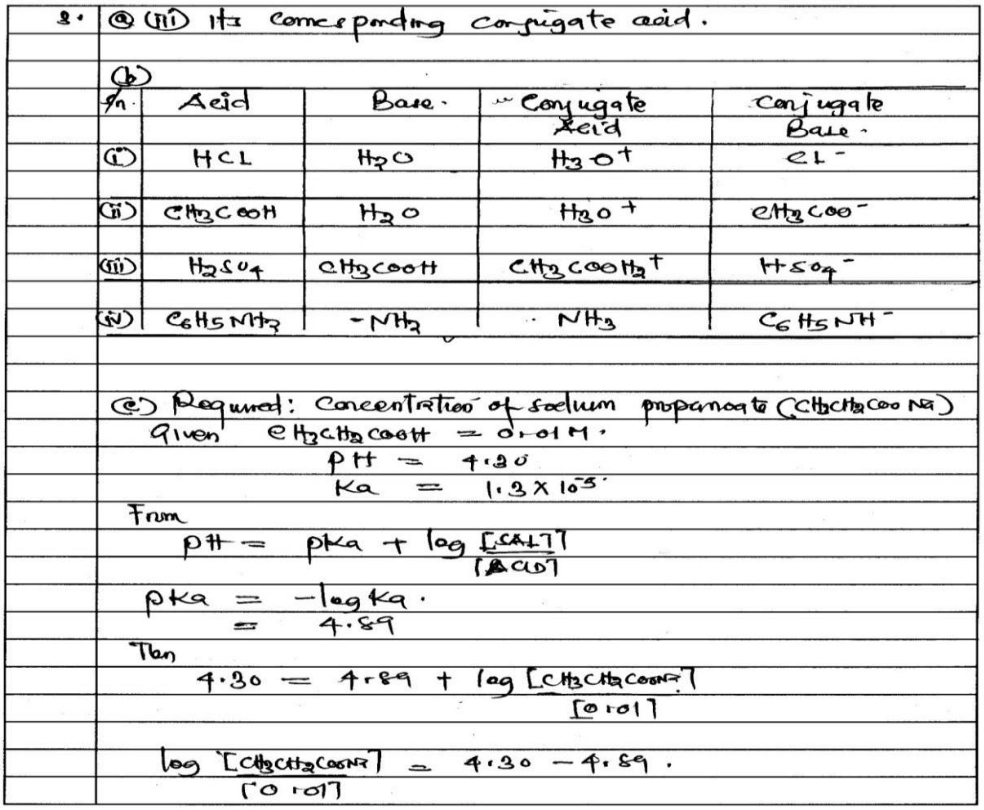
Extract 17.1



3. (a) (i) Conjugate base – Is an acid after losing proton (hydrogen atom) OR Is a base formed when the acid donate a proton

(ii) Conjugate acid – Is a base after accepting proton (hydrogen atom) OR. Is an acid formed after the base has accepted a proton

(iii) conjugate acid – base pair – Is a pair of acid with its Corresponding conjugate base and base with



3. (a) (iii) its corresponding conjugate acid.

(b)

S/n.	Acid	Base.	Conjugate Acid	Conjugate Base.
(i)	HCL	H_2O	H_3O^+	CL^-
(ii)	CH_3COOH	H_2O	H_3O^+	CH_3COO^-
(iii)	H_2SO_4	CH_3COOH	$CH_3COOH_2^+$	HSO_4^-
(iv)	$C_6H_5NH_2$	$^-NH_2$	NH_3	$C_6H_5NH^-$

(c) Required: Concentration of sodium propanoate (CH_3CH_2COONa)

Given $CH_3CH_2COOH = 0.01M$.

$pH = 4.30$

$Ka = 1.3 \times 10^{-5}$.

From

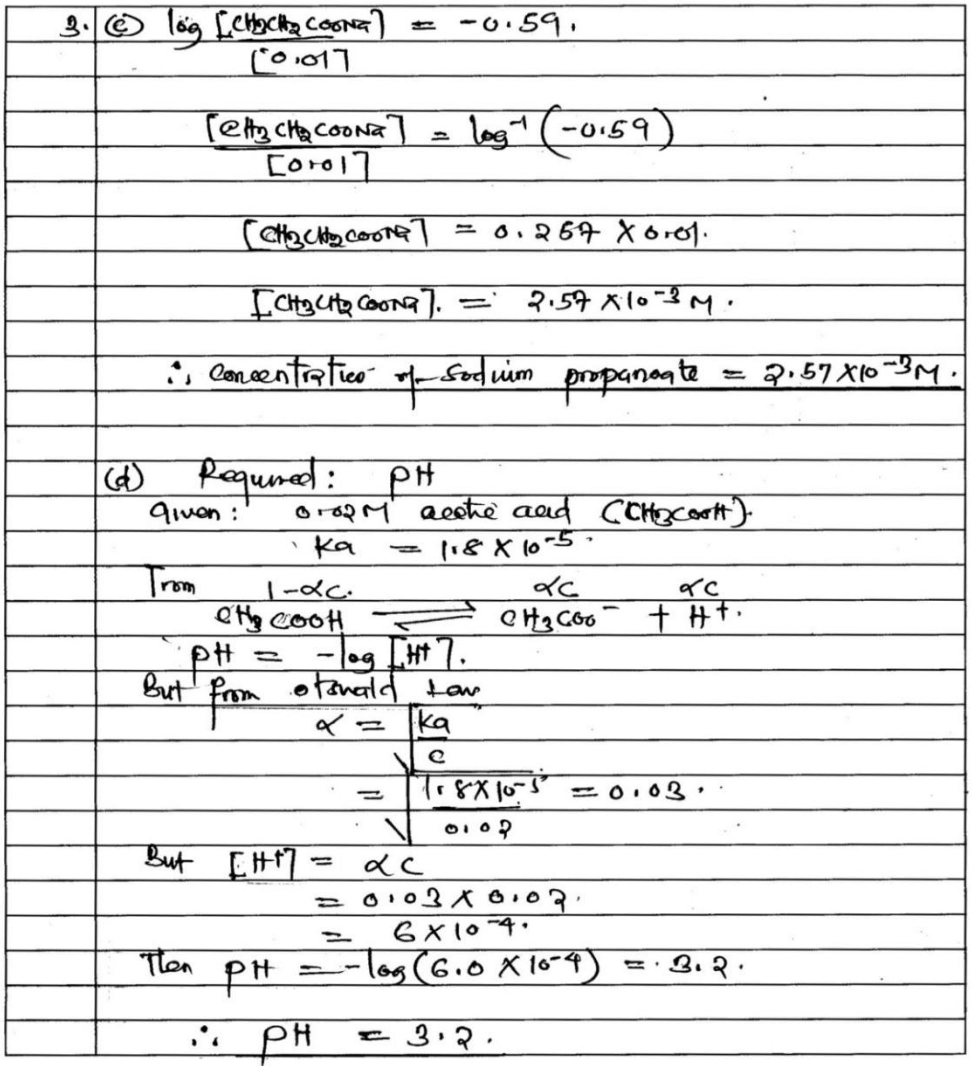
$$pH = pKa + \log\frac{[SALT]}{[ACID]}$$

$$pKa = -\log Ka.$$
$$= 4.89$$

Then

$$4.30 = 4.89 + \log\frac{[CH_3CH_2COONa]}{[0.01]}$$

$$\log\frac{[CH_3CH_2COONa]}{[0.01]} = 4.30 - 4.89.$$



3. (c) $\log \frac{[CH_3CH_2COONa]}{[0.01]} = -0.59.$

$\frac{[CH_3CH_2COONa]}{[0.01]} = \log^{-1}(-0.59)$

$[CH_3CH_2COONa] = 0.257 \times 0.01.$

$[CH_3CH_2COONa]. = 2.57 \times 10^{-3} M.$

∴ Concentration of sodium propanoate $= 2.57 \times 10^{-3} M.$

(d) Required: pH

given: 0.02M acetic acid (CH_3COOH).

$Ka = 1.8 \times 10^{-5}.$

From $1-\alpha c. \quad \alpha c \quad \alpha c$

$CH_3COOH \rightleftharpoons CH_3COO^- + H^+.$

$pH = -\log[H^+].$

But from ostwald law

$\alpha = \sqrt{\frac{Ka}{c}}$

$= \sqrt{\frac{1.8 \times 10^{-5}}{0.02}} = 0.03.$

But $[H^+] = \alpha c$

$= 0.03 \times 0.02.$

$= 6 \times 10^{-4}.$

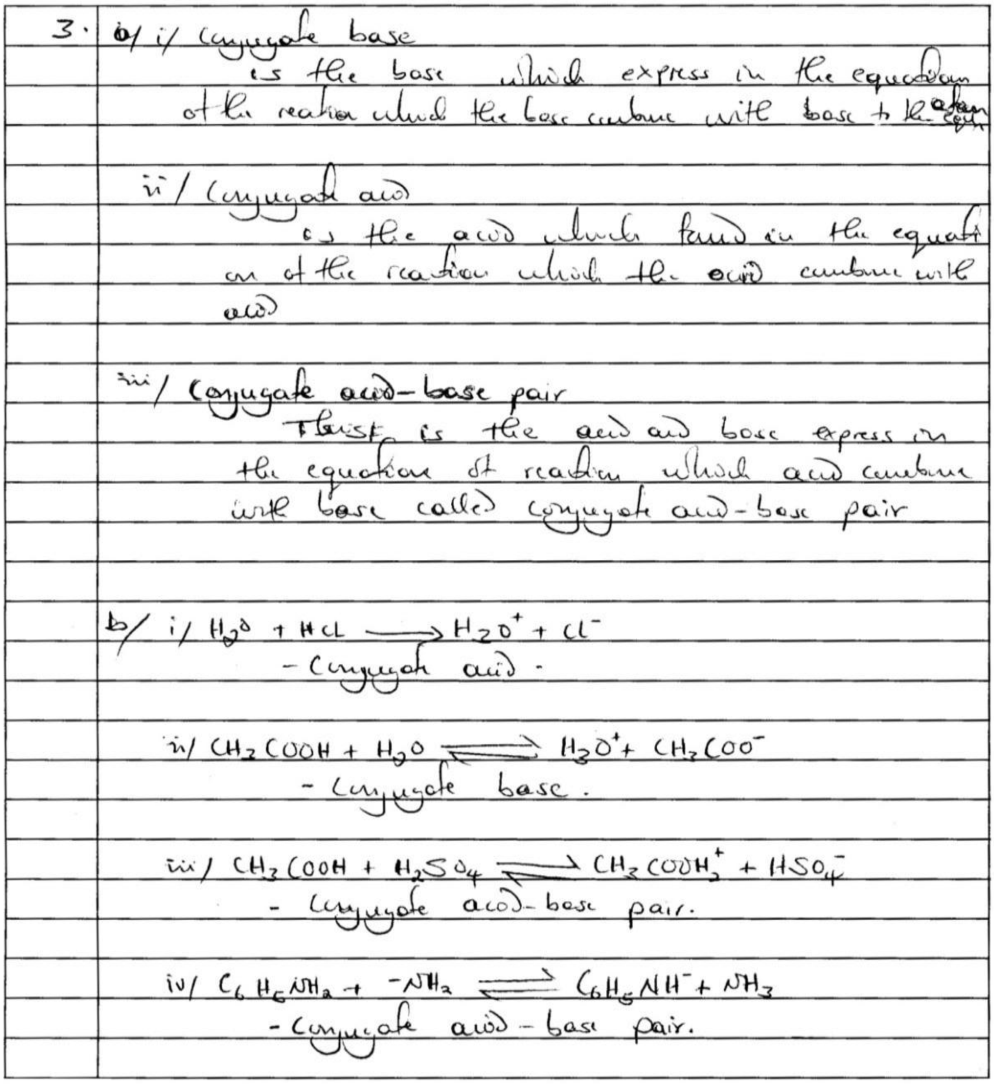
Then $pH = -\log(6.0 \times 10^{-4}) = 3.2.$

∴ $pH = 3.2.$

Extract 17.1 shows responses where by the candidate provided correct definitions, and identified the acid and bases with their conjugate pairs. He/she also applied the Ostwald law of dilution properly to calculate the required pH.

Some candidates who scored low marks in this question missed some key words in the definition of conjugate base, conjugate acid and conjugate acid-base pair and some gave irrelevant responses. This is an indication of little knowledge on acid-base pair concepts and difficulties in language proficiency. In part (b), some of the candidates could not identify the acid, base, conjugate acid and conjugate base in each of the given reactions. This is an indication that some of them had insufficient knowledge about concepts of Brønsted-Lowry theory of acids and bases as well as Lewis and Arrhenius theories. In part (c), some of the candidates were not able to calculate the concentration of sodium propanoate (CH_3CH_2COONa) that was supposed to be present in a 0.01 M solution of propanoic acid (CH_3CH_2COOH) to produce a pH of 4.30 from the given K_a value of propanoic acid. This could be attributed to insufficient knowledge on the concept of buffer solutions and their related calculations. In part (d), some of the candidates faced difficulties in calculating the pH of 0.02 M acetic acid (CH_3COOH) from the given dissociation constant (K_a) of acetic acid. The candidates failed to demonstrate the mastery of Ostwald's dilution law in calculating hydrogen ion concentration. Extract 17.2 depicts an example of poor responses from one of the candidates.

Extract 17.2



3. a/ i/ Conjugate base
is the base which express in the equation of the reaction which the base combine with base to the [illegible]

ii/ Conjugate acid
is the acid which found in the equation of the reaction which the acid combine with acid

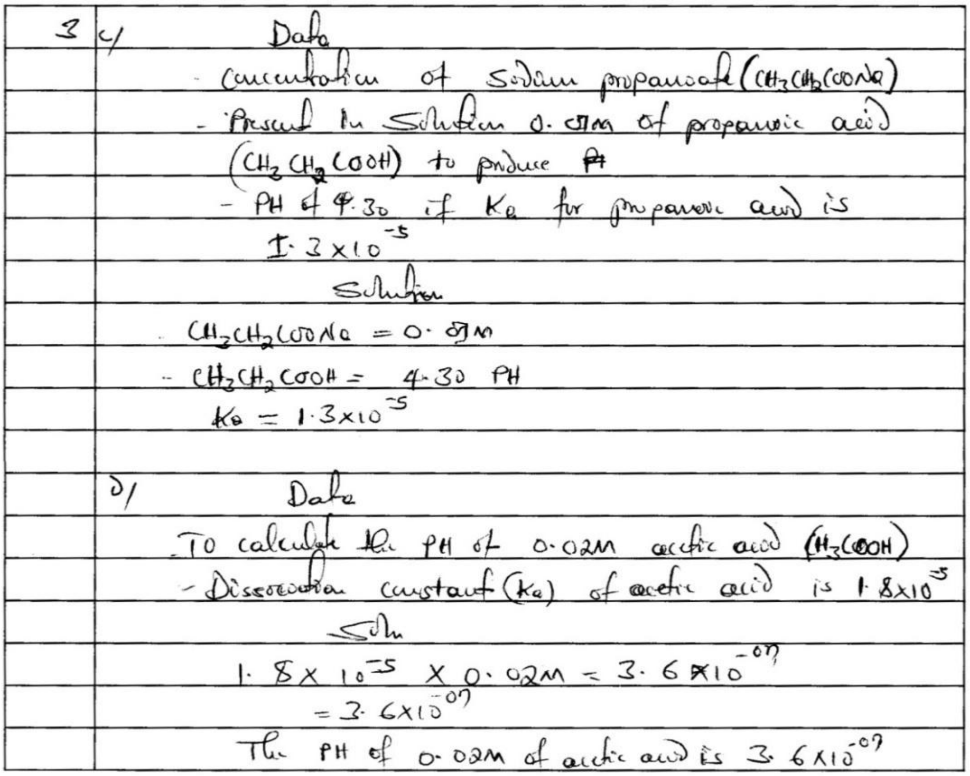
iii/ Conjugate acid-base pair
Thist is the acid and base express in the equation of reaction which acid combine with base called conjugate acid-base pair

b/ i/ $H_2O + HCl \longrightarrow H_2O^+ + Cl^-$
- Conjugate acid.

ii/ $CH_3COOH + H_2O \rightleftharpoons H_3O^+ + CH_3COO^-$
- Conjugate base.

iii/ $CH_3COOH + H_2SO_4 \rightleftharpoons CH_3COOH_2^+ + HSO_4^-$
- Conjugate acid-base pair.

iv/ $C_6H_5NH_2 + {}^-NH_2 \rightleftharpoons C_6H_5NH^- + NH_3$
- Conjugate acid-base pair.



3 c/ Data

- concentration of sodium propanoate (CH_3CH_2COONa)
- Present in solution 0. 07M of propanoic acid (CH_3CH_2COOH) to produce ~~PH~~
- PH of 4.30 if Ka for propanoic acid is 1.3×10^{-5}

Solution

$CH_3CH_2COONa = 0.07M$

- $CH_3CH_2COOH = 4.30$ PH

$Ka = 1.3 \times 10^{-5}$

d/ Data

To calculate the pH of 0.02M acetic acid (CH_3COOH)

- Dissociation constant (Ka) of acetic acid is 1.8×10^{-5}

Soln

$1.8 \times 10^{-5} \times 0.02M = 3.6 \times 10^{-07}$

$= 3.6 \times 10^{-07}$

The pH of 0.02M of acetic acid is 3.6×10^{-07}

In Extract 17.2, the candidate incorrectly defined the terms, gave inappropriate chemical equations and calculated pH without applying the Ostwald law of dilution.

2.2.4 Question 4: Solubility, Solubility Product and Ionic Product

This question had three parts: (a), (b) and (c). Part (a) required the candidates to write the solubility product constant (K_{sp}) expressions for the solubility of Copper (I) bromide, Bismuth sulphide (Bi_2S_3), Copper (II) iodate, $Cu(IO_3)_2$ and Silver chromate (Ag_2CrO_4). In part (b), the candidates were given $[Ag^+]$ of a solution = 4×10^{-3} and were required to calculate the $[Cl^-]$ that must be exceeded before AgCl can precipitate given that the K_{sp} of AgCl is 1.0×10^{-10}. In part (c), the candidates were given the information that, "25 cm^3 of 0.001 M $BaCl_2$ solution were mixed with 40 cm^3 of 0.002 M Na_2SO_4 solution" and then required to determine if $BaSO_4$ will precipitate from the solution given the K_{sp} of $BaSO_4$ at 25°C is 1.12×10^{-10} $mol^2\,dm^{-6}$. In part (d)(i), the candidates were required to outline four factors which affect the solubility of sparingly soluble salts. In part (d)(ii), the candidates were required to calculate the solubility of AgCl in 0.20 M $AgNO_3$ solution given the K_{sp} of AgCl = 1.0×10^{-10}.

This question was opted by 59.4 percent of the candidates. The statistical data show that 24 percent of the candidates scored 0 - 6.5 marks, 38.1 percent scored 7.0 - 11.5 marks and 37.9 percent scored 12 - 20 marks. The general performance was good since 76.0 percent of the candidates scored 7.0 marks and above. Figure 17 summarizes the performance of the candidates in this question.

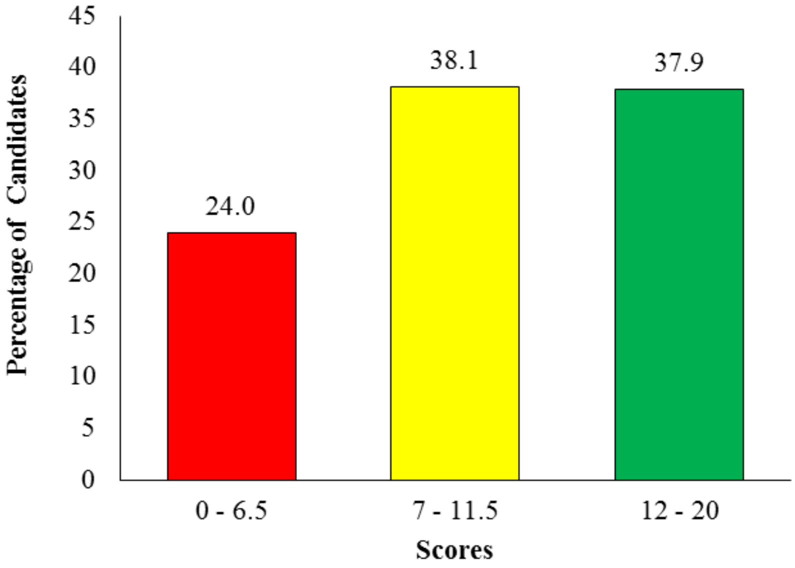
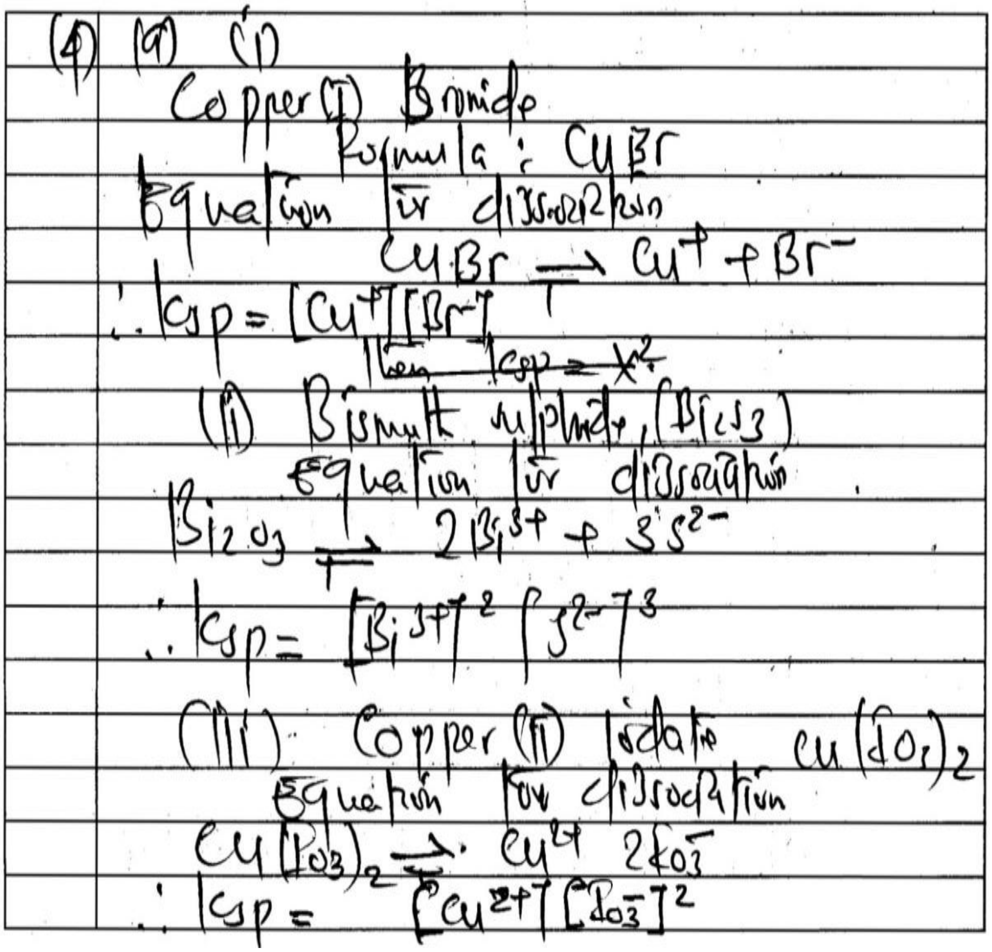


Figure 17: *Performance of the candidates in question 4.*

The majority of the candidates with high scores answered correctly most parts of this question. The candidates with high scores showed good understanding of the concept of solubility and solubility product hence, deduced correctly the solubility product expressions as required. They demonstrated competences in manipulating the data provided to arrive at correct decision that $BaSO_4$ was able to form a precipitate from the solution. Extract 18.1 represents an example of good responses. However, the candidate incorrectly mentioned concentration as one of the factors affecting solubility of sparingly soluble salts.

Extract 18.1



(4) (a) (i)

Copper(I) Bromide

Formula : $CuBr$

Equation for dissociation

$CuBr \rightleftharpoons Cu^+ + Br^-$

$\therefore Ksp = [Cu^+][Br^-]$

~~then Ksp = x²~~

(ii) Bismuth sulphide, (Bi_2S_3)

Equation for dissociation

$Bi_2S_3 \rightleftharpoons 2Bi^{3+} + 3S^{2-}$

$\therefore Ksp = [Bi^{3+}]^2[S^{2-}]^3$

(iii) Copper(II) Iodate $Cu(IO_3)_2$

Equation for dissociation

$Cu(IO_3)_2 \rightleftharpoons Cu^{2+}\ 2IO_3^-$

$\therefore Ksp = [Cu^{2+}][IO_3^-]^2$

4(a)(iv) Silver chromate (Ag_2CrO_4)

Equation for dissociation

$$Ag_2CrO_4 \rightleftharpoons 2Ag^+ + CrO_4^{2-}$$

$$\therefore K_{sp} = [Ag^+]^2[CrO_4^{2-}]$$

(b) Data provided.

Concentration of Ag^+ $[Ag^+] = 4\times10^{-3}$

K_{sp} of $AgCl$ = ~~6~~ 1.0×10^{-10}.

Required is $[Cl^-]$

Equation for AgCl

$$AgCl_{(s)} \rightleftharpoons Ag^+_{(aq)} + Cl^-_{(aq)}$$

$$K_{sp} = [Ag^+][Cl^-]$$

Then

$$[Cl^-] = \frac{K_{sp}}{[Ag^+]}$$

$$[Cl^-] = \frac{1.0\times10^{-10}}{4\times10^{-3}} = 2.5\times10^{-8}$$

$$[Cl^-] = 2.5\times10^{-8}$$

$\therefore$ The $[Cl^-]$ that must be exceeded before AgCl can precipitate is 2.5×10^{-8}.

(c) Data provided

$25cm^3$ of $0.001M$ $BaCl_2$

$40cm^3$ of $0.002M$ Na_2SO_4

K_{sp} of $BaSO_4$ is $1.12\times10^{-10}mol^2dm^{-6}$

4c Ksp of BaSO4

$BaSO_4 \rightleftharpoons Ba^{2+} + SO_4^{2-}$

Then

$BaCl_2 \rightleftharpoons Ba^{2+} + 2Cl^-$

Number of moles of Ba^{2+} in $BaCl_2$ before mixing

$= \frac{25cm^3}{1000} \times 0.001 = 2.5 \times 10^{-5}$

Then $BaCl_2 \rightarrow Ba^{2+} + 2Cl^-$ mixing

$1 \quad 2.5 \times 10^{-5} \quad (2 \times 2.5 \times 10^{-5})$

But the volume after mixing become

$40cm^3 + 25cm^3 = 65cm^3$

In $dm^3 = 65/1000 = 0.065 dm^3$

∴ concentration of Ba^{2+} $[Ba^{2+}]$ after mixing

$= 2.5 \times 10^{-5} mol / 0.065 dm^3$

$= 3.85 \times 10^{-4} M$

For Na_2SO_4

$Na_2SO_4 \rightleftharpoons 2Na^+ + SO_4^{2-}$

Number of moles before mixing

$= \frac{40cm^3}{1000} \times 0.002 = 8 \times 10^{-5}$

4(c) Then $Na_2SO_4 \rightarrow 2Na^+ + SO_4^{2-}$

$2\times8\times10^{-5}$ $\quad 8\times10^{-5}$

The concentration of SO_4^{2-} after mixing becomes ~~8×5~~ $\frac{8\times10^{-5}\text{ mole}}{0.065\,dm^3}$

$= 1.23\times10^{-3}$ M

But $Qsp = [Ba^{2+}][SO_4^{2-}]$

$Qsp = 3.85\times10^{-4} \times 1.23\times10^{-3}$ M

$Qsp = 4.74\times10^{-7}$ mol^2dm^{-6}

Since $Qsp > Ksp$
Then the precipitate will occur

(d) (i) - Common ion effect which depresses solubility
- Complex formation this increases solubility
- Temperature - it affects depending on nature of reaction with whether exothermic or endothermic
- Concentration.

(ii) Data provided,
Ksp of (AgCl) $= 1.0\times10^{-10}$
concentration of $AgNO_3$ = 0.2 M

Ksp equation for dissolving AgCl
$AgCl \rightleftharpoons Ag^+ + Cl^-$

4(a)(iii) Rer $AgNO_3$

$Ag \longrightarrow Ag^+ \; NO_3$

0.2M 0.2M 0.2M

Then K_{sp} for $AgCl = [Ag^+][Cl^-]$

$1.0\times10^{-10} = 0.2y$

where where y is the solubility for AgCl.

$$\frac{1.0\times10^{-10}}{0.2} = \frac{0.2y}{0.2}$$

Solubility (y) = 5×10^{-10}

∴ The solubility for AgCl is 5×10^{-10} M

4

(a) Solubility product expressions!

(b) Copper (I) bromide (CuBr)

then $CuBr_{(aq)} \rightleftharpoons Cu^+_{(aq)} + Br^-_{(aq)}$

$K_{sp} = [Cu^+][Br^-]$

(ii) Bismuth Sulphide (Bi_2S_3)

$Bi_2S_{3(aq)} \rightleftharpoons 2Bi^{3+} + 3S^{2-}$

$K_{sp} = [Bi^{3+}]^2[S^{2-}]^3$

(iii) Copper (II) Iodate, $Cu(IO_3)_2$

$Cu(IO_3)_2 \rightleftharpoons Cu^{2+}_{(aq)} + 2IO^-_{3(aq)}$

$K_{sp} = [Cu^{2+}][IO_3^-]^2$

4(a)
(iv) Silver Chromate, Ag_2CrO_4

$$Ag_2CrO_{4(aq)} \rightleftharpoons 2Ag^+_{(aq)} + CrO_4{}^{2-}_{(aq)}$$

$Ksp = [Ag^+]^2[CrO_4{}^{2-}]$.

(b) Data given;
Concentration of $[Ag^+] = 4 \times 10^{-3}$ M
Ksp, solubility product $= 1.0 \times 10^{-10}$
Req; $[Cl^-] = ?$

from;

$$AgCl_{(aq)} \rightleftharpoons Ag^+_{(aq)} + Cl^-_{(aq)}$$

thus

$$AgCl_{(aq)} \rightleftharpoons \underset{X}{Ag^+_{(aq)}} + \underset{X}{Cl^-_{(aq)}}$$

$Ksp = X^2$

$Ksp = [Ag^+][Cl^-]$

$$[Cl^-] = \frac{Ksp}{[Ag^+]}$$

$$= \frac{1.0 \times 10^{-10}}{4 \times 10^{-3}}$$

$$= 2.5 \times 10^{-8}$$

Thus for precipitation to occur, the $[Cl^-]$ must exceed 2.5×10^{-8}

(c) Data given;
Volume of $BaCl_2$ $[V_B] = 25 cm^3$
Volume of Na_2SO_4 $[V_A] = 40 cm^3$
Concentration of $BaCl_2$, $[M_B] = 0.001$ M
Concentration of Na_2SO_4 $[M_A] = 0.002M$

40 Ksp. of $BaSO_4$ = 1.12×10^{-10} Mol^2 dm^{-6}

thus, for $BaSO_4$:

$$BaSO_{4(aq)} \rightleftharpoons Ba^{2+}_{(aq)} + SO_{4(aq)}^{2-}$$

thus

$$Ksp = [Ba^{2+}][SO_4^{2-}]$$

Also, for $BaCl_2$

$$BaCl_2 \longrightarrow Ba^{2+} + 2Cl^-$$

mole Ratio of $BaCl_2$ to Ba^{2+} is 1.

Thus

Amount of moles of Ba^{2+} produced.

$$n_B = \text{Volume} \times \text{Molarity}$$
$$= V_B \times M_B$$
$$n_B = {}^{25}/_{1000} \times 0.001$$
$$= 2.5 \times 10^{-5} \text{ Moles}$$

thus Now

$$[Ba^{2+}] = \frac{n_B}{V_T}$$
$$= \frac{2.5 \times 10^{-5} \times 1000}{(25 + 40)}$$
$$= 3.846 \times 10^{-4} \text{ M.}$$

for Na_2SO_4

$$Na_2SO_{4(aq)} \longrightarrow 2Na^+ + SO_4^{2-}$$

thus n_N = Molarity × Volume

$$= M_N \times V_N$$
$$= 0.002 \times {}^{40}/_{1000}$$
$$= 8 \times 10^{-5} \text{ Moles}$$

Molarity of SO_4^{2-}, $[SO_4^{2-}] = \frac{n_N}{V_T}$

4ⓒ New Concentration of SO_4^{2-}

$$[SO_4^{2-}] = \frac{n_p \times 1000}{V_T}$$

$$= \frac{8\times10^{-5} \times 1000}{65}$$

$$= 1.23 \times 10^{-3} M,$$

then

$$Q_{sp} = [Ba^{2+}][SO_4^{2-}]$$

$$= [3.846\times10^{-4}][1.23\times10^{-3}]$$

$$= 4.73058\times10^{-7}\ Mol^2dm^{-6}$$

Since, $Q_{sp} > K_{sp}$, Thus $BaSO_4$ will precipitate in this solution.

ⓓ(i) Factors which affect the solubility of sparingly soluble salts:

- Common ion affect
- Temperature
- Complex compound formation.
- Nature of the solute or salt

ⓘⓘ Data given:

Solubility product Ksp of AgCl $= 1.8\times10^{-10}$

Concentration of $AgNO_3$, C = 0.2M.

Req; solubility of AgCl,

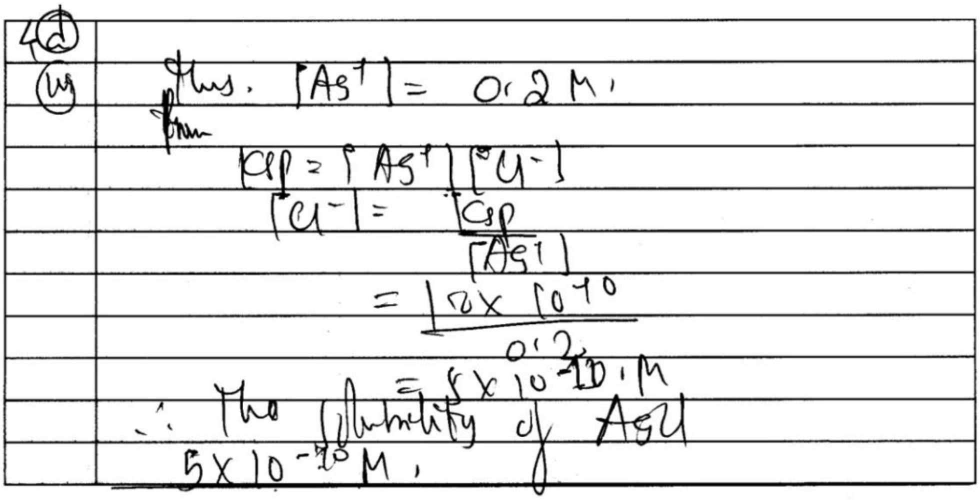
From

$$AgCl_{(aq)} \rightleftharpoons Ag^+_{(aq)} + Cl^-_{(aq)}$$

$$K_{sp} = [Ag^+][Cl^-]$$

Also

$$\underset{0.2M}{AgNO_{3(aq)}} \longrightarrow \underset{0.2M}{Ag^+_{(aq)}} + \underset{0.2M}{NO_{3(aq)}}$$



4(d) (ii) thus. $[Ag^+] = 0.2\,M.$

from

$K_{sp} = [Ag^+][Cl^-]$

$[Cl^-] = \frac{K_{sp}}{[Ag^+]}$

$= \frac{1.0 \times 10^{-10}}{0.2}$

$= 5 \times 10^{-10}\,M$

∴ The solubility of AgCl $5 \times 10^{-10}\,M.$

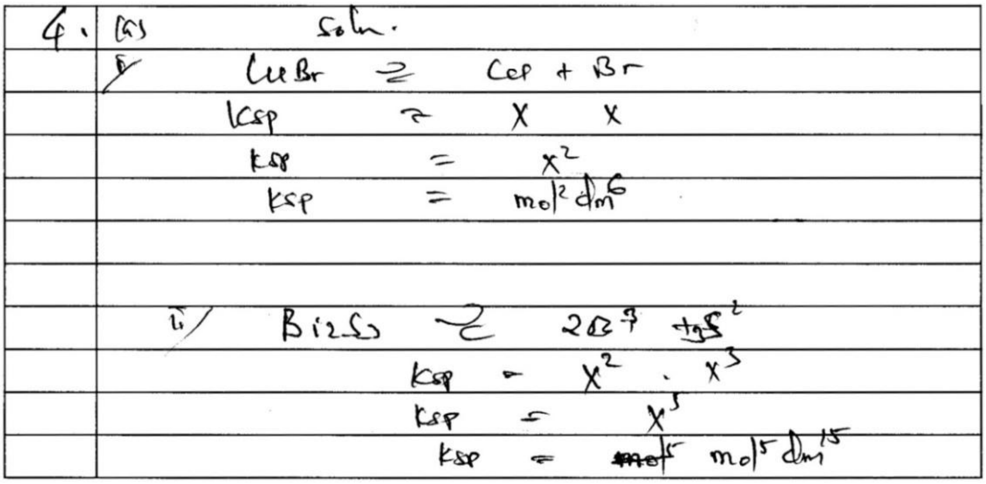
In Extract 18.1, the candidate appropriately calculated K_{sp} and Q_{sp} values and managed to rule out correctly that $BaSO_4$ would be precipitated. He/she also stated the factors affecting solubility properly and calculated the solubility of AgCl correctly.

The candidates who scored low marks (0 to 6.5 marks) failed to write correctly the solubility product constant (K_{sp}) expressions for the solubility of Copper(I) bromide, Bismuth sulphide (Bi_2S_3), Copper(II) iodate, $Cu(IO_3)_2$, and Silver chromate, Ag_2CrO_4. In part (b), some of the candidates failed to write the correct balanced dissociation equation of silver chloride. This misled them to getting the incorrect expressions of solubility product and hence incorrect $[Cl^-]$.

In part (c), some candidates were unable to do the calculations and compare Q_{sp} to K_{sp} in order to predict on whether $BaSO_4$ will precipitate from the solution or not. Instead they concluded on the formation of the precipitate without doing any relevant calculations. Those who attempted the calculations, they either used incorrect formulae for barium sulphate or solubility equation and failed to manipulate the data to predict the formation of the precipitate. This implies that the candidates had insufficient knowledge on the concept of common ion effect in relation to precipitation.

In part (d)(i), some of the candidates were unable to outline four factors which affect the solubility of sparingly soluble salts. The candidates failed to integrate the concepts of properties of compounds of metals with the concept of solubility and solubility product of sparingly soluble salts. In part (d)(ii), some of the candidates had difficulties in calculating the solubility of AgCl in 0.20 M $AgNO_3$ solution from the given K_{sp} of AgCl. This is attributed to inability of the candidates to write the solubility product expression of AgCl. They also failed to apply the concept of common ion effect to arrive at the correct value of solubility of AgCl which was 5 x 10^{-10} M. Extract 18.2 gives a sample of candidates' poor responses for part (a).

Extract 18.2



4. (a) Soln.

i) $CuBr \rightleftharpoons Cu^{+} + Br^{-}$

$Ksp = X \quad X$

$Ksp = X^2$

$Ksp = mol^2 dm^6$

ii) $Bi_2S_3 \rightleftharpoons 2Bi^{3} + 3S^{2}$

$Ksp = X^2 . X^3$

$Ksp = X^5$

$Ksp =$ ~~mol⁵~~ $mol^5 dm^{15}$

Extract 18.2 shows a response from a candidate who gave incorrect K_{sp} expressions. He/she skipped the remaining part of the question.

2.2.5 Question 5: Periodic Classification

This question had four parts (a), (b), (c) and (d). Part (a) required the candidates to explain why hydrogen element was placed in group I in the modern periodic table. Part (b) of the question required the candidates to account for the following facts: (i) The cationic size of an element is smaller than its atomic size, (ii) Group I elements are called alkaline metals, (iii) Group II elements melt at higher temperature than group I elements and (iv) Some compounds are said to be polarized.

In part (c), the candidates were asked to explain the following facts: (i) Every first member of the group in the periodic table behaves anomalously from other members, (ii) Some elements in the Periodic Table show diagonal relationships, (iii) Some elements are called d-block elements and (iv) The compounds of Sc^{3+} are colourless.

In part (d), the candidates were given the information that "The valency shell electronic configuration of element X is represented as $6s^2 6p^3$" and they were asked to: (i) Give the block, group and period of element X in the Periodic Table, (ii) Give the possible oxidation states of element X and (iii) Give the formula of the oxide of X.

The question was opted by 21,667 candidates equivalent to 62.2 percent. The candidates who scored 0 - 6.5, 7.0 - 11.5 and 12 - 20 marks were 50.5, 31.8 and 17.7 percent, respectively (Figure 18).

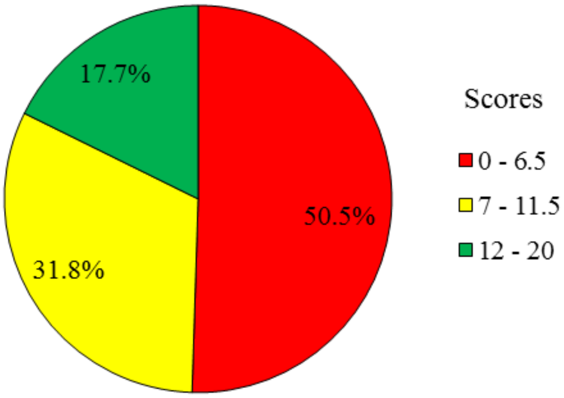
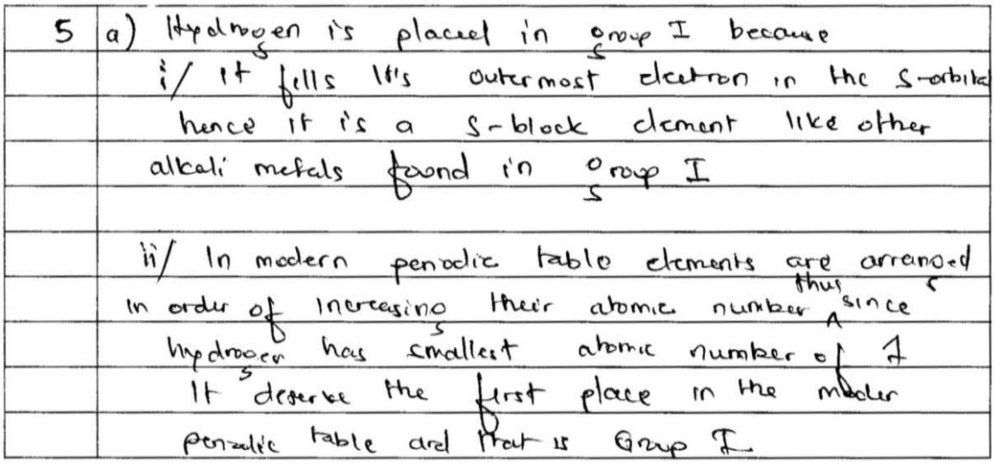


Figure 18: *Performance of the candidates in question 5.*

Figure 18 shows that 49.5 percent of the candidates scored marks ranging from 7.0 - 20 which shows that the overall performance was average. Only few candidates, 17.7 percent scored good marks.

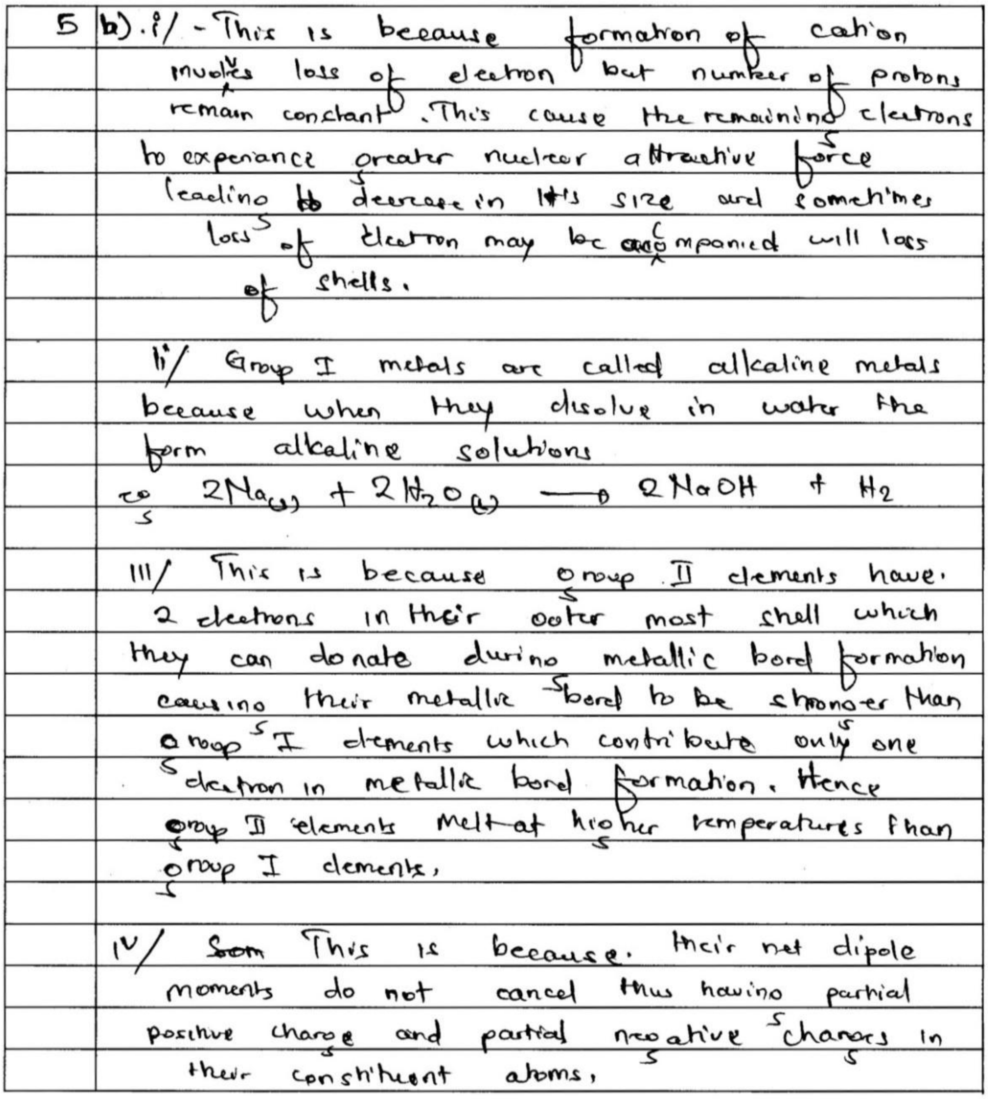
The candidates who scored high marks managed to answer correctly most of the parts of the question. Most of them showed good mastery of the topic as they provided appropriate responses. Extract 19.1 shows one of the responses from a candidate with high scores. However, the candidate failed to explain why some compounds are said to be polarized and could not state the possible oxidation state of element X.

Extract 19.1



5 a) Hydrogen is placed in group I because
i/ It fills It's outermost electron in the s-orbital
hence it is a s-block element like other
alkali metals found in group I

ii/ In modern periodic table elements are arranged
in order of increasing their atomic number thus since
hydrogen has smallest atomic number of 1
It deserve the first place in the moder
periodic table and that is Group I.

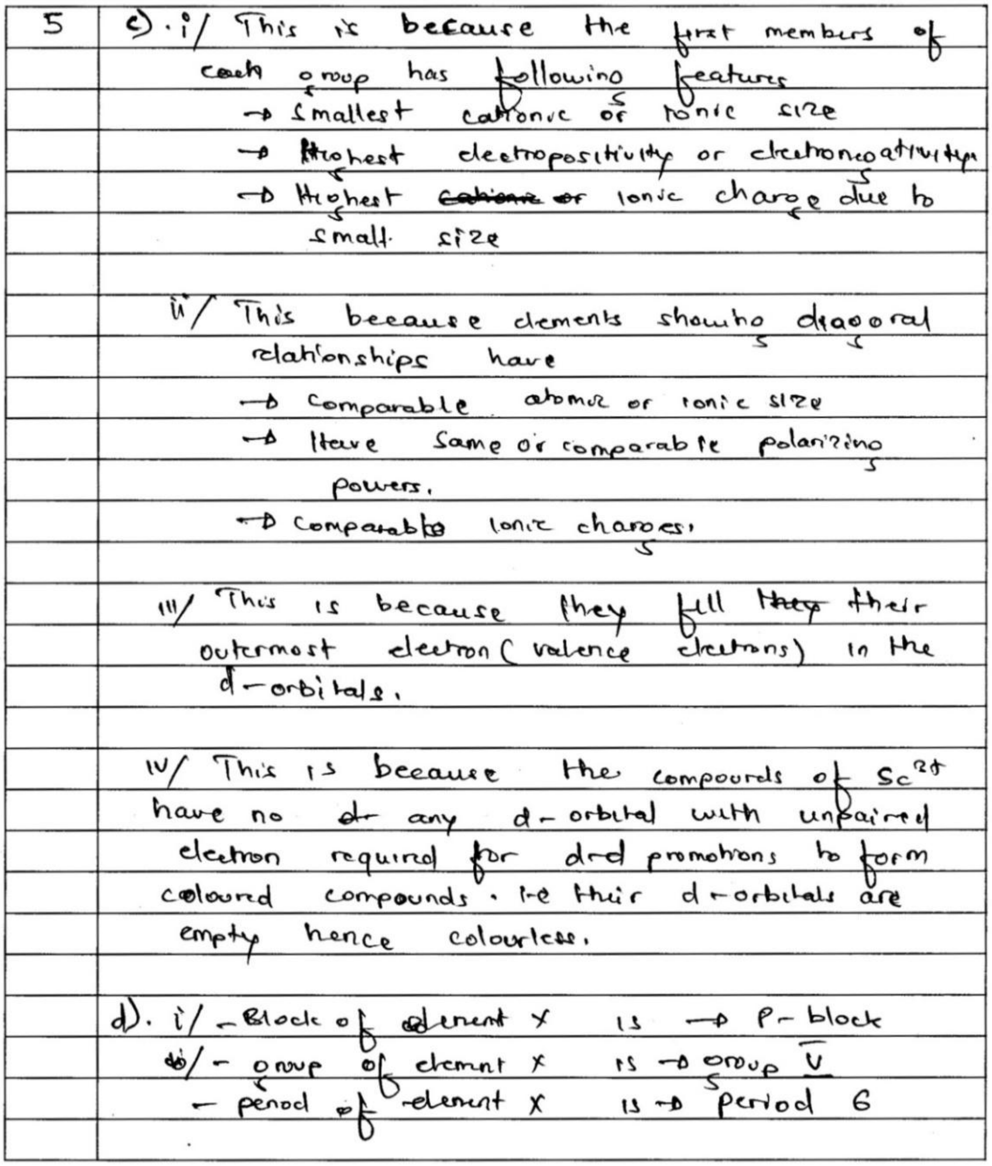


5 b).i/ - This is because formation of cation
involves loss of electron but number of protons
remain constant. This cause the remaining electrons
to experiance greater nuclear attractive force
leading ~~to~~ decrease in ~~It~~'s size and sometimes
loss of electron may be ~~acco~~mpanied will loss
of shells.

ii/ Group I metals are called alkaline metals
because when they disolve in water the
form alkaline solutions
eg $2Na_{(s)} + 2H_2O_{(l)} \longrightarrow 2NaOH + H_2$

iii/ This is because group II elements have.
2 electrons in their outer most shell which
they can donate during metallic bond formation
causing their metallic bond to be stronger than
group I elements which contribute only one
electron in metallic bond formation. Hence
group II elements melt at higher temperatures than
group I elements,

iv/ ~~Som~~ This is because. their net dipole
moments do not cancel thus having partial
positive charge and partial negative charges in
their constituent atoms,



5 c). i/ This is because the first members of each group has following features

→ Smallest cationic or ionic size

→ Highest electropositivity or electronegativity

→ Highest ~~cationic or~~ ionic charge due to small size

ii/ This because elements showing diagonal relationships have

→ Comparable atomic or ionic size

→ Have same or comparable polarizing powers.

→ Comparable ionic charges.

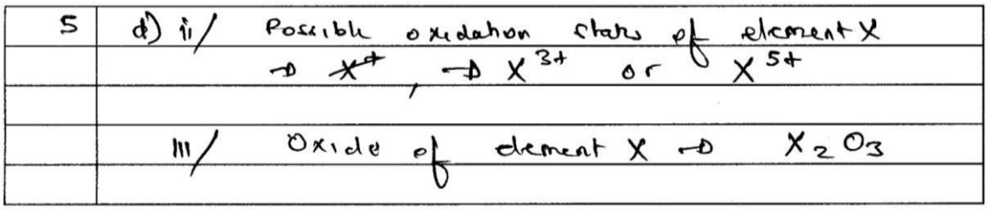
iii/ This is because they fill ~~they~~ their outermost electron (valence electrons) in the d-orbitals.

iv/ This is because the compounds of Sc^{3+} have no ~~d~~ any d-orbital with unpaired electron required for d-d promotions to form coloured compounds. i.e their d-orbitals are empty hence colourless.

d). i/ - Block of element X is → P-block

ii/ - group of element X is → group $\overline{V}$

\- period of element X is → period 6



5 d) ii/ Possible oxidation states of element X

→ ~~X^{+}~~, → X^{3+} or X^{5+}

iii/ Oxide of element X → X_2O_3

In Extract 19.1, the candidate applied correctly the concept of modern periodic law to attempt part (a), (b) and (c). He/she managed to give the oxidation states of element X and its oxide correctly.

For most of the candidates who gave unsatisfactory answers the following were observed: In part (a), some of them failed to link the concept of electronic configuration of elements and their positions in the Periodic

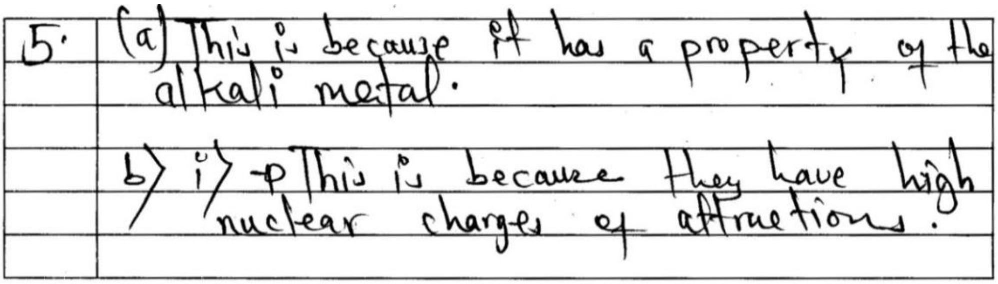
Table. Hence, they failed to show one of the main reasons for the placement of hydrogen in the first position in the modern Periodic Table.

In part (b), most of the candidates showed insufficient knowledge on periodicity, hence they failed to establish the effect of trends that could be observed in effective nuclear charge, ionization energy and electronegativity of elements both down the group and across the period. This is because they also had inadequate knowledge on the concept of metallic bonding hence, they failed to establish its effects on the physical and chemical properties of the elements.

In part (c), some of the candidates failed to explain the facts asked. They could not establish the elecronegativity trends along the period and down the group with respect to the position of elements in the Periodic Table. Possibly, the candidates did not understand the concept of properties of transition elements and the relationship between electronic configuration and position of elements in the block of elements in the Periodic Table.

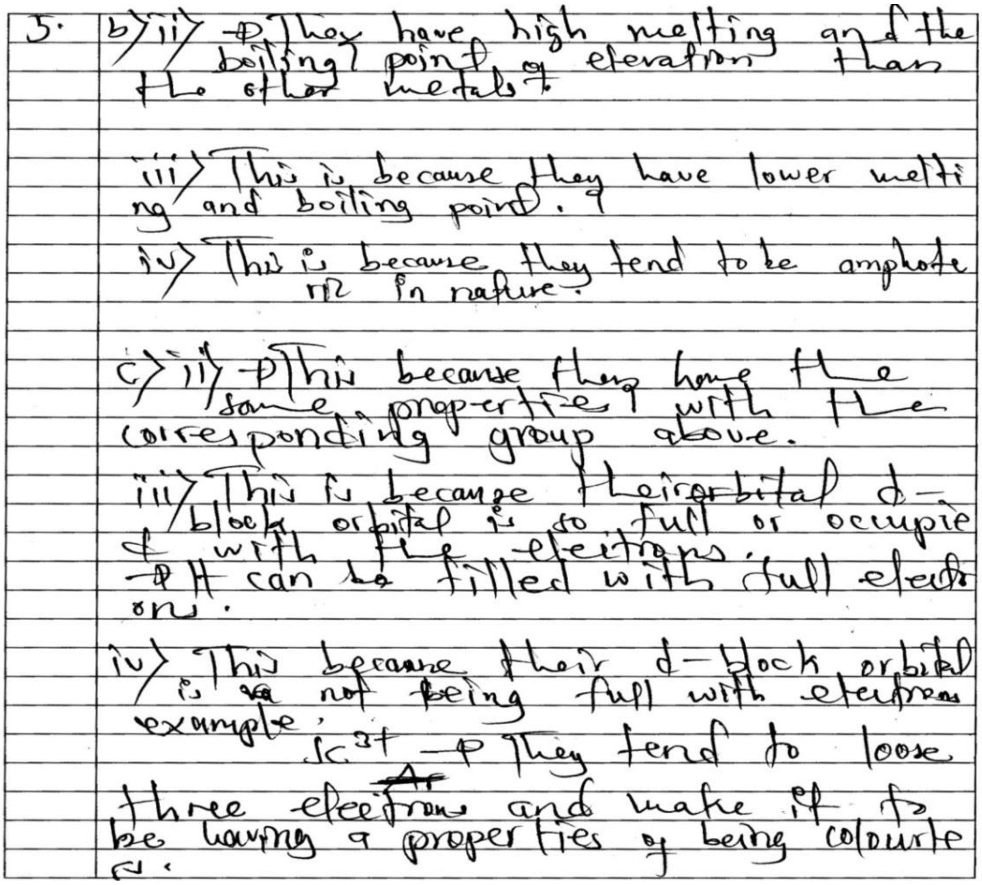
Some of the candidates failed to fulfill the requirements of part (d). This unsatisfactory performance was associated with inability to relate the position of elements with the blocks of elements in the Periodic Table. Generally, poor performance in this topic is due to lack of enough competence on the topic of Periodic Classification. Extract 19.2 gives an example of poor responses given by one of the candidates to question 5.

Extract 19.2



5. (a) This is because it has a property of the alkali metal.

b) i) → This is because they have high nuclear charges of attractions.



5. b) ii) → They have high melting and the
boiling point of elevation than
the other metals.

iii) This is because they have lower melti
ng and boiling point.
iv) This is because they tend to be amphote
ric in nature.

c) ii) → This because they have the
same properties with the
corresponding group above.
iii) This is because their orbital d-
block orbital is so full or occupie
d with the electrons.
→ It can be filled with full electr
ons.
iv) This because their d-block orbital
is ~~va~~ not being full with electrons
example;
Sc^{3+} → They tend to loose
three electrons and make it to
be having a properties of being colourle
ss.

In Extract 19.2, the candidate gave one of the properties of group I elements which is not the reason for the placement of hydrogen in position 1. In subsequent responses the candidate provided unclear statements.

2.2.6 Question 6: Extraction of Metals

This question consisted of three parts; (a), (b) and (c). Part (a) required the candidates to describe the extraction process of tin (Sn) from its chief ore. In part (b), the candidates were required to describe the chemical extraction of aluminium (Al) from its chief ore.

This question was opted by 10,524 candidates corresponding to 31.7 percent. The performance was as shown in Figure 19.

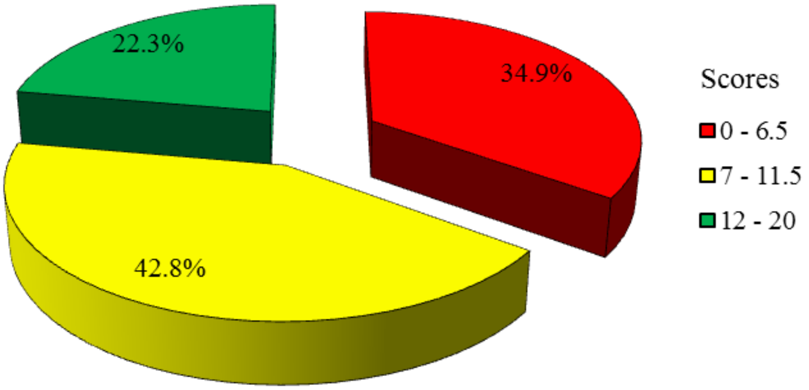


Figure 19: *Performance of the candidates in question 6.*

Figure 19 shows that 42.8 percent of the candidates scored from 7.0 - 11.5 marks. The candidates who scored from 0 - 6.5 marks were 34.9 percent while those who scored from 12 - 20 marks were 22.3 percent The general performance in this question was good as 65.1 percent of the candidates scored 7 marks and above.

The candidates who scored high marks in this question were able to attempt most parts of the question appropriately. Few of them managed to answer all parts of the question correctly. This is an indication that the candidates had sufficient knowledge on how to extract tin and aluminium from their ores. Also it means that they really understood the requirement of the question. Extract 20.1 shows a sample of good responses in this question.

Extract 20 .1

6 (a) The extraction of tin from its chief ore.

Steps involved in extraction of tin

1: Chief ore of tin

since tin is more reactive it exists in a combined state to form an oxide

- Cassiterite (tin stone) - SnO_2

ii: Concentration of the ore

The concentration of ore is done by separation the earth impurities from tin, this involves grinding of the tin ore into smaller pieces then separating them from the lighter impurities.

iii: Washing

The powdered ore contains earth impurities which become separated from tin by gravity separation whereby the lighter siliceous impurities are washed away by the current of water.

ie silicon containing impurities are washed away.

iv: Roasting

The impurities in the tin ore include iron and arsenic which tend to react to form the oxides which are more volatile and tend to escape like vapour.

ie

$$4\,As + 3\,O_2 \rightarrow 2\,As_2O_3$$

$$2\,Fe + O_2 \rightarrow 2\,FeO$$

V: Leaching and washing

This is done to remove the sulphates of copper and iron that act as impurities in extraction of tin and the tin obtained is black tin.

6(a) vi: Smelting

This is done in the reveberatory funance in which tin ore is reduced to tin and the impurities of silicates are removed.

$CaCO_3 \xrightarrow[\Delta]{} CaO + CO_2$

$CaO + SiO_2 \rightarrow CaSiO_3 \rightarrow$ removed as impurity

$SnO_2 + 2C \rightarrow Sn + 2CO$

vii: Purification of tin.

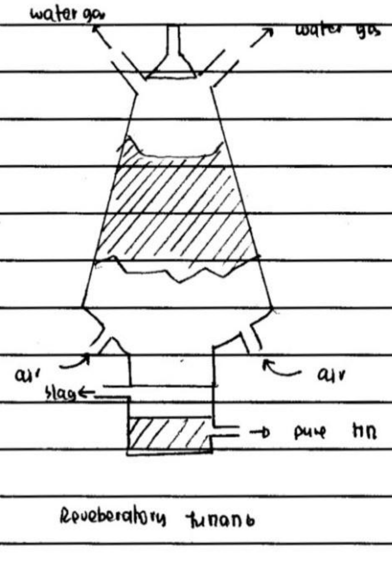
This can be done through Liquation and electrolysis whereby in electrolysis within electrolytic cell the electrolyte is H_2SO_4 and $CuSO_4$ whereby pure tin is collected at cathode and Impure at anode

At cathode

$Sn^{2+} + 2\bar{e} \rightarrow Sn$

At anode

$Sn \rightarrow Sn^{2+} + 2\bar{e}$



Reveberatory funance

6(b). The chemical extraction of aluminium from its ore.

Steps in extraction

1: chief ore

- Bauxite $Al_2O_3 \cdot xH_2O$

Other ores

- Kaolin
- Felspar
- Cryolite - $Na_3[AlF_6]$

Impurities

- TiO
- FeO
- SiO_2.

ii: concentration of the ore

The chief ore of aluminium is crushed to smaller pieces then treated with concentrated NaOH at higher pressure whereby the ore and SiO_2 react.

$$NaOH + Al_2O_3 + H_2O \xrightarrow[\Delta]{\text{high pressure}} Na[Al(OH)_4]$$

$NaOH + SiO_2 \rightarrow Na_2SiO_3$

TiO + ~~SiO~~ NaOH → no reaction

FeO + NaOH → no reaction

iii: Filtration and separation

On filtration and separation the $Na[Al(OH)_4]$ and Na_2SiO_3 are the filtrates while TiO and FeO are moved as the residuals.

6b) iv: The reaction with carbondioxide

Only $Na[Al(OH)_4]$ reach with carbondioxide to form $Al(OH)_3$ while Na_2SiO_3 does not react with carbondioxide

ie

$$Na[Al(OH)_4] + CO_2 \rightarrow Al(OH)_3 + Na_2CO_3 + H_2O$$

$$Na_2SiO_3 + CO_2 \rightarrow \text{no reaction}$$

v: Separation and filtration

On separation $Al(OH)_3$ will be the residue while Na_2SiO_3 will be the filtrate

$Al(OH)_3 \rightarrow$ residue

$Na_2SiO_3 \rightarrow$ filtrate

vi: Formation of alumuna (Al_2O_3)

This is done through decomposition reaction by heating $Al(OH)_3$ in intensive heat to form Al_2O_3 and H_2O

$$Al(OH)_3 \xrightarrow[\Delta]{} Al_2O_3 + H_2O$$

vii: Electrolysis

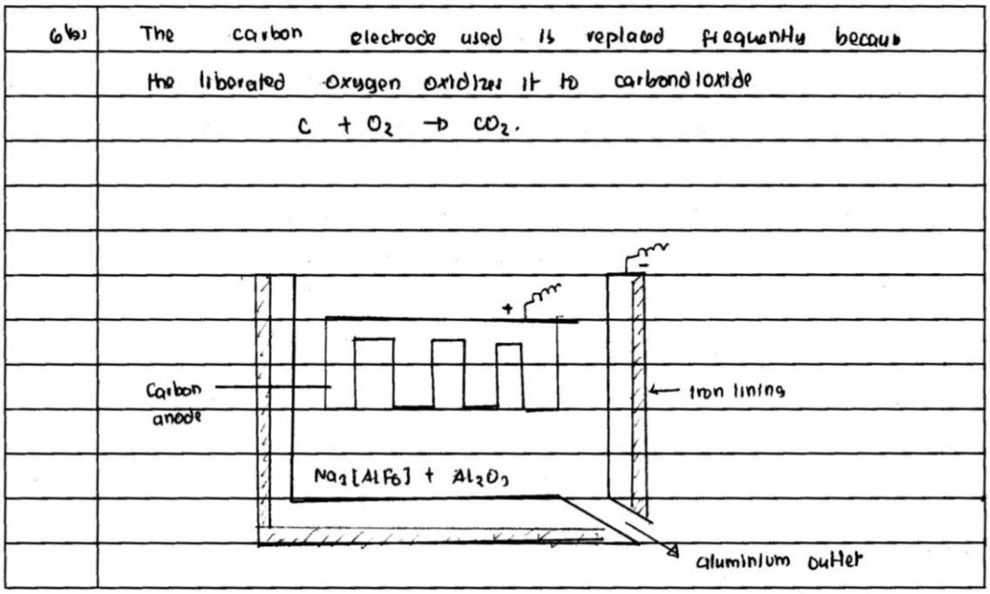
During electrolysis the pure aluminium is collected at the cathode, in the electrolytic cell there is the use of cryolite that helps in increasing conductivities of aluminium and lowers melting point of aluminium

At cathode

$$Al^{3+} + 3\bar{e} \rightarrow Al$$

At anode

$$O_2 + 2\bar{e} \rightarrow O^{2-}$$



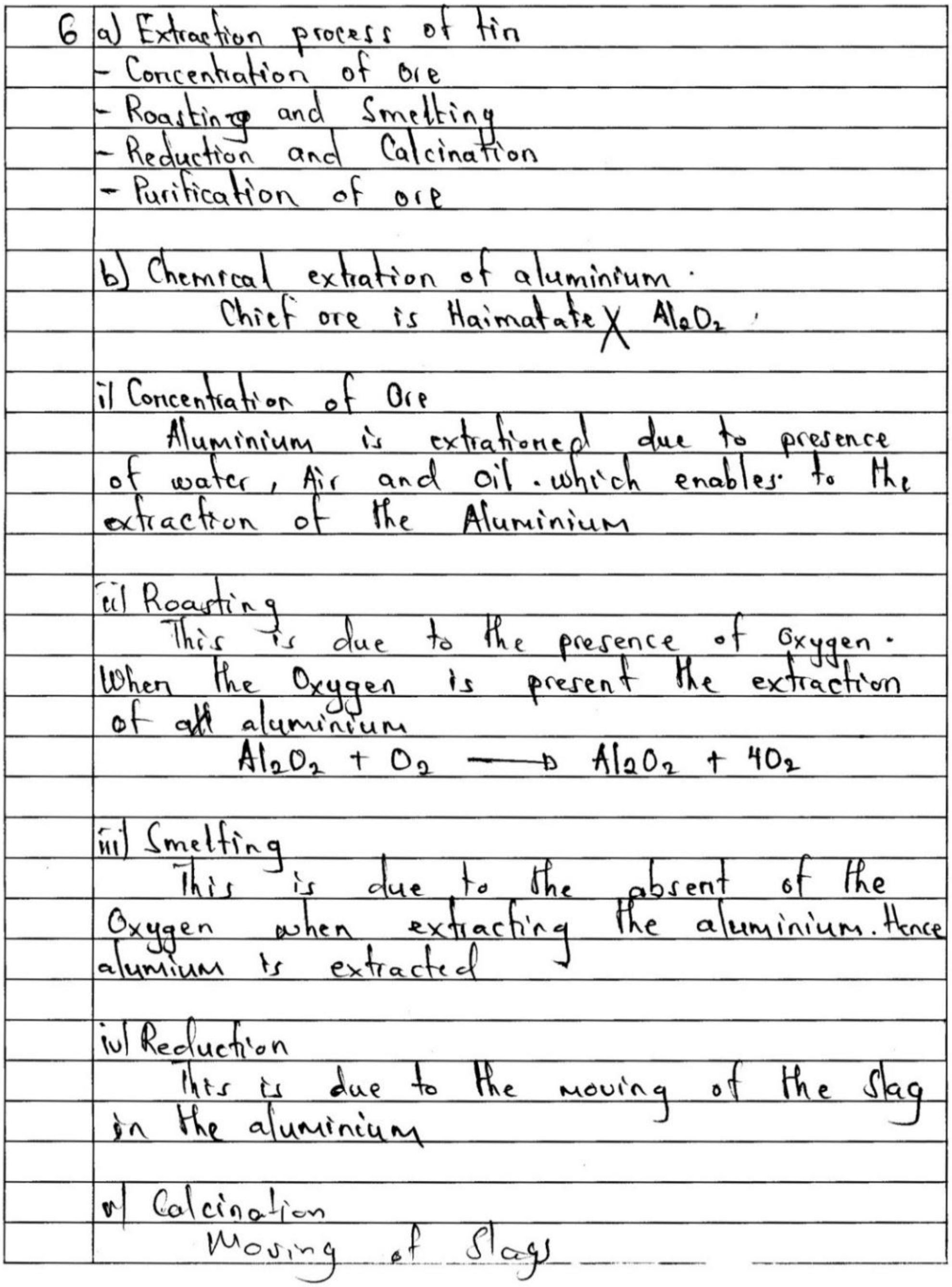
6(b) The carbon electrode used is replaced frequently becau the liberated oxygen oxidizes it to carbondioxide

$C + O_2 \rightarrow CO_2$.

Extract 20.1 shows a set of correct responses from a candidate who explained correctly, with the support of illustrations, the basic stages involved in extraction process of tin and aluminium from their chief ores.

Some of the candidates who performed poorly in this question failed to name correctly the chief ores of tin and aluminium. One of the candidates for example, used haematite instead of bauxite as the chief ore of aluminium. Majority of the candidates failed to write the formula of the ores of tin as well as aluminum. Consequently, they failed to write the required reduction equations proprly. Some of the candidates were unable to give the balanced chemical equations required for each process. The analysis also revealed that some of the candidates wrote incorrectly the discharge equation of aluminum Al^{3+} ions at the cathode. This is an indication that the candidates failed to integrate the knowledge of electrolysis with the process of aluminium extraction. Extract 20.2 shows a set of responses from a candidate who performed poorly in the question.

Extract 20.2



6 a) Extraction process of tin
- Concentration of ore
- Roasting and Smelting
- Reduction and Calcination
- Purification of ore

b) Chemical extration of aluminium.

Chief ore is Haimatate X Al_2O_2

i) Concentration of Ore

Aluminium is extrationed due to presence of water, Air and oil. which enables to the extraction of the Aluminium

ii) Roasting

This is due to the presence of Oxygen. When the Oxygen is present the extraction of ~~all~~ aluminium

$$Al_2O_2 + O_2 \longrightarrow Al_2O_2 + 4O_2$$

iii) Smelting

This is due to the absent of the Oxygen when extracting the aluminium. Hence alumium is extracted

iv) Reduction

This is due to the moving of the Slag in the aluminium

v) Calcination

Moving of Slags

Extract 20.2 shows that the candidate provided the general methods of metal extraction instead of specific methods for the extraction of tin. In part (b), the candidate mentioned haematite incorrectly as the chief aluminium ore. In subsections (i) - (iv), he/she provided incorrect stages that are not specific for the process of aluminium extraction.

2.2.7 Question 7: Selected Compounds of Metals

This question had four parts; (a), (b), (c) and (d). Part (a)(i) required the candidates to classify the oxides Al_2O_3, Na_2O, ZnO and CaO as amphoteric, basic or acidic. Part (a)(ii) required the candidates to explain with examples, five uses of sulphates of selected metals in different fields. Moreover, part (b) of the question required the candidates to explain the following facts using suitable equations: (i) the aqueous solution of iron (III) chloride being acidic (ii) gaseous iron (III) chloride at low temperature exist as a dimmer and being a covalent compound (iii) red hot iron decomposes steam reversibly, and (iv) the aqueous solution of sodium hydrogen carbonate is alkaline. In part (c), the candidates were required to give reasons for the notion that iron (III) carbonate does not exist. Part (d) required the candidates to describe with examples the chemistry of Zinc oxide (ZnO).

This was the least opted question being attempted by only 1,513 candidates equivalent to 4.6 percent. This was the most poorly performed question. 95.9 percent of the candidates scored low marks ranging from 0 to 6.5. The candidates who managed to score average marks were 3.0 percent, while only 1.1 percent scored high marks from 12 - 20. The performance of the candidates is as shown in Figure 20.

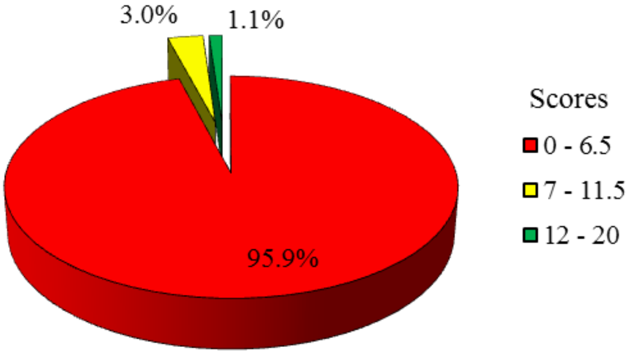


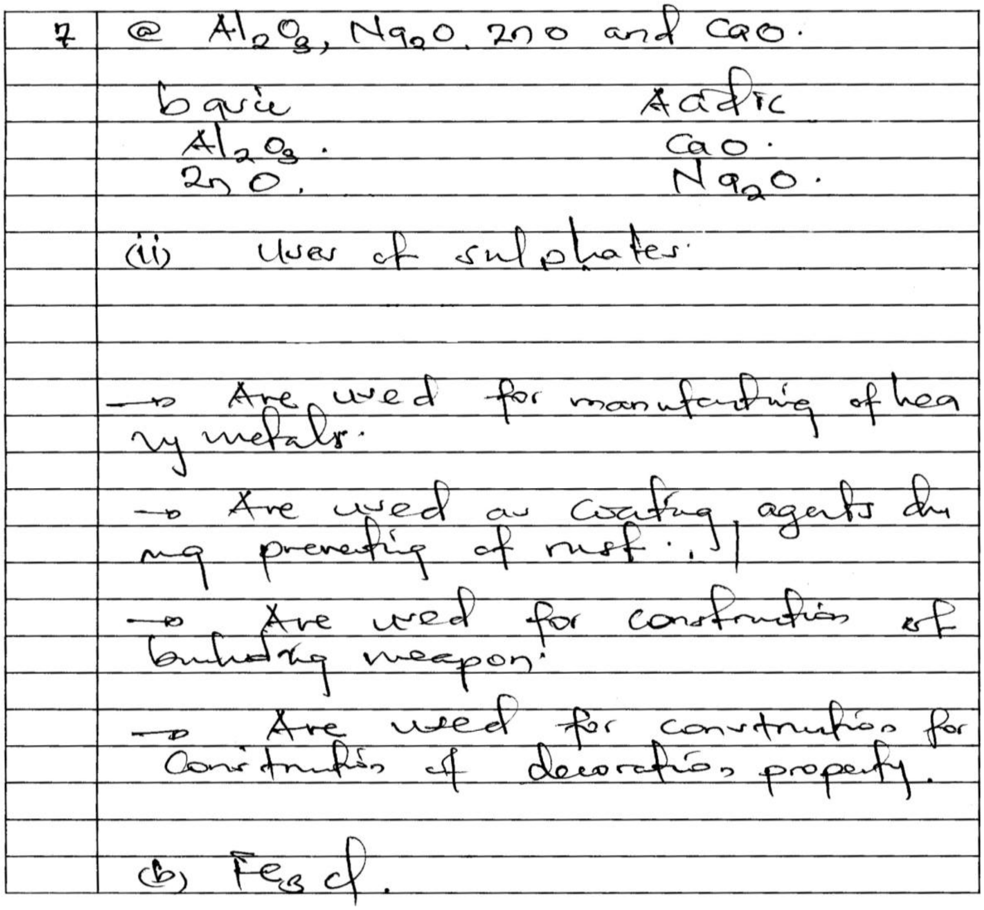
Figure 20: *Performance of the candidates in question 7.*

Figure 20 depicts that the overall performance of the candidates in the question was poor as 95.9 percent scored below 7.0 marks. Analysis of the candidates answers showed that majority of those who had unsatisfactory performance failed to classify the given oxides as required. Such performance indicates that they were unable to relate the trends in properties of oxides with the position of the corresponding elements in the Periodic Table as well as reactivity series of metals. In part (a) (ii), most of the candidates failed to explain with examples the five uses of sulphates of selected metals in different fields. This suggests that the majority of the candidates did not attain the appropriate competencies stipulated in the syllabus hence had insufficient knowledge on the application of sulphates in daily life.

In part (b), most of them faced difficulties in explaining with suitable equations the facts presented in the question. This shows that the candidates had insufficient knowledge on the concept of salt hydrolysis, the cation bond polarization, and the reactivity series of metals. Such concepts are part and parcel towards understanding properties of metals and their compounds. In part (c), most of the candidates failed to give reasons for the non-existence of iron (III) carbonate which suggested that the candidates did not comprehend the way small size and high charge of cations affect stability of carbonate compounds. Few candidates who attempted part (d) failed to describe with suitable examples the chemistry of Zinc oxide (ZnO). This indicates that they had insufficient knowledge on the properties of compounds of metals and the position of elements in the Periodic Table with respect to their corresponding oxides.

The overall analysis on the responses given by most of the candidates who performed poorly suggests inadequate knowledge of Inorganic Chemistry oriented questions, particularly properties of selected compounds of metals. There is likelihood that the competence in this topic was not adequately attained since most of the candidates skipped the question. Extract 21.1 is a sample of poor responses from one of the candidates.

Extract 21.1



7 (a) Al_2O_3, Na_2O, ZnO and CaO.

basic	Acidic
Al_2O_3.	CaO.
ZnO.	Na_2O.

(ii) Uses of sulphates.

→ Are used for manufacturing of heavy metals.

→ Are used as coating agents during preventing of rust.

→ Are used for construction of building weapon.

→ Are used for construction for construction of decoration property.

(b) Fe_3Cl.

Extract 21.1 shows that the candidate incorrectly classified amphoteric oxides Al_2O_3 and ZnO as amphoteric instead of basic oxides and the basic oxides (CaO and Na_2O) as acidic oxides. In part (a)(ii), the candidate gave uses of metal sulphates which were not specific.

On the other hand there were few candidates who managed to answer correctly most parts of the question. Extract 21.2 shows a response from one of the candidates who scored high marks.

Extract 21.2

7 (a) (i) Oxides: Al_2O_3, Na_2O, ZnO and CaO.

Na_2O and CaO are basic oxides since when are dissolved in water tends to give alkaline solutions.

$Na_2O + H_2O \longrightarrow NaOH + H_{2(g)}$

$CaO + H_2O \longrightarrow Ca(OH)_2 + H_{2(g)}$

Therefore are called basic oxides since gives alkaline solution when dissolved in water.

- Al_2O_3 and ZnO are amphoteric oxides. this imply that they have both basic and acidic characteristics.

As base: they reacts with acids to gives salt and water. Consider the equation below as base.

$Al_2O_{3(s)} + HCl_{(aq)} \longrightarrow AlCl_{3(s)} + H_2O_{(l)}$

$ZnO + 2HCl_{(aq)} \longrightarrow ZnCl_{2(aq)} + H_2O$

As acids: they reacts with base to form complex of tetrahydroxoaluminate (III)

Consider the equations.

$Al_2O_3 + NaOH \longrightarrow [2NaAl(OH)_4] + H_2O$

~~$ZnO + NaOH$~~

$Al_2O_3 + 2NaOH \longrightarrow 2NaAlO_2 + H_2O$

$ZnO + 2NaOH \longrightarrow Na_2ZnO_2 + H_2O$

the two complexes are soluble.

7ⓐ ① The following are the uses of sulphates

(a) They are used as fertilizers in agricultural activities. Example $(NH_4)_2SO_4$ hence supply nutrients.

(b) Sulphates are used in the laboratories in the qualitative analysis of salts. example $CaSO_4$.

(c) Sulphates also are used in formation of permanent hardness of water example $MgSO_4$.

ⓓ Used in production of Nylon.

7(b) (i) the aqueous solution of Iron (III) chloride is acidic because in aqueous solution they undergoes hydrolysis leads to the formation of Hydroxnium Ions (H_3O^+) which cause the acidic nature.

Equation

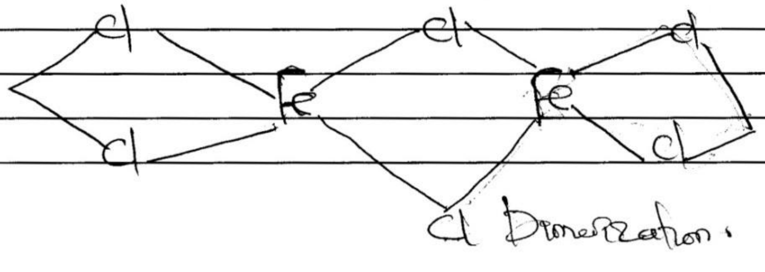
$$Fe^{3+} + H_2O_{(l)} \longrightarrow [Fe(H_2O)_6]^{3+}$$
$$[Fe(H_2O)_6]^{3+} + H_2O \longrightarrow [Fe(H_2O)_5]^{2+} + H_3O^+$$
$$[Fe(H_2O)_5]^{2+} + H_2O \longrightarrow [Fe(H_2O)_4OH]^{+} + H_3O^+$$

Therefore formation of hydroxnium Ions (H_3O^+) cause the acidic nature.

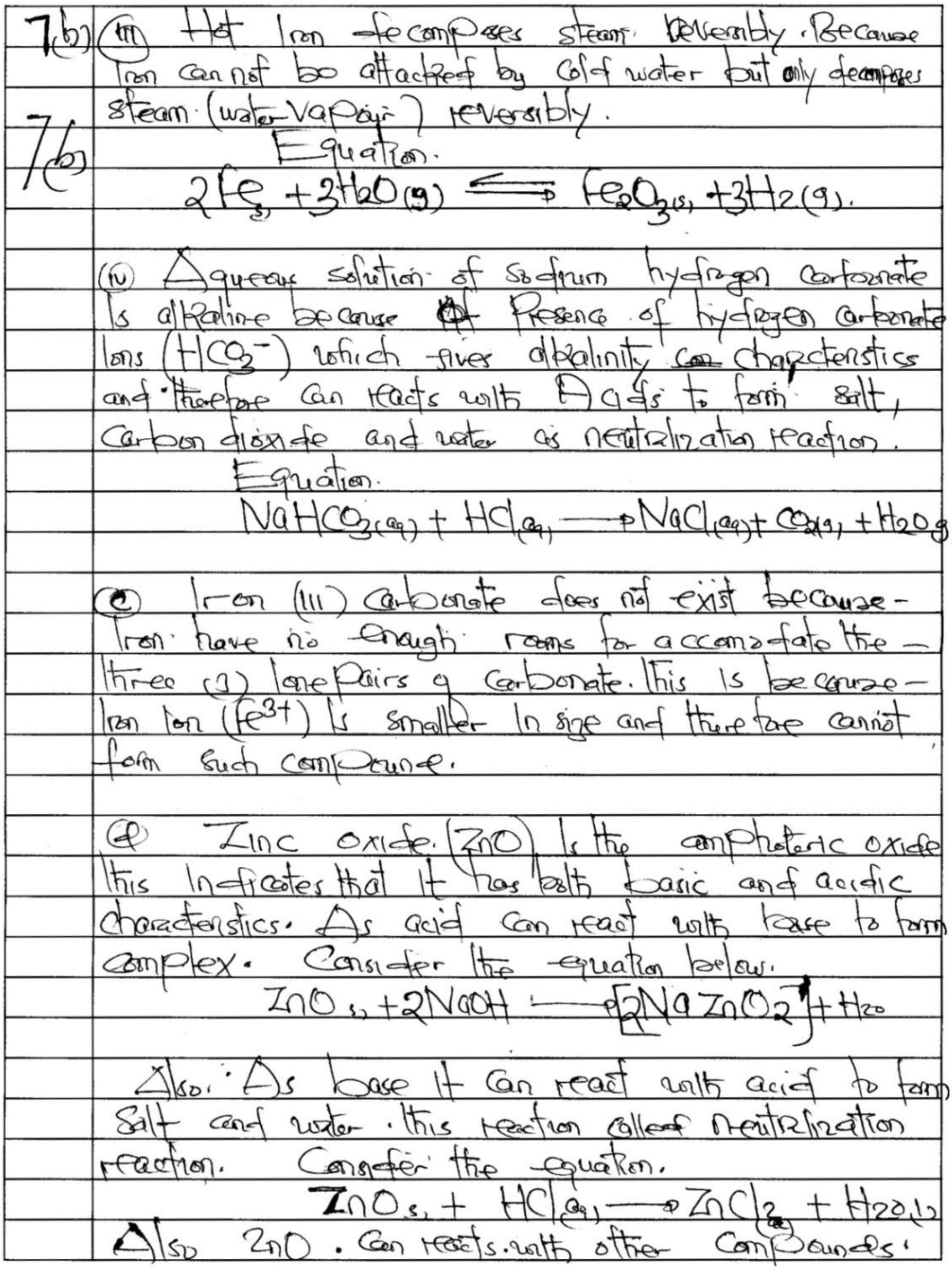
(ii) Iron (III) Chloride at gaseous state undergoes dimerization to form dimer and its molecular mass become twice than expected.

Δ

$$FeCl_3 + FeCl_3 \rightarrow Fe_2Cl_6.$$



Dimerization.



7(b) (iii) Hot Iron decomposes steam reversibly. Because Iron can not bo attacked by cold water but only decomposes steam (water vapour) reversibly.

7(b)

Equation.

$2Fe_{(s)} + 3H_2O_{(g)} \rightleftharpoons Fe_2O_{3(s)} + 3H_{2(g)}$.

(iv) Aqueous solution of Sodium hydrogen carbonate is alkaline because ~~of~~ Presence of hydrogen carbonate ions (HCO_3^-) which gives alkalinity ~~con~~ charcteristics and therefore can reacts with Acids to form salt, Carbon dioxide and water as neutralization reaction.

Equation.

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

(c) Iron (III) Carbonate does not exist because - Iron have no enough rooms for accomodate the - three (3) lone pairs of Carbonate. This is because - Iron ion (Fe^{3+}) is smaller in size and therefore cannot form such compound.

(d) Zinc oxide (ZnO) is the amphoteric oxide this indicates that it has both basic and acidic characteristics. As acid can react with base to form complex. Consider the equation below.

$ZnO_{(s)} + 2NaOH \longrightarrow [2NaZnO_2] + H_2O$

Also: As base it can react with acid to form salt and water. this reaction called neutralization reaction. Consider the equation.

$ZnO_{(s)} + HCl_{(aq)} \longrightarrow ZnCl_{2(aq)} + H_2O_{(l)}$

Also ZnO. Can reacts with other compounds.

Extract 21.2 shows a response whereby the candidate classified correctly the oxides of metals given, gave three correct uses of metal sulfates with examples. In other parts of the question the candidate responded correctly and included appropriate chemical equations.

2.2.8 Question 8: Environmental Chemistry

This question had three parts; (a), (b), and (c). Part (a) required the candidates to outline any six control measures which are useful in minimizing the chemical pollution of water bodies. Part (b) required the candidates to outline any four possible causes of environmental degradation. In part (c), the candidates were required to explain eight effects of air pollution to living organisms.

The question was attempted by 27,304 candidates corresponding to 82.2 percent. This was one of the most opted questions. Analysis of the performance indicated that 87.4 percent of the candidates scored 12 - 20 marks, 11.1 percent scored 7 - 11.5 marks while only 1.5 percent scored 0 - 6.5 marks. Figure 21 shows performance of the candidates in question 8.

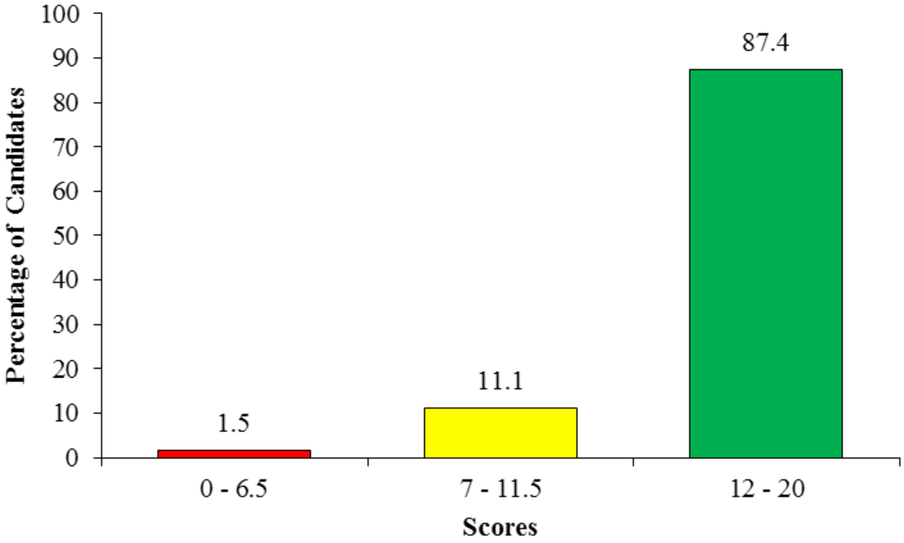
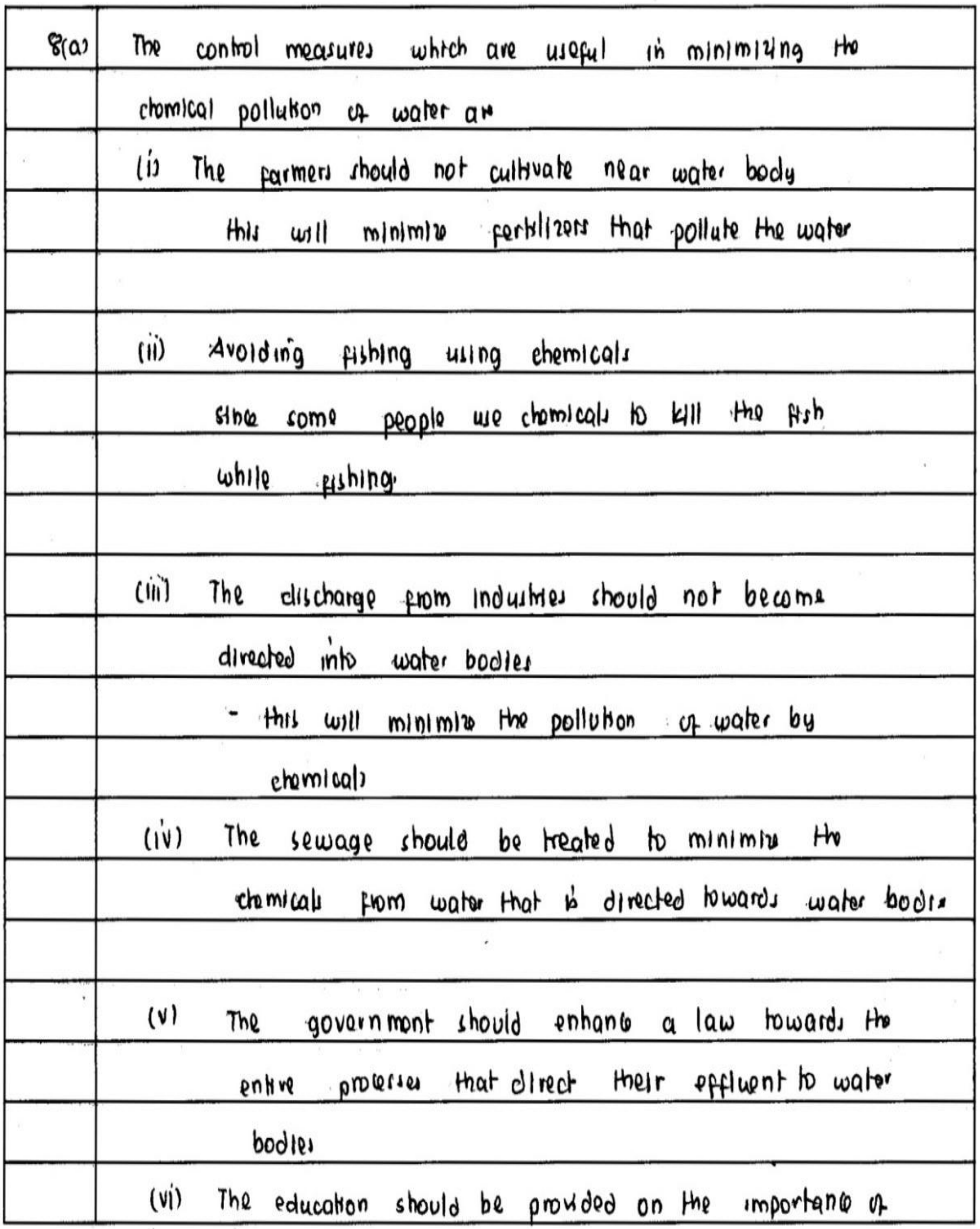


Figure 21: *Performance of the candidates in question 8.*

Figure 21 shows that majority of the candidates corresponding to 98.5 percent passed the question. The overall performance in this question was good. The candidates who scored high marks managed to answer most parts of the question correctly. This is attributed to the nature of the topic which cross-cuts several disciplines as one among the most current issues in the globe. Therefore, the candidates had ample time both at school and at home to acquire the knowledge of environmental chemistry in their daily life activities and probably from different media outlets. The candidates who managed to score all the marks communicated their responses in good language and precisely to the point. Hence, they got full marks. Extract 22.1 is a sample of a good response from one of the candidates who scored full marks.

Extract 22.1



8(a) The control measures which are useful in minimizing the
chemical pollution of water are

(i) The farmers should not cultivate near water body
this will minimize fertilizers that pollute the water

(ii) Avoiding fishing using chemicals
since some people use chemicals to kill the fish
while fishing.

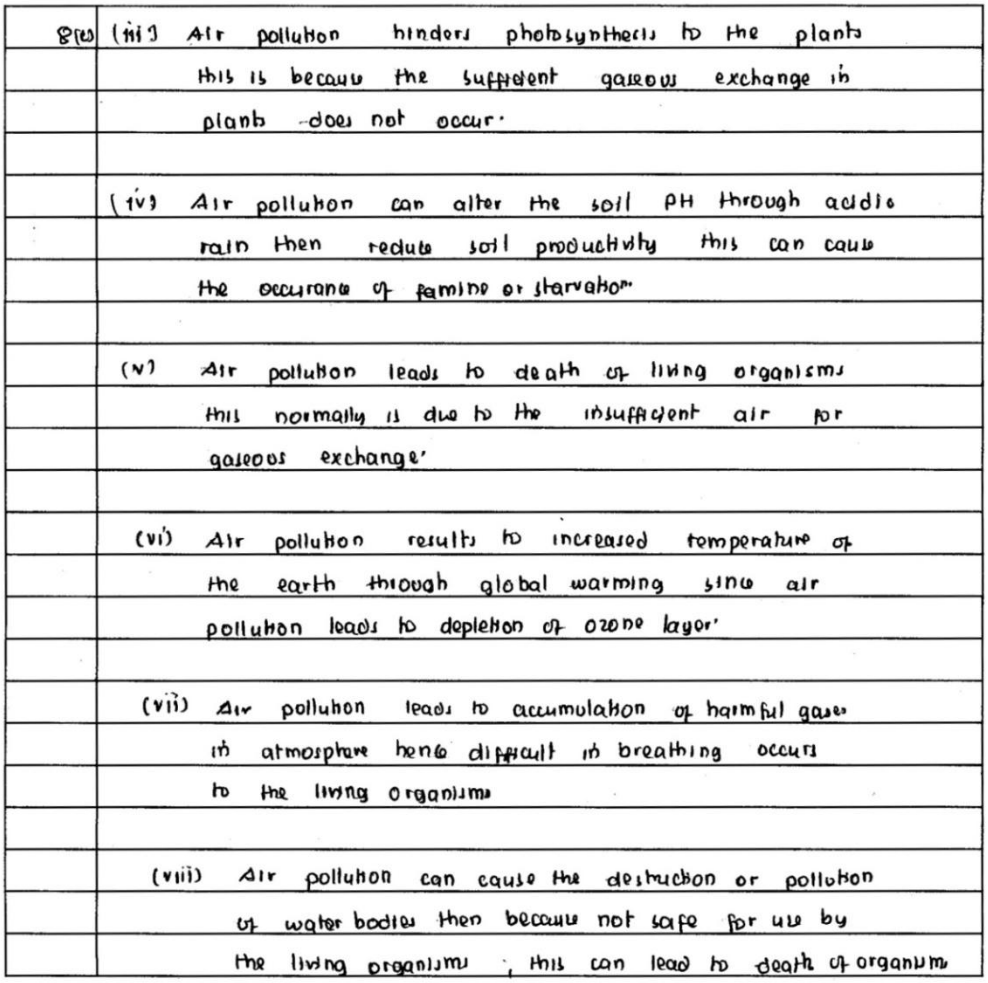
(iii) The discharge from industries should not become
directed into water bodies
- this will minimize the pollution of water by
chemicals

(iv) The sewage should be treated to minimize the
chemicals from water that is directed towards water bodies

(v) The government should enhance a law towards the
entire processes that direct their effluent to water
bodies

(vi) The education should be provided on the importance of

8(a)(i)	the availablity of water body this will minimize the
	chemical pollution of water.
8 (b)	The four possible causes of environmental degradation are;
	as follows
	(i) The chemicals released from industries
	- they can be in gaseous or liquid state
	(ii) ~~Domette~~ Domestic waste materials also cause
	environmental degradation
	ie pieces of cloth, food remains.
	(iii) Mining activities
	They tend to leave the land bare hence suffer
	erosion and soil become infertile
	(iv) Defforestation this also causes environmental
	degradation that cause erosion to the land'
8(c)	The eight effect of air pollution to living organisms
	include below
	(i) Air pollution cause the loss of vision to the people
	especially when there is a formation of smog
	this in turn can lead to accident'
	(ii) Air pollution cause the spread of diseases
	Like the respiratory tract infections that can
	lead to decrease in number of organisms



8(c) (iii) Air pollution hinders photosynthesis to the plants
this is becaus the suffiecent gaseous exchange in
plants does not occur.

(iv) Air pollution can alter the soil PH through acidic
rain then reduce soil productivity this can cause
the occurance of famine or starvation.

(v) Air pollution leads to death of living organisms
this normally is due to the insufficient air for
gaseous exchange.

(vi) Air pollution results to increased temperature of
the earth through global warming since air
pollution leads to depletion of ozone layer.

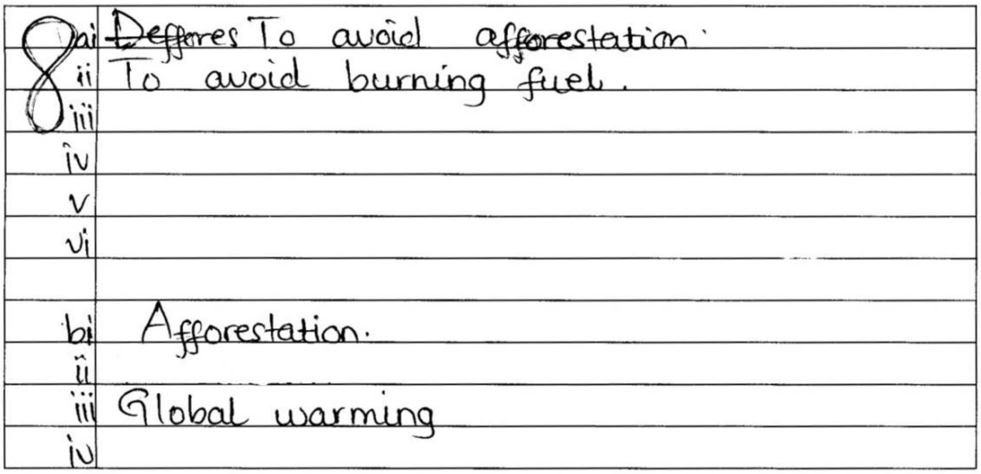
(vii) Air pollution leads to accumulation of harmful gases
in atmosphere hence difficult in breathing occurs
to the living organisms

(viii) Air pollution can cause the destruction or pollution
of water bodies then because not safe for use by
the living organisms, this can lead to death of organism.

Extract 22.1 represents a set of correct responses whereby the candidate demonstrated appropriate competencies; outlined six measures useful in minimizing the chemical pollution of water, outlined correctly the four causes of environmental pollution and explained the eight effects of air pollution to living organisms.

Despite the fact that most candidates attempted well this question, some few candidates did not understand the requirements of the question items. One of the candidates for example, mentioned afforestation and global warming as the causes of environmental degradation. This revealed that the candidates were not knowledgeable enough on the concept of environmental pollution. Language proficiency was another factor which contributed to the poor performance of some candidates in this question. Extract 22.2 represents a sample of the poor responses from one of the candidates.

Extract 22.2



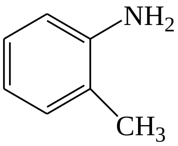
8 a i ~~Deffores~~ To avoid afforestation.
ii To avoid burning fuel.
iii
iv
v
vi

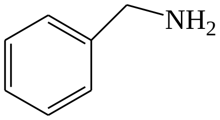
b i Afforestation.
ii
iii Global warming
iv

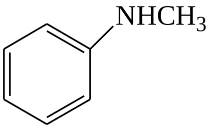
Extract 22.2 shows a response whereby the candidate gave incorrect answers in part (a). Furthermore, the candidate mentioned afforestation and global warming as causes of environmental degradation contrary to the fact. He/she could not answer some question items.

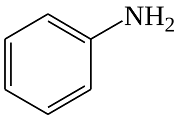
2.2.9 Question 9: Amines

This question had four parts namely (a), (b), (c) and (d). Part (a) required the candidates to arrange (with reasons), the following amines in order of increasing basic strength:









Part (b) required the candidates to show how *n*-propylamine could be prepared from each of the following compounds: (i) *n*-propyl bromide, (ii) *n*-propyl alcohol, (iii) *n*-butyl alcohol and (iv) propanitrile. In part (c), the candidates were required to describe in two steps, the conversion of benzene into aniline (phenyl amine) while part (d) required candidates to give the structures and names of the organic products formed when phenyl amine reacted with; (i) Ethanoic anhydride, (ii) Aqueous bromine, (iii) Ethanoic anhydride followed by bromine water and (iv) Sodium nitrite and hydrochloric acid below 10°C.

Only 1,261 (3.8 percent) candidates attempted this question, being the least opted question in this paper. Statistical data indicated that 59.2, 29.7 and 11.1 percent of the candidates scored 0 - 6.5, 7 - 11.5 and 12 - 20 marks respectively. Summary of these statistics is given in Figure 22.

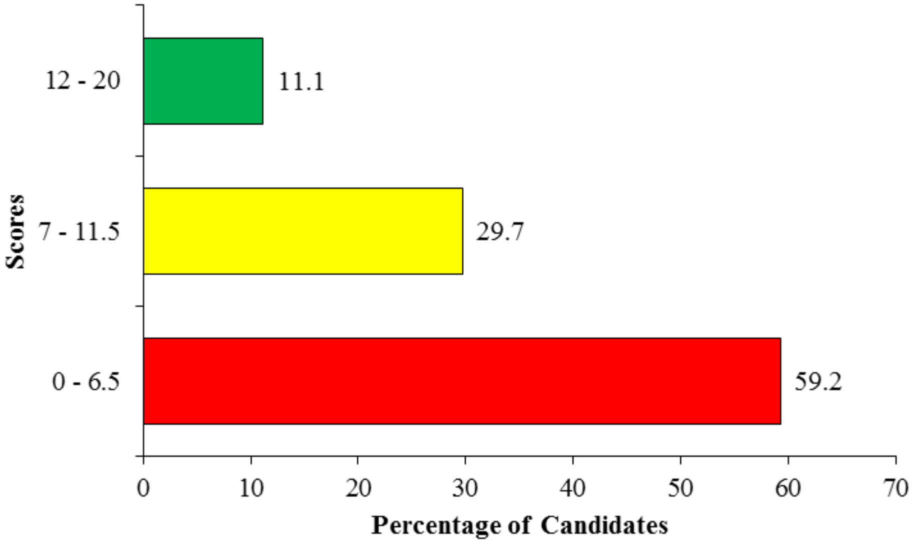
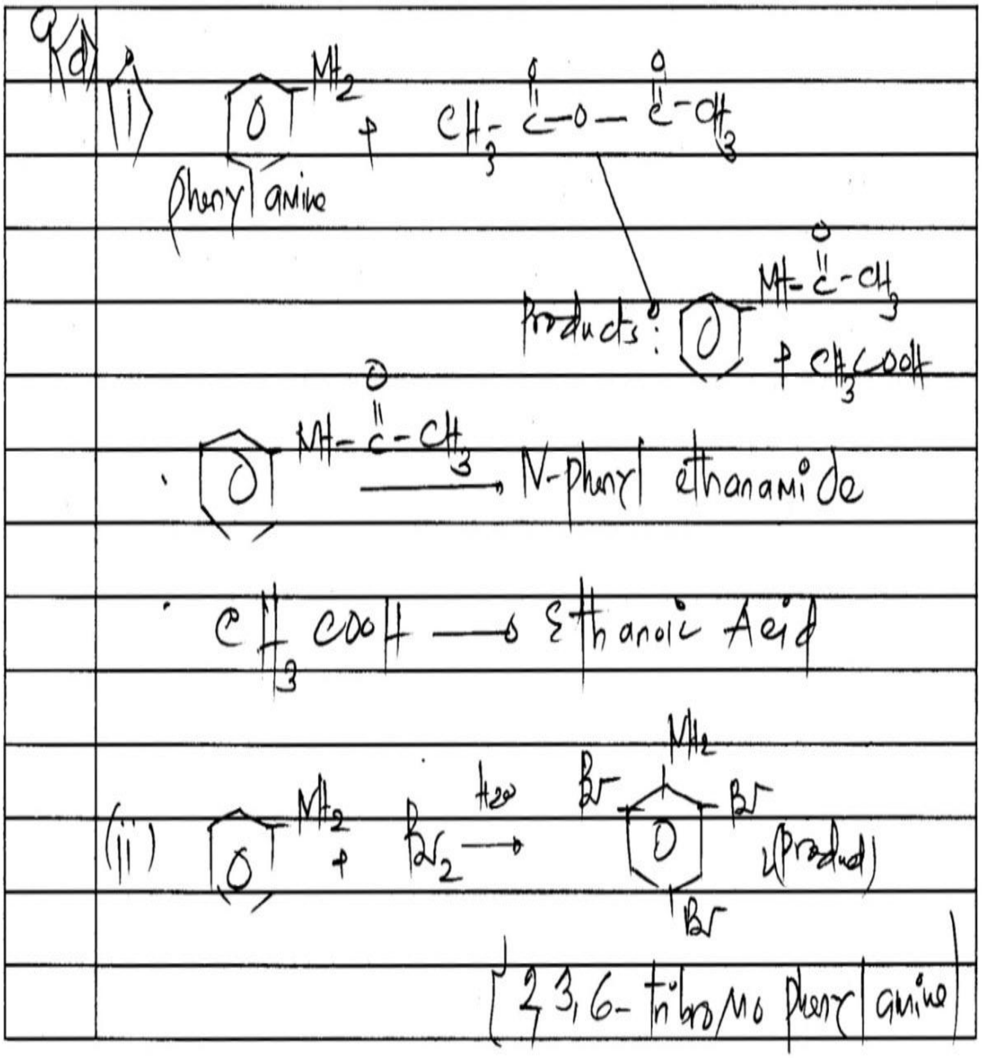


Figure 22: *Performance of the candidates in question 9.*

The general analysis from figure 22 shows that majority (59.2 percent) of the candidates scored below average (0 - 6.5 mark). Further analysis shows that 191 candidates amounting to 15.1 percent scored zero mark. However, 40.8 percent of the candidates scored 7 marks and above Therefore, the overall performance in this question leaned towards the lower side of the average performance (35 - 59 percent).

Most of the candidates who managed to score high marks in this question showed a good understanding on the topic of amines. Hence, they were able to give correct arrangement of given amines in order of increasing basic strength. Most of the candidates in this group were conversant with the methods of preparation of amines hence, gave the plausible synthetic pathways for the synthesis of *n*-propylamine from the given precursors. Extract 23.1 depicts responses from the script of a candidate with high scores in the question. However, the candidate failed to give the structure and name of the product formed in part (d)(iii).

Extract 23.1



Q(d) (i) NH_2 + $CH_3-\overset{O}{\overset{\|}{C}}-O-\overset{O}{\overset{\|}{C}}-CH_3$

Phenyl amine

Products: $NH-\overset{O}{\overset{\|}{C}}-CH_3$ + CH_3COOH

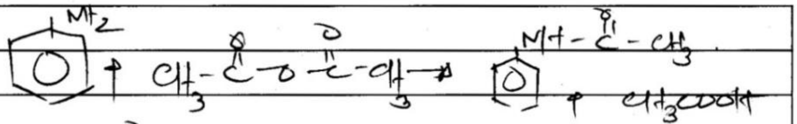
$NH-\overset{O}{\overset{\|}{C}}-CH_3$ ⟶ N-phenyl ethanamide

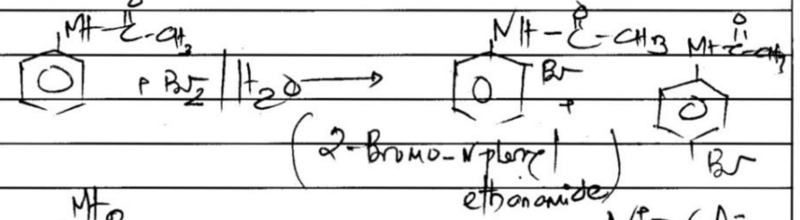
CH_3COOH ⟶ Ethanoic Acid

(ii) NH_2 + $Br_2 \xrightarrow{H_2O}$ Br, NH_2, Br, Br (Product)

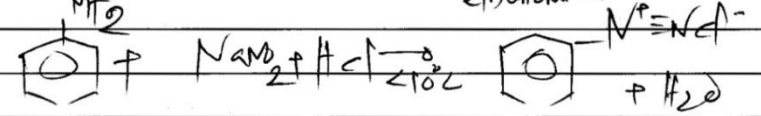
[2 3, 6- tribromo phenyl amine]

(iii)

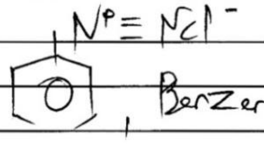




(iv)



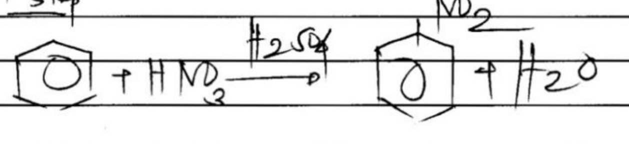
Product:



, Benzene diazonium chloride

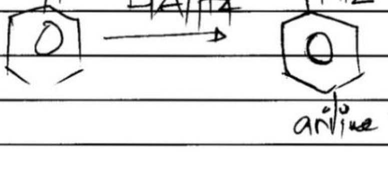
9(c) - with the Detailed CONVERSION. Benzene into aniline.

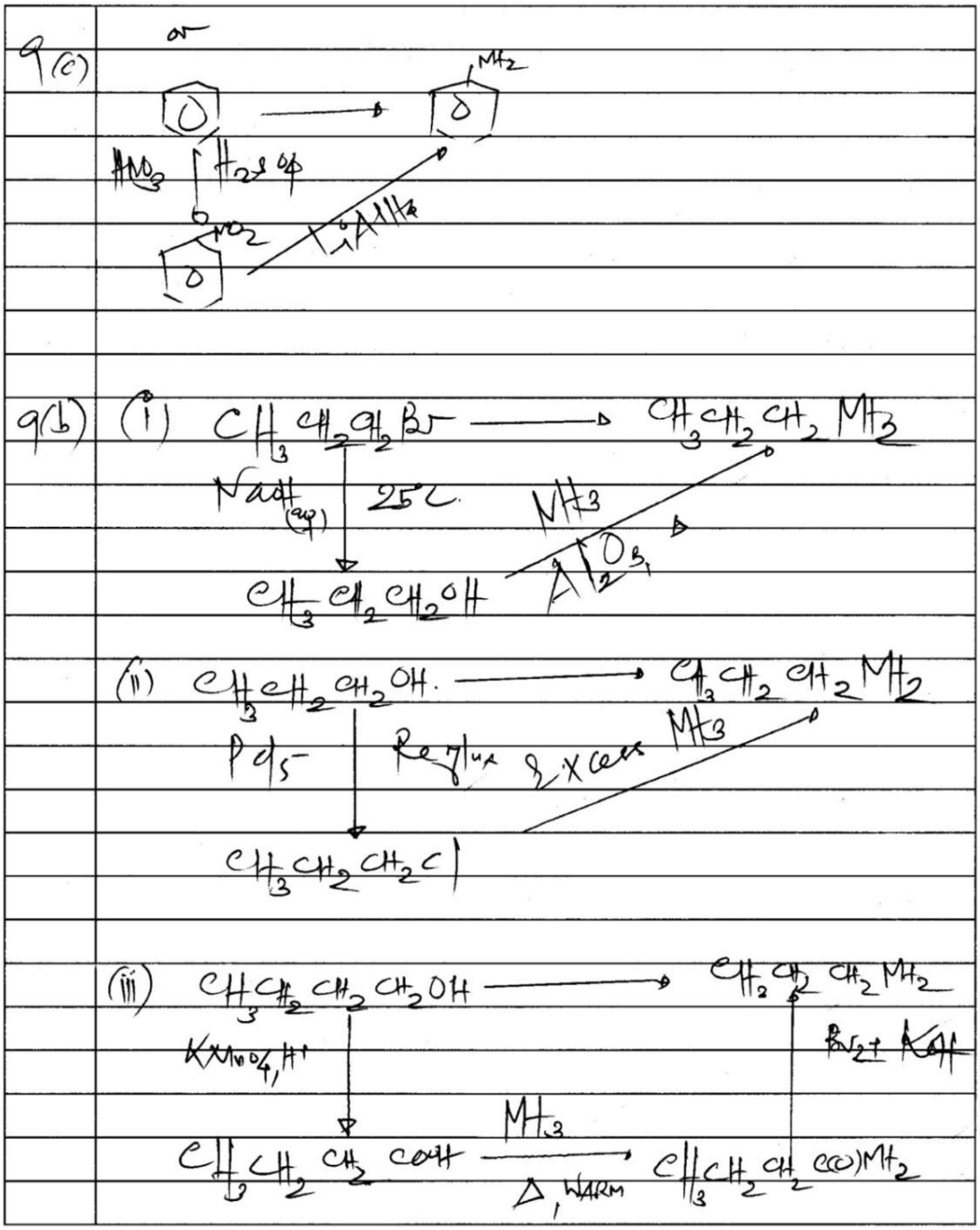
1st step



2nd step

Reduction of Nitrobenzene





9(c) or

$\xrightarrow{}$ NH2

HNO_3 | H_2SO_4

NO_2 $\xrightarrow{LiAlH_4}$

9(b) (i) $CH_3CH_2CH_2Br \longrightarrow CH_3CH_2CH_2NH_2$

$NaOH_{(aq)}$ | 25C

$CH_3CH_2CH_2OH$ $\xrightarrow{NH_3}$ Al_2O_3, Δ

(ii) $CH_3CH_2CH_2OH. \longrightarrow CH_3CH_2CH_2NH_2$

PCl_5 | Reflux & excess NH_3

$CH_3CH_2CH_2Cl$

(iii) $CH_3CH_2CH_2CH_2OH \longrightarrow CH_3CH_2CH_2NH_2$

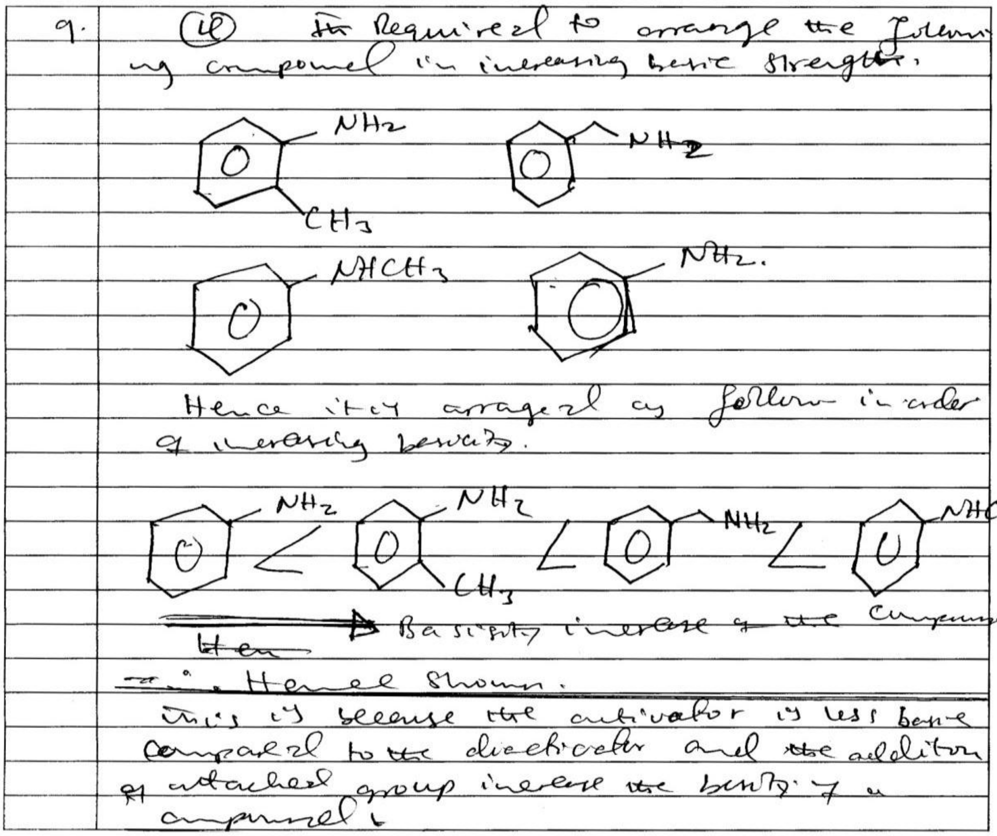
$KMnO_4, H^+$ | $Br_2 + KOH$

$CH_3CH_2CH_2COOH \xrightarrow[\Delta,\ WARM]{NH_3} CH_3CH_2CH_2CONH_2$

Extract 23.1 gives responses from one of the candidates who demonstrated a good understanding on the topic of amines by supplying correct reactions and names of the products in most parts of the question.

Most of the candidates with low performance failed to arrange the given list of amines in order of increasing basic strength. This implied that, they had insufficient knowledge about the directive influences of activators such as methyl group on the basicity strength of aromatic and aliphatic amines, and their corresponding classes. This is due to insufficient competencies regarding the concepts of mesomerism and delocalization as well as inductive effects. Although some candidates managed to arrange the compounds according to basic strength, they could not justify their responses hence, lost some marks. Most of the candidates also failed to show how *n*-propylamine could be prepared from the given compounds. This indicated inadequacy of the knowledge on the reactions and properties of different functional groups in the preparation of amines. Such observation is attributed to insufficient exposure and practices on the topic. The clear evidence from the candidates answers shows that most of them had inadequate knowledge about the principles of reaction mechanisms, the factors effecting organic reactions and interconversion from one functional group to the other. Extract 23.2 represents one of the candidates poor responses.

Extract 23.2



9. (a) ~~It~~ Required to arrange the following compound in increasing basic strength.

Hence it is arranged as follow in order of increasing basicity.

Basicity increase of the compound ~~then~~

∴ Hence shown.

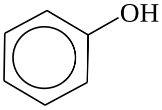
This is because the activator is less base compared to the deactivator and ~~the~~ addition of attached group increase the basicity of a compound.

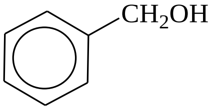
Extract 23.2 portrays a portion of sample responses in which the candidate gave incorrect arrangement of the amines in terms of their basic strength. He/she accounted erroneously for the stated arrangement.

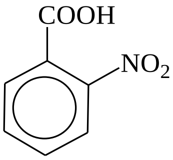
2.2.10 Question 10: Carboxylic Acids and Derivatives

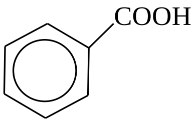
This question had four parts; (a), (b), (c) and (d). Part (a) required the candidates to arrange the following compounds in order of increasing acidic strength:

(i)







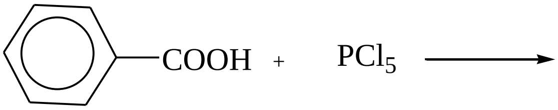


(ii) Ethanoic acid, propanoic acid, methanoic acid, 2-chloroethanoic acid and 2-methylpropanoic acid.

Part (b) required the candidates to provide the major products of the reactions:

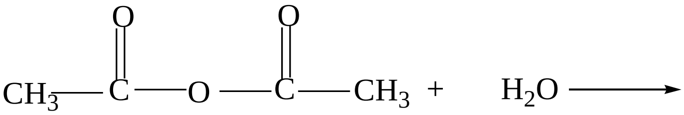
(i) $CH_3CH_2OH + KMnO_4, H_2O, H^+ \rightarrow$

(ii)



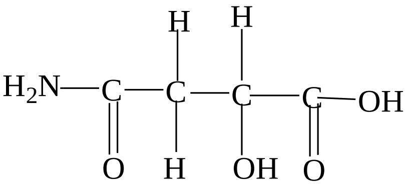
(iii) $CH_3COOH + C_2H_5OH \xrightarrow{H^+}$

(iv)



$$CH_3-\overset{O}{\overset{\|}{C}}-O-\overset{O}{\overset{\|}{C}}-CH_3 + H_2O \longrightarrow$$

In part (c), the candidates were given structural formula of compound A which was extracted from certain yellow flowers:



$$H_2N-\underset{\underset{O}{\|}}{C}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{OH}{C}}-\underset{\underset{O}{\|}}{C}-OH$$

and were required to give the organic product that will be formed when the compound was treated with: (i) Nitrous acid, (ii) Ethanol, (iii) $LiAlH_4$, (iv) Potassium dichromate and (v) PCl_5. Part (d) required the candidates to explain the uses and hazards of carboxylic acids.

The question was attempted by 8,661 candidates constituting 26.1 percent of all candidates. The distribution of candidates performance is as shown in Figure 23.

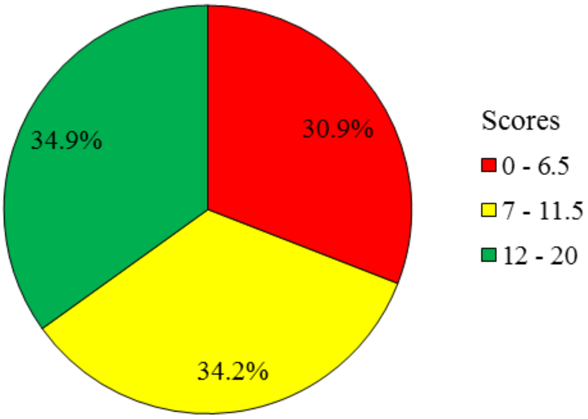


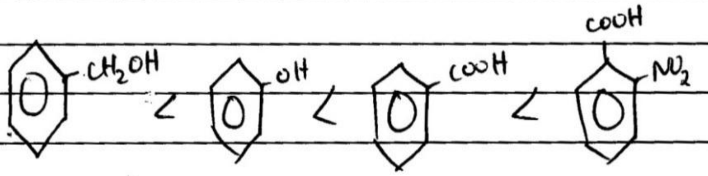
Figure 23: *Performance of the candidates in question 10.*

The statistical data shows that 34.9, 34.2 and 30.9 percent of the candidates scored marks ranging from 12 - 20, 7 - 11.5 and 0 - 6.5, respectively. Analysis indicated that the overall performance in this question was good as majority of the candidates amounting to 69.1 percent scored 7 marks and above.

Most of the candidates who scored high marks answered correctly in most parts of the question. Majority of them were able to arrange properly the carboxylic acid compounds given in order of increasing acidic strength. Furthermore, they demonstrated understanding the concept of stability of carbocations hence, they predicted correctly the major products in the reaction equations provided. Moreover, some of them were able to give all the structures with correct IUPAC names on part (c) of the question and scored all the marks. Extract 24.1 shows a sample of good responses from the script of one of the candidates who managed to score nearly all of the marks allocated to this question.

Extract 24.1

10. ⓐ ⓘ



$\xrightarrow{\hspace{4em}}$

increasing acidity strength

ⓘⓘ

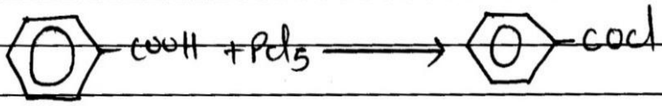
2-methylpropanoic acid < propanoic acid < ethanoic acid < methanoic acid < 2-chloroethanoic acid.

$\xrightarrow{\hspace{4em}}$

increasing acidic strength

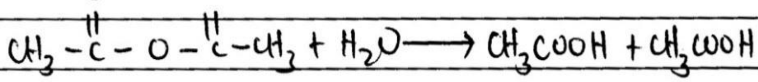
ⓑ ⓘ $CH_3CH_2OH + KMnO_4, H_2O, H^+ \longrightarrow CH_3COOH$

ⓘⓘ



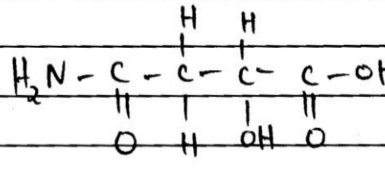
ⓘⓘⓘ $CH_3COOH + C_2H_5OH \xrightarrow{H^+} CH_3COOC_2H_5$

(IV)



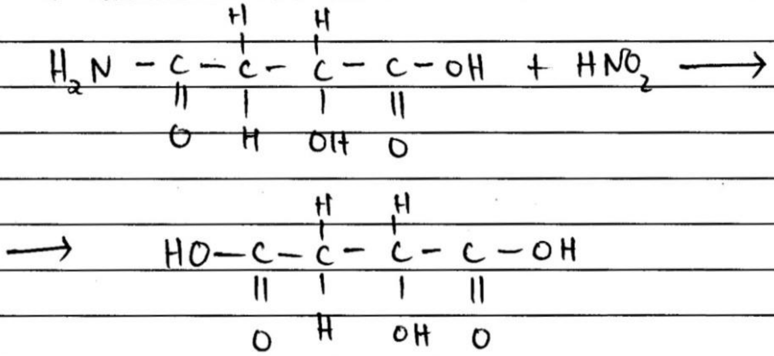
$CH_3-\overset{\overset{O}{\|}}{C}-O-\overset{\overset{O}{\|}}{C}-CH_3 + H_2O \longrightarrow CH_3COOH + CH_3COOH$

ⓒ given



$H_2N-\underset{\underset{O}{\|}}{C}-\overset{H}{\underset{H}{\overset{|}{\underset{|}{C}}}}-\overset{H}{\underset{OH}{\overset{|}{\underset{|}{C}}}}-\underset{\underset{O}{\|}}{C}-OH$

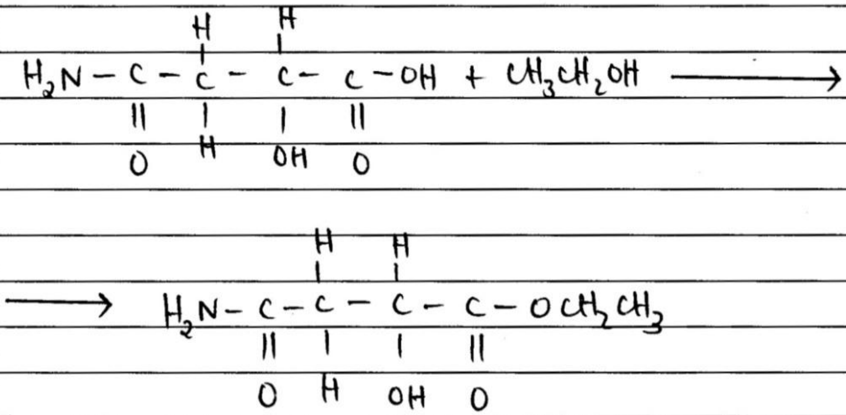
10. ⓒ ① Nitrous acid (HNO_2)



$$H_2N-\underset{\underset{O}{\|}}{C}-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-\overset{\overset{H}{|}}{\underset{\underset{OH}{|}}{C}}-\underset{\underset{O}{\|}}{C}-OH + HNO_2 \longrightarrow$$

$$\longrightarrow HO-\underset{\underset{O}{\|}}{C}-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-\overset{\overset{H}{|}}{\underset{\underset{OH}{|}}{C}}-\underset{\underset{O}{\|}}{C}-OH$$

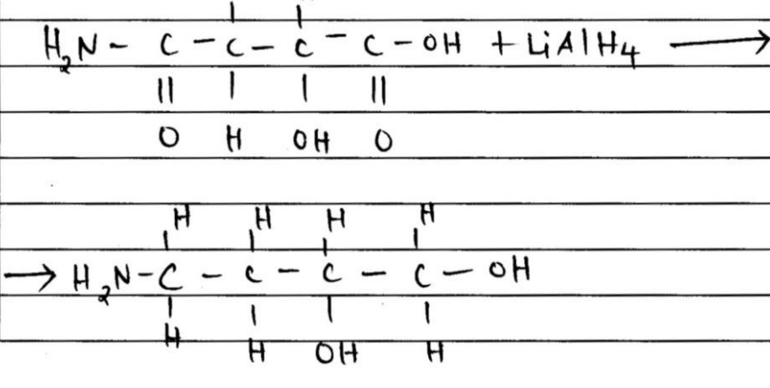
(ii) Ethanot (CH_3CH_2OH)



$$H_2N-\underset{\underset{O}{\|}}{C}-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-\overset{\overset{H}{|}}{\underset{\underset{OH}{|}}{C}}-\underset{\underset{O}{\|}}{C}-OH + CH_3CH_2OH \longrightarrow$$

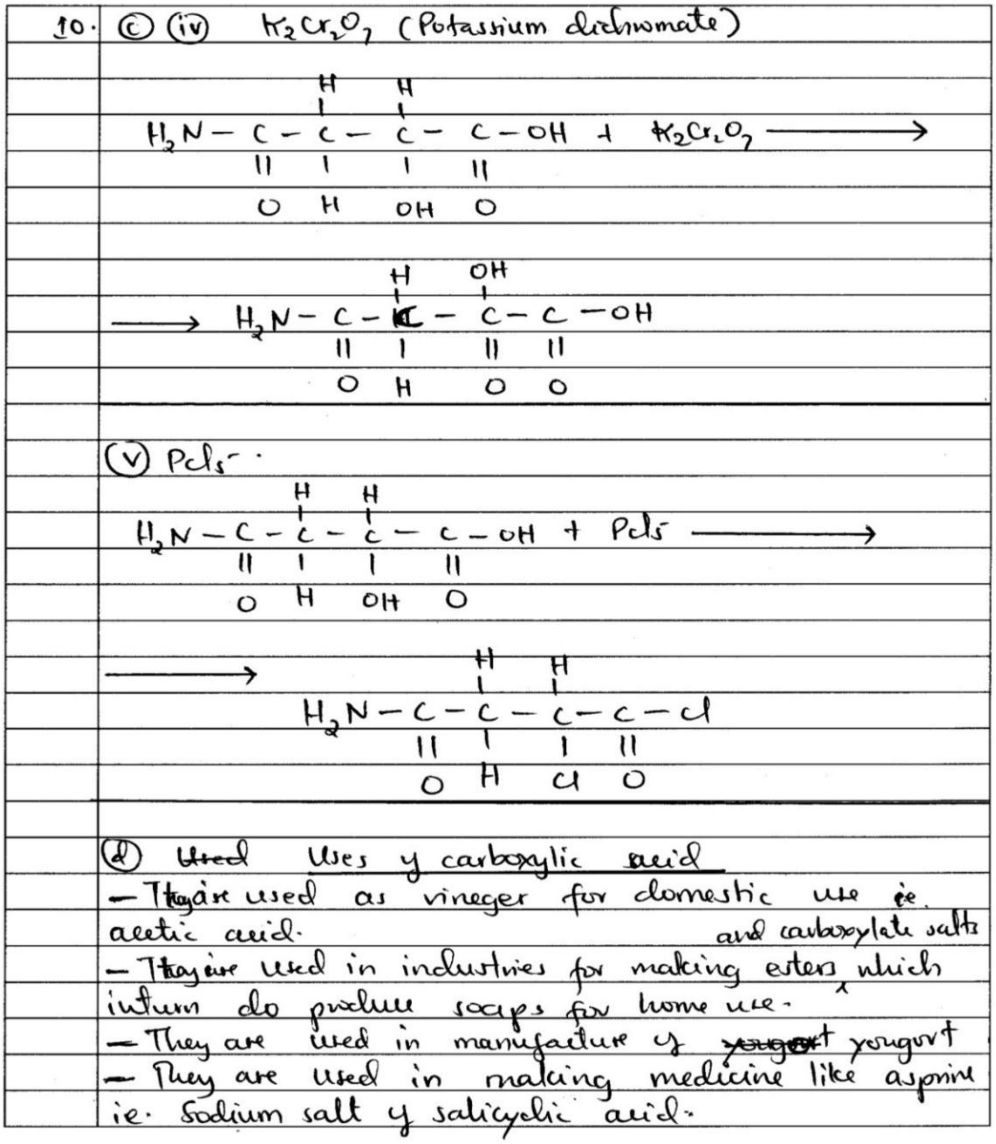
$$\longrightarrow H_2N-\underset{\underset{O}{\|}}{C}-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-\overset{\overset{H}{|}}{\underset{\underset{OH}{|}}{C}}-\underset{\underset{O}{\|}}{C}-OCH_2CH_3$$

(iii) $LiAlH_4$



$$H_2N-\underset{\underset{O}{\|}}{C}-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-\overset{\overset{H}{|}}{\underset{\underset{OH}{|}}{C}}-\underset{\underset{O}{\|}}{C}-OH + LiAlH_4 \longrightarrow$$

$$\longrightarrow H_2N-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-\overset{\overset{H}{|}}{\underset{\underset{OH}{|}}{C}}-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-OH$$



10. ⓒ (iv) $K_2Cr_2O_7$ (Potassium dichromate)

$$H_2N-\underset{\underset{O}{\|}}{C}-\overset{H}{\underset{\underset{H}{|}}{\overset{|}{C}}}-\overset{H}{\underset{\underset{OH}{|}}{\overset{|}{C}}}-\underset{\underset{O}{\|}}{C}-OH + K_2Cr_2O_7 \longrightarrow$$

$$\longrightarrow H_2N-\underset{\underset{O}{\|}}{C}-\overset{H}{\underset{\underset{H}{|}}{\overset{|}{C}}}-\overset{OH}{\underset{\underset{O}{\|}}{\overset{|}{C}}}-\underset{\underset{O}{\|}}{C}-OH$$

ⓥ PCl_5.

$$H_2N-\underset{\underset{O}{\|}}{C}-\overset{H}{\underset{\underset{H}{|}}{\overset{|}{C}}}-\overset{H}{\underset{\underset{OH}{|}}{\overset{|}{C}}}-\underset{\underset{O}{\|}}{C}-OH + PCl_5 \longrightarrow$$

$$\longrightarrow H_2N-\underset{\underset{O}{\|}}{C}-\overset{H}{\underset{\underset{H}{|}}{\overset{|}{C}}}-\overset{H}{\underset{\underset{Cl}{|}}{\overset{|}{C}}}-\underset{\underset{O}{\|}}{C}-Cl$$

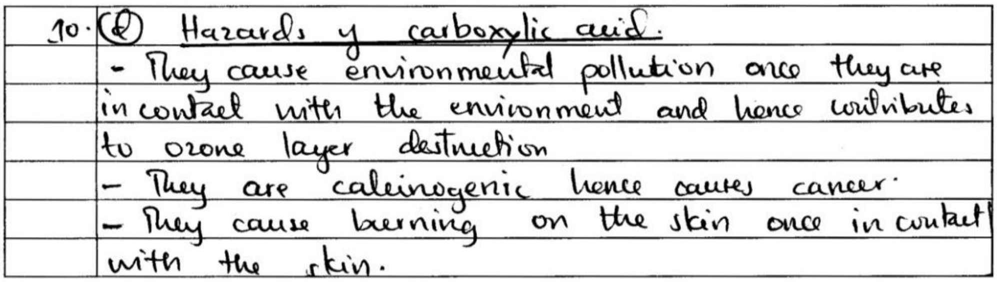
ⓓ ~~Used~~ Uses of carboxylic acid

– They are used as vineger for domestic use ie. acetic acid.

– They are used in industries for making esters and carboxylate salts which inturn do produce soaps for home use.

– They are used in manufacture of ~~yougurt~~ yougurt

– They are used in making medicine like asprine ie. Sodium salt of salicyclic acid.



10. ⓔ Hazards of carboxylic acid.

- They cause environmental pollution once they are in contact with the environment and hence contributes to ozone layer destruction

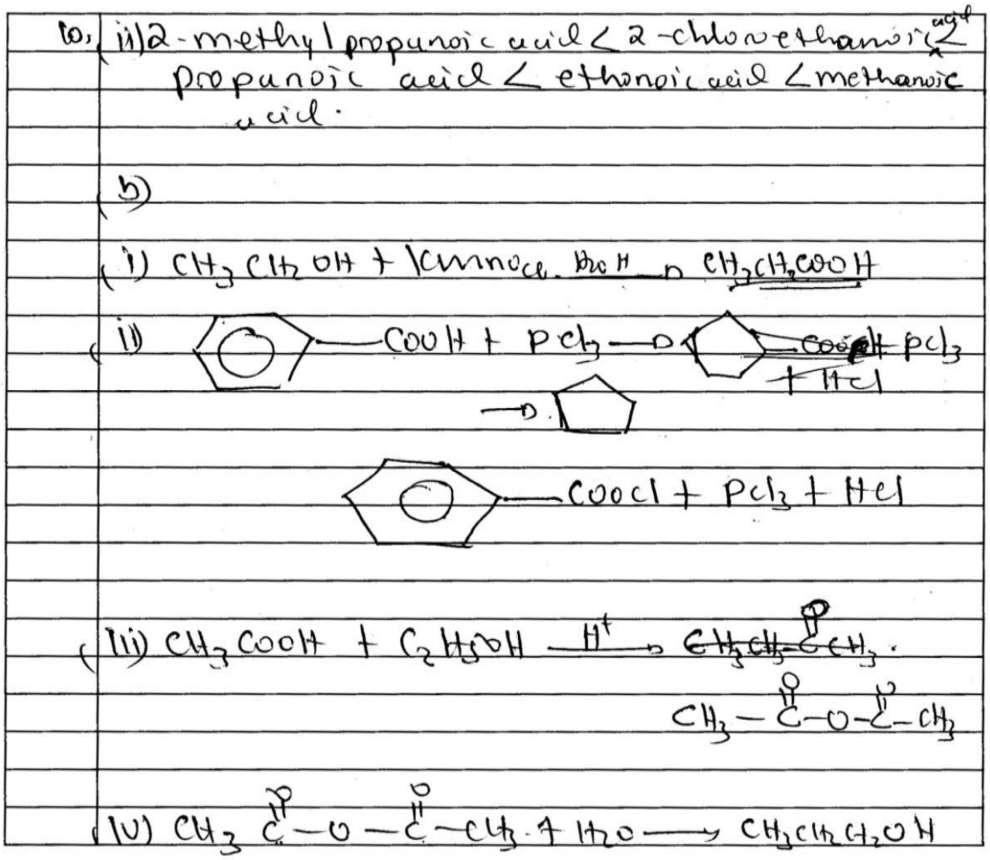
– They are carcinogenic hence causes cancer.

– They cause burning on the skin once in contact with the skin.

Extract 24.1 represents a set of responses from one of the candidate who was conversant with the topic of carboxylic acid and derivatives by answering properly nearly all parts of the question.

The candidates who performed poorly in this question failed to apply the concepts of mesomerism and inductive effects to establish plausible trend in acidic strength of the compounds given in part (a). In subsequent sections, most of the candidates showed inappropriate understanding on reaction mechanisms and therefore could not deduce the plausible structures for the products. Furthermore, some of them were not able to relate the type of the reaction with the respective functional groups given. Consequently, some candidates failed to explain the uses and hazards of carboxylic acids due to insufficient exposure and competence on the application of carboxylic acids in daily life. Extract 24.2 represents a sample of a poor response from one of the candidates.

Extract 24.2



(a) (ii) 2-methyl propanoic acid < 2-chloroethanoic acid < propanoic acid < ethonoic acid < methanoic acid.

b)

(i) $CH_3CH_2OH + KMnO_4 \xrightarrow{\text{[illegible]}} CH_3CH_2COOH$

(ii) $-COOH + PCl_3 \rightarrow$ ~~$-COOH$~~ $PCl_3 + HCl$

$\rightarrow$

$-COOCl + PCl_3 + HCl$

(iii) $CH_3COOH + C_2H_5OH \xrightarrow{H^+}$ ~~$CH_3CH_2\overset{O}{\overset{\|}{C}}CH_3$~~.

$CH_3-\overset{O}{\overset{\|}{C}}-O-\overset{O}{\overset{\|}{C}}-CH_3$

(iv) $CH_3\overset{O}{\overset{\|}{C}}-O-\overset{O}{\overset{\|}{C}}-CH_3 + H_2O \longrightarrow CH_3CH_2CH_2OH$

In Extract 24.2, the trend in acidic strength presented in part (a)(ii) is incorrect. He/she supplied propanoic acid instead of ethanoic acid in part b(i). Furthermore, the candidate gave incorrect structures for the products in the subsequent sections.

3.0 ANALYSIS OF THE CANDIDATES' PERFORMANCE IN EACH TOPIC

A total of twenty (20) topics were examined in paper 1 and paper 2. The candidates performed well in the following topics: Environmental Chemistry (98.5%), Acids, Bases and Salts (88.2%); Chemical Kinetics (88.1%), The Atom (79.3%), Solubility, Solubility Product and Ionic Product (76.0%), Gases (72.2%), Carboxylic Acids and Derivatives (69.1%), Extraction of Metals (65.1%), Chemical Equilibrium (63.3%) and Electrochemistry (62.5%).

The Good performance in the stated topics was attributed to the fact that most of the candidates had adequate knowledge and clearly understood the requirements of the respective questions. Moreover, most of them were able to use correctly the English language in answering the questions which required explanations.

The candidates had an average performance in the topics of Aromatic Hydrocarbons (56.7%), Chemical Bonding (55.3%), Periodic Classification (49.5%), Aliphatic Hydrocarbons (48%), Amines (40.8%) and Two Components Liquid System (36.4%). On the other hand, the candidates had weak performance in the topics of Energetics (33.3%), Halogen Derivatives of Hydrocarbons (22.5%), Relative Molecular Masses in Solution (7.6%) and Selected Compounds of Metals (4.1%).

Poor performance in the four stated topics reflected to a great extent inadequate knowledge and incompetence in writing appropriate formula equations. In the topic of Selected Compounds of Metals for example, most of the candidates failed to give the application of metal sulphates as well as description regarding the chemistry of zinc oxide (ZnO). Such low performance was attributed to insufficient competencies in inorganic chemistry, specifically the properties of Selected Compounds of Metals. It is noted that the candidates did not understand the topic or probably did not cover the topic.

The comparison of the candidates' performance between the year 2017 and 2018 shows that, the performance in 9 topics has increased, while it has decreased in 11 topics. More details of the performance in different topics are presented in the appendix.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusion

The question analysis of the performance in Chemistry paper 1 and 2 for the ACSEE 2018 has shown that overall candidates' performance was good.

The analysis shows that 10 topics had good performance, 6 topics had average performance and 4 topics had weak performance. Good performance was attributed to good mastering 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. Hence, they failed to interpret scientific observations. They had insufficient ability to tackle chemistry problems which involves mathematical manipulation. This was evident in the analysis made on the poorly performed questions from the content areas of Energetics, Halogen Derivatives of Hydrocarbons, Relative Molecular Masses in Solution and Selected Compounds of Metals.

Among other factors, this performance could be greatly attributed to:

(a) Lack of mathematical skills and inadequate knowledge on the tested topics. This was evident from some of the candidates who gave responses which did not relate to 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 is shown by some of the candidates who substituted data into formulae without units agreement while at the same time skipping a couple of necessary steps.

(c) Failure of the candidates to understand the requirements of the questions. Some candidates were unable to identify the key words used in the questions. For example, they responded synonymously on the question words such as define and explain.

(d) 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.

(e) Failure to apply appropriate formulae and chemical equations. For example some candidates incorrectly wrote van der Waal's equation.

(f) Failure to integrate classroom lessons with the real life situations. This was observed from candidates who failed to relate the common chemical substances such as sulphates with their common uses in daily life.

(g) Lack of enough exposure to practicals. This was justified due to presence of incorrect responses from some of the candidates who failed to interpret the experimental data provided in some questions.

4.2 Recommendations

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

(i) Teachers should put more emphasis on mathematical-based concepts and skills related to Energetics, Halogen Derivatives of Hydrocarbons, Relative Molecular Masses in Solution and Selected Compounds of Metals.

(ii) Teachers should encourage prospective candidates to participate actively in the process of teaching and learning (Competence based approach). This will help to raise the interest and curiosity of candidates. Furthermore, the teachers should provide the prospective candidates with relevant experiments and effective assessment to build their confidence and appropriate competences regarding the subject matter.

(iii) Teachers should ensure that all of the topics stipulated in the syllabus are covered properly and systematically within the recommended boundaries of time limits. This recommendation is highly encouraged so as to allow ample time for the prospective candidates to do a lot of exercise and revision.

(iv) 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 inter-school and intra school debate competitions as well as morning speeches on chemistry topics, are hereby highly recommended as a possible remedy.

(v) Teachers are emphasized to integrate both the theory and practicals in their teaching. This will allow the prospective candidates to build confidence and appropriate competencies in the subject matter. Furthermore, the prospective candidates will be able to establish long term memory on the subject matter. Educators (teachers) should emphasize on the use of chemical symbols, formulae and equations following IUPAC system as these are the cornerstones in Chemistry. In addition, teachers should teach appropriate use of units and dimensions in line with SI.

Appendix: Summary of the Performance of Candidates – Topicwise

S/N	Topic	2017			2018		
		Number of Questions	The Percentage of the Candidates who scored an Average of 35 or Above	Remarks	Number of Questions	The Percentage of the Candidates who scored an Average of 35 or Above	Remarks
1.	Environmental Chemistry	1	26.0	Weak	1	98.5	Good
2.	Acids, Bases and Salts.	1	58.1	Average	1	88.2	Good
3.	Chemical Kinetics.	1	73.3	Good	1	88.1	Good
4.	The Atom.	1	82.4	Good	1	79.3	Good
5.	Solubility, Solubility Product and Ionic Product.	1	59.9	Average	1	76.0	Good
6.	Gases.	2	77.2	Good	2	72.2	Good
7.	Carboxylic Acids and Derivatives.	1	70.4	Good	1	69.1	Good
8.	Extraction of Metals.	1	18.9	Weak	1	65.1	Good
9.	Chemical Equilibrium.	1	54.9	Average	1	63.3	Good
10.	Electrochemistry.	1	38.9	Average	1	62.5	Good
11.	Aromatic Hydrocarbons.	2	64.9	Good	1	56.7	Average
12.	Chemical Bonding.	1	68.6	Good	2	55.3	Average
13.	Periodic Classification.	1	26.8	Weak	1	49.5	Average
14.	Aliphatic Hydrocarbons.	1	71.8	Good	1	48	Average
15.	Amines.	1	55.9	Average	1	40.8	Average
16.	Two Components Liquid system.	2	37.1	Average	2	36.4	Average
17.	Energetics.	2	25.9	Weak	1	33.3	Weak
18.	Halogen Derivatives of Hydrocarbons.	1	53.9	Average	2	22.5	Weak
19.	Relative Molecular Masses in Solution.	1	41.6	Average	1	7.6	Weak
20.	Selected Compounds of Metals.	1	32.6	Weak	1	4.1	Weak