THE NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

CANDIDATES' ITEMS RESPONSE ANALYSIS REPORT FOR THE ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION (ACSEE) 2016

132 CHEMISTRY

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CONTENTS

FOREWORD

The purpose of preparing this Candidates' Item Response Analysis report was to give feedback to educational stakeholders including students, teachers, parents, educational administrators, school managers, policy makers and the public in general on the performance of the candidates in Chemistry subject in the Advanced Certificate of Secondary Education Examination (ACSEE) 2016.

The Advanced Certificate of Secondary Education Examination is a summative evaluation, which among other things, shows the effectiveness of the educational system in general and education delivery system in particular. Basically, 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 certificate of secondary education.

The analysis presented in this report is intended to contribute towards understanding some of the reasons behind the performance of candidates in Chemistry subject. The report highlights some of the factors that made the candidates score high or low marks in the questions. Nevertheless, some of the factors which made few candidates fail to score high marks include general lack of knowledge in relation to a particular concept and inability to answer the questions which demanded mathematical manipulations or explanation supporting chemical reactions. The feedback provided 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 preparation of this report. We would like also to express sincere appreciation to all the staff who participated in preparing and analyzing the data used in this report.

The National Examinations Council of Tanzania will highly appreciate comments and suggestions from teachers, students and the public in general, that can be used for improving future reports.

Dr. Charles E. Msonde
EXECUTIVE SECRETARY

1.0 INTRODUCTION

This report on Analysis of Candidates' Response to the Examination Items was prepared in order to provide feedback to educational stakeholders on the performance of the candidates who sat for the Chemistry subject in the Advanced Certificate of Secondary Education Examination (ACSEE) in 2016. The examination papers were set according to the ACSEE format which was revised in 2011 to suit the 2010 ACSEE chemistry syllabus.

Paper 1 consisted of sections A, B and C. Section A consisted of six (6) questions of which the candidates were required to choose four (4). Sections B and C had four (4) questions each, of which the candidates were required to answer three (3) from each section.

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

A total of 26,395 candidates sat for the Chemistry examination in 2016, out of which 87.50 percent passed. In 2015 the percentage of the candidates who passed was 96.40. This shows that, there is a drop of 8.9 percent of the candidates who passed in 2016.

This report is presented into four sections. It starts with the introduction, followed by the analysis of the candidates' performance in each question, and then the analysis of performance in each topic. Finally, the conclusion and recommendations for action are given.

The following section presents the analysis of the candidates' performance in each question.

2.0 ANALYSIS OF THE CANDIDATES' PERFORMANCE BY QUESTIONS

For each of the analyzed question, an overview of what the candidates were required to do, general performance and the possible reasons for the observed performance, have been provided. Samples of extracts of 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 is termed poor; 35 to 59 average and 60 to 100 good. Furthermore, green, yellow and red colours have been used in different figures, to denote good, average and poor performance respectively.

2.1 132/1-CHEMISTRY 1

This paper had a total of fourteen (14) questions carrying 10 marks each.

2.1.1 Question 1: The Atom

In part (a), the candidates were required to state the postulates and shortcomings of Bohr's atomic model. In part (b), they were provided with wavelength 2420Å of an electromagnetic radiation which was sufficient to ionize sodium atom, and required to calculate the ionization energy of sodium atom in $kJmol^{-1}$. In part (c), they were required to calculate the wave number of the longest wavelength transition in Balmer series of atomic hydrogen.

The question was attempted by 87.2 percent of the candidates. Statistics show that 52.3 percent of the candidates scored from 3.5 to 6.0 out of 10 marks; 19.9 percent scored from 6.5 to 10 marks of which only 11 candidates (0.047%) scored all the 10 marks. The candidates who scored below 3.5 marks were 27.8 percent, of which 1.9 percent scored a zero mark. Figure 1 is shows the distribution of the candidates' scores.

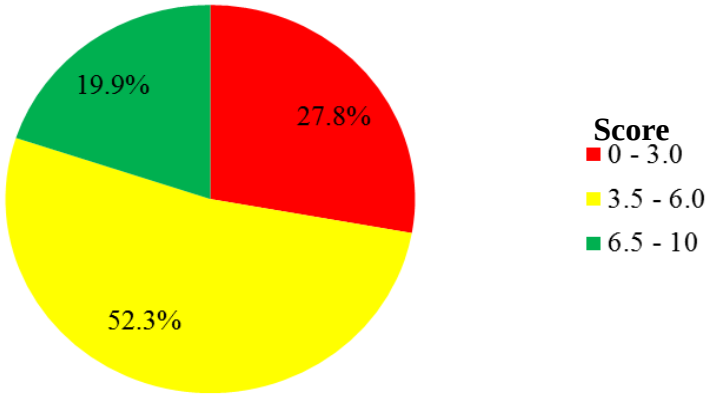


Figure 1: Performance of the candidates in question 1.

Figure 1 shows that, 72.2 percent of the candidates scored from 3.5 to 10 marks, an indication of good performance in this question. Most of the candidates who performed well in this question were able to state Bohr's atomic model and write correctly the shortcomings of the model. They also correctly calculated the ionization energy of sodium atom and the wave number of the longest wavelength transition in Balmer series of hydrogen atomic spectrum. Extract 1.1 is an example of a good response to the question.

Extract 1.1

1(a) (i) Postulates of Bohr's atomic Model.

⇒ Electron revolve in an atom in a certain circular path called orbit.

⇒ Each orbit is associated with energy and called energy level or Energy shell.

⇒ The angular momentum of electron in an atom is quantized and given by

$$mvr \geq \frac{h}{2\pi}$$

⇒ When electron gain energy they move to the higher energy level and when they lose energy they move to the lower energy level.

⇒ The energy of various energy level of hydrogen is given by

$$E = \frac{-13.6eV}{n^2}$$

(ii) Shortcomings of the Bohr's atomic Model

⇒ Bohr's could not explain Spectra of Multielectron atom

⇒ Bohr's could not explain Fine structure of an electron

⇒ Bohr's could not explain presence of Zeeman and Stalk effect.

⇒ Bohr's could not explain three dimension of an electron rather regard electron to be Flat.

1(b) Given Data

λ (wavelength) $= 2420 Å = 2420 \times 10^{-10} m$

From

Planks equation

$E = hf$

$f = c/\lambda$

$$E = \frac{hc}{\lambda}$$

$$E = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^{8}}{2420 \times 10^{-10}}$$

$$E = 8.219 \times 10^{-19} J$$

$$E = 8.219 \times 10^{-22} kJ.$$

Then.

$$E \times N_A = 8.219 \times 10^{-22} kJ \times 6.02 \times 10^{23} Mol^{-1}$$

$E = 494.78 \text{ KJ/Mol}$.

Hence Ionization energy of Sodium atom is 494.78 KJ/Mol.

1(c) Given; Balmer series.

For the longest wavelength:

$n_1 = 2$

$n_2 = 3$

From Rydberg equation

$$\frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\bar{v} = \frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\bar{v} = R_H\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$$

$$\bar{v} = 1.09678 \times 10^7\left(\frac{1}{4} - \frac{1}{9}\right)$$

$$\bar{v} = 1523305.556 \text{ m}^{-1}$$

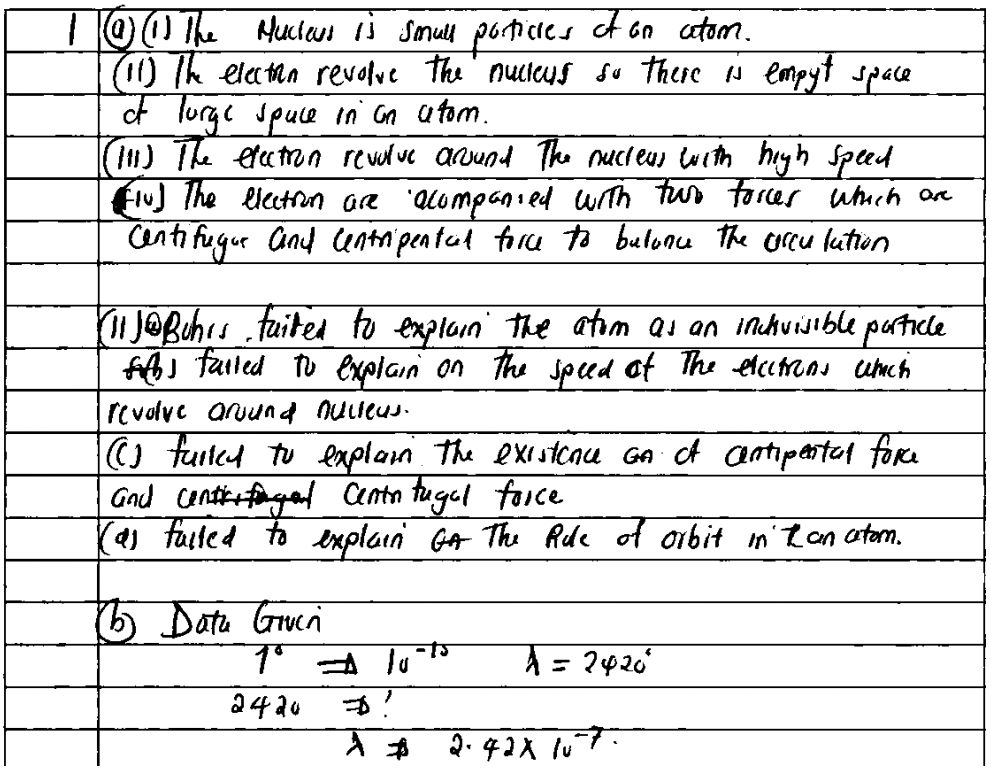
Hence wavenumber of the longest wavelength is $1523305.556 \text{ m}^{-1}$.

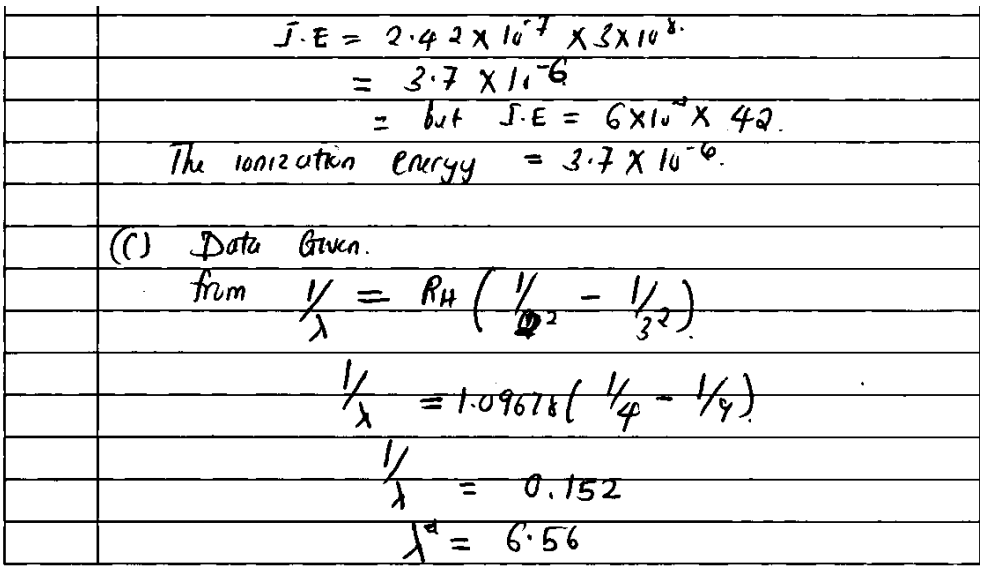
In Extract 1.1, the candidate stated well the postulates of Bohrs' atomic model but failed to state only one shortcoming of the model. The candidate also correctly calculated the ionization energy of sodium atom and was able to calculate the wave number of the longest wavelength transition in the Balmer series of hydrogen atomic spectrum.

The candidates who scored low marks mixed up the Bohr's atomic model with other atomic models. For instance some stated Rutherford atomic model and others Dalton's atomic model instead of Bohr's atomic model. In other cases, some used the term orbital instead of orbit in stating the Bohr's atomic model. This shows that the candidates had insufficient knowledge of the atomic models put forward by different scientists.

Moreover, some of the candidates failed to calculate correctly the ionization energy of sodium atom in $kJmo^{-1}$, as most of them failed to apply the appropriate formula, while others failed to convert the units from angstrom into metres and energy in joules per mole into kilojoules per mole ($Jmol^{-1}$ to $kJmol^{-1}$). This indicates that, the candidates had inadequate knowledge on unit conversion, which is a basic tool in solving scientific problems. They also failed to calculate the wave number of the longest wavelength transmission in the Balmer series of hydrogen atom. Some of the candidates failed to relate the energy resulting from electron transition in quantum numbers and wavelength. For example, some of them wrote that, the energy with the longest wavelength transition in the Balmer series of hydrogen spectrum *is from infinity to principal quantum number 2*. Some used electron transition from n = 1 to n = 4, while others interchanged the values (initial value and final value) in Rydberg equation, hence obtained wrong value of the wave number. This is an indication of insufficient knowledge of atomic structure. Extract 1.2 indicates one of the poor responses.

Extract 1.2


1 (a) (i) The Nucleus is small particles of an atom.
(ii) The electron revolve the nucleus so there is empyt space of large space in an atom.
(iii) The electron revolve around the nucleus with high speed
(iv) The electron are accompanied with two forces which are Centrifuge and Centripental force to balance the circulation
(ii) (a) Bohrs failed to explain the atom as an indivisible particle
(b) failed to explain on the speed of the electrons which revolve around nucleus.
(c) failed to explain the existence of Centripetal force and centrifugal Centrifugal force
(d) failed to explain ~~on~~ The Rdc of orbit in an atom.
(b) Data Given
1° = 10^{-10} λ = 2420
2420 = ?
λ = 2.42×10^{-7}



In Extract 1.2, the candidate did not state well the postulates of Bohr's atomic model and the shortcoming of the model. The candidate was unable to calculate the ionization energy of sodium atom. He/she used the wrong value of Rydberg constant, leading to incorrect value of the wave number.

2.1.2 Question 2: The Atom

The candidates were provided with the following question:

(a) Define the following:
  (i) Principal quantum number.
  (ii) Azimuthal quantum number.

(b) Given the quantum number, n = 3. Answer the following questions:
  (i) List all possible orbitals present in this quantum energy.
  (ii) Write possible values of m_l and m_s for this quantum number.

(c) The mass spectrum of an element enables the relative abundance of each isotope of the element to be determined. Data relating to mass spectrum of an element X, whose atomic number is 35 appear as indicated in the table below. Study the data and answer the question that follows:

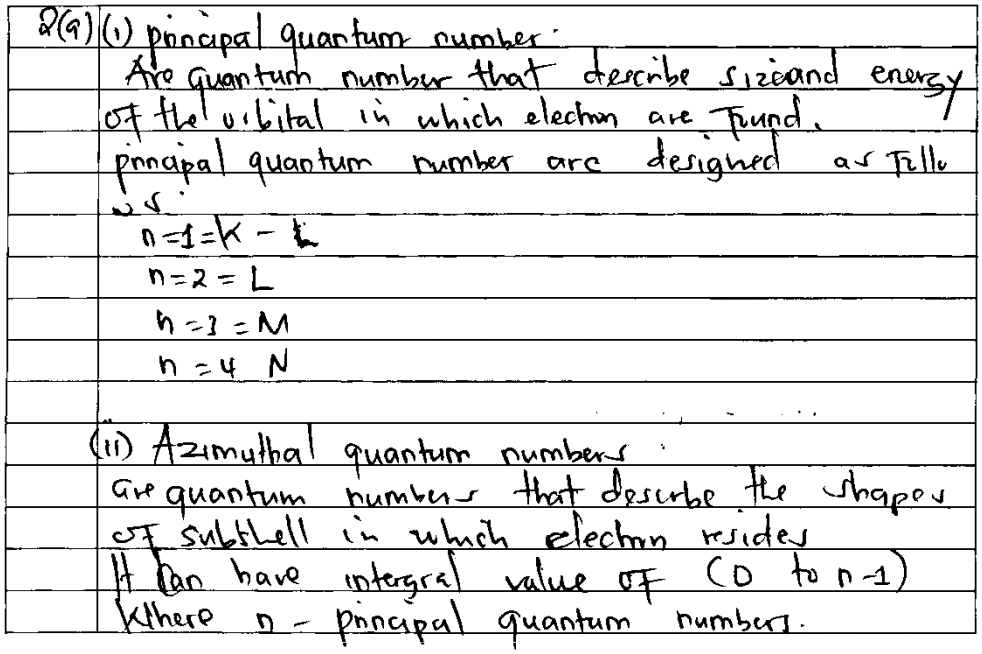
Mass number of isotopes	Relative abundance
75	50.5%
81	49.5%

  (i) Define the term isotope.
  (ii) Write the conventional symbols for the two isotopes of element X.
  (iii) Calculate the relative atomic mass of X to three significant figures.

The majority of the candidates (93.6%) attempted the question and 44.8 percent of them scored from 3.5 to 6.0 out of 10 marks. The candidates who scored from 6.5 to 10 marks were 34.8 percent, with 1.3 percent scoring all the 10 marks. On the other hand, the candidates who scored below 3.5 marks were 20.4 percent of which 1.7 percent scored a zero mark. This question had good performance as 79.6 percent of the candidates scored above 3 marks.

The candidates who scored all the marks were able to give the definitions of the given terms and listed possible orbitals present in quantum number n = 3. They also managed to write all the possible values of m_l and m_s for the given quantum number. Furthermore, they correctly wrote the conventional symbols for the two isotopes of element X and lastly calculated the relative atomic mass of the element lettered X to three significant figures, from the provided information. Extract 2.1 represents good answers given by one of the candidates.

Extract 2.1


2(a) (i) principal quantum number:
Are quantum number that describe size and energy of the orbital in which electron are found.
principal quantum number are designed as follows:
n=1=K - L
n=2 = L
n=3 = M
n=4 N

(ii) Azimuthal quantum numbers:
are quantum numbers that describe the shapes of subshell in which electron resides
It can have integral value of (0 to n-1)
Where n - principal quantum numbers.

2(b) Given $n = 3$

(i) When $n = 3$:

$l = 0 \quad 1 \quad 2$

n	3								
l	0	1			2				
m	0	-1	0	1	-2	-1	0	1	2
M_s	$\pm 1/2$	$\pm 1/2$	$\pm 1/2$	$\pm 1/2$	$\pm 1/2$	$\pm 1/2$	$\pm 1/2$	$\pm 1/2$	$\pm 1/2$

possible orbitals present in this quantum energy are

S-orbital $l = 0$

P-orbital $l = 1$

d-orbital $l = 2$

(ii) possible values of M_l is $0, -1, 0, 1, -2, -1, 0, 1, 2$.

possible values of M_s are $\pm 1/2, \pm 1/2, \pm 1/2, \pm 1/2, \pm 1/2, \pm 1/2, \pm 1/2, \pm 1/2, \pm 1/2$

(ii) Conventional symbols are $^{79}_{35}X$, $^{81}_{35}X$

(iii) From

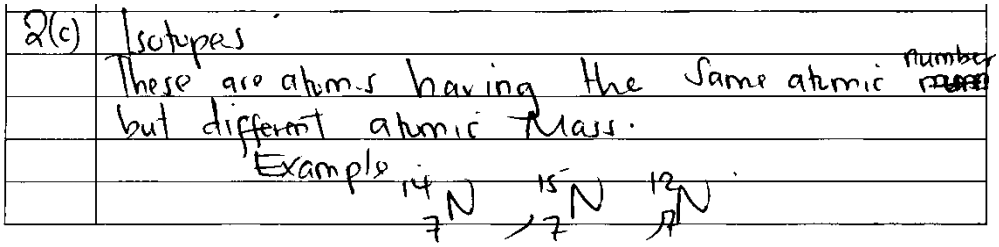
$$R.A.M = \frac{\text{relative abundance} \times \text{isotopic mass}}{\text{total abund}}$$

$$= \frac{50.5 \times 79 + 49.5 \times 81}{100}$$

$$= 79.99$$

$$\approx 80.0$$

Hence the relative atomic Mass of X is 80.0

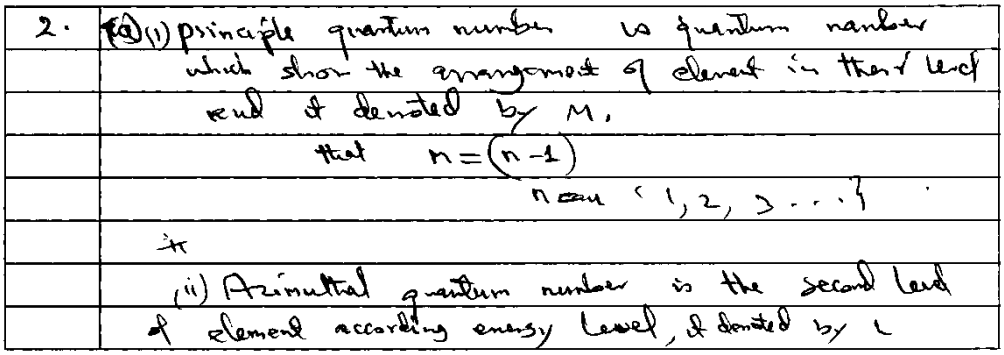


In Extract 2.1, the candidate correctly answered all the parts of the question.

On the contrary, the candidates who had low scores failed to define the given terms in part (a). The candidates also failed to list the possible orbitals present in quantum number n = 3, which had a negative effect on writing the possible values of m_l and m_s. The analysis shows that the majority lacked sufficient knowledge of quantum numbers. For instance in responding to part (b)(ii), some of the candidates failed to understand that possible values of m_s are only ±½. It was noted that they wrote different values including fractions and whole numbers.

Other candidates were not familiar with the conventional symbols for different nuclides which are the basic concepts for representing atomic numbers and mass numbers of isotopes. The analysis indicates that many candidates exchanged the position of mass number with atomic number and vice versa, while writing conventional symbols of two isotopes of element X, hence could not get the correct answer. Similarly, they failed to write the correct formula to calculate the relative atomic mass of X, hence ended up with incorrect values. Failure of the candidates in these items implies that the candidates lacked application of basic knowledge of the atomic structure. Extract 2.2 is a response from a candidate who scored low marks.

Extract 2.2



2 (b)(i) Given

$n = 3$

(a) orbital = required

Solution

$n(n-1)$ $n = 0, 1, 2, 0, -1, -2, -1$

$n = 3 - 1 = 2$

$2 - 1 = 1$

$1 - 1 = 0$

$-3 - 1 = -4$

$-2 - 1 = -3$

$-1 - 1 = -2$

∴ Possible orbital can be 2, 1, 0, −4, −3, −2, −1

(ii) Given

$n = 1$

m = required

Solution

$m = \pm\frac{1}{2}$ or $-\frac{1}{2}$ 1

$m = \pm 1$ $= \frac{1}{2}, 1, 0, \frac{1}{4}, -\frac{1}{2}, -\frac{3}{2}, -\frac{1}{2}$

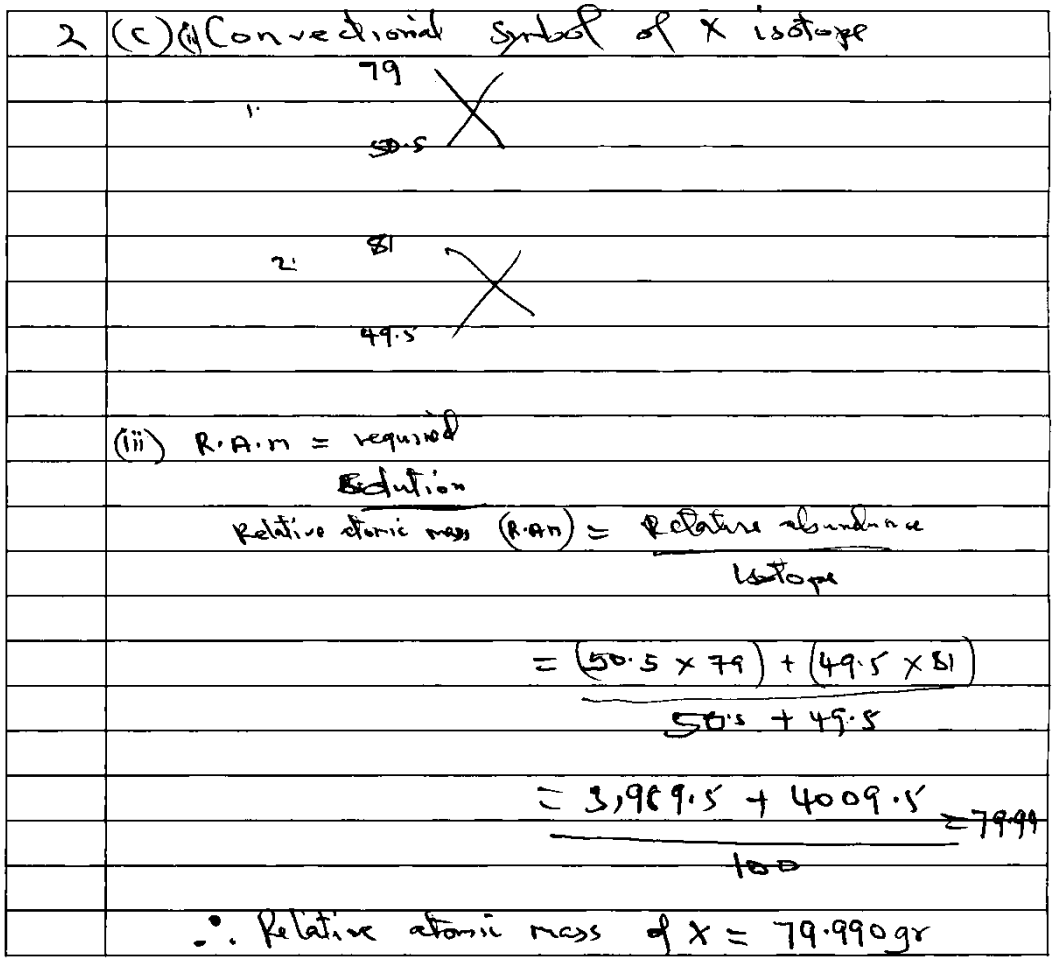
∴ $M = +\frac{1}{2}, 1, 0, -\frac{1}{4}, \frac{1}{2}, -1, 0$

(c) Given

Isotope = 79 and 81

Abundance = 50.5 and 49.5

(d) Isotope is atom of the same element which have the different mass number and atomic number



Extract 2.2 shows an answer in which the candidate answered most parts of the question wrongly. The candidate managed only to calculate the relative atomic mass but failed to write it in three significant figures.

2.1.3 Question 3: Chemical Bonding

In part (a) of the question, the candidates were required to give reasons for the following scientific observations: Both sodium and hydrogen occur in group IA of the periodic table, yet the melting point of sodium chloride is 800^{o}C, while that of HCl is -114^{o}C; Sodium chloride is soluble in water but not in benzene. Although both oxygen and sulphur occur in the same group of the periodic table, the hydride of oxygen (H_2O) is a liquid but the hydride of sulphur (H_2S) is a gas at room temperature. In part (b) of the question, the candidates were required to study the following compounds: hydrogen fluoride (HF), ammonia (NH_3), hydrogen sulphide (H_2S), chloroform ($CHCl_3$) and ethanoic acid (CH_3COOH) and required to describe with reasons the compounds which contain and those which do not contain

hydrogen bond. Furthermore, they were required to briefly explain why dimethyl ether is more volatile than ethanol, although their molecular weights are the same.

Few candidates (26.9%) attempted this question and 39.0 percent of them scored from 3.5 to 6.0 out of 10 marks, 24.8 percent scored from 6.5 to 10 marks with 0.3 percent scoring all 10 marks. The candidates who scored below 3.5 marks were 36.2 percent, out of which 6 percent scored a zero mark. Figure 2 shows the distribution of the candidates' scores.

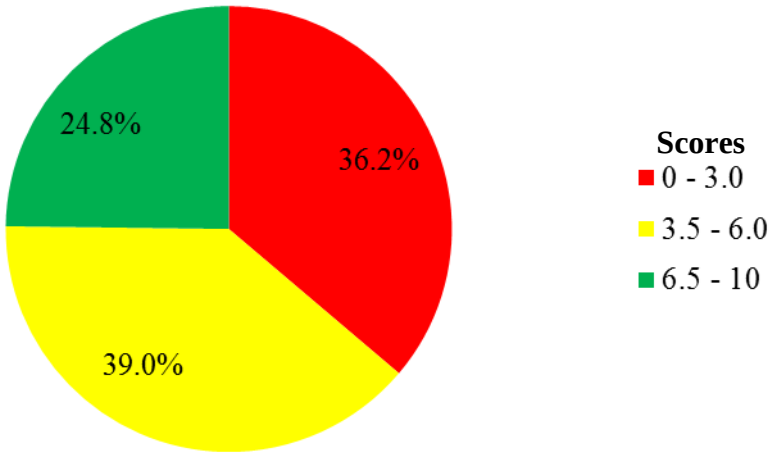


Figure 2: Performance of the candidates in question 3.

Figure 2 indicates that the majority of the candidates (63.8%) scored high marks (3.5 to 10 marks), an indication of good performance in this question. The majority of the candidates who performed well gave correct reasons for the given observations. The candidates clarified with reasons that sodium chloride was soluble in water but not in benzene and both oxygen and sulphur are in the same group of the periodic table, but the hydride of oxygen is a liquid while that of sulphur is a gas at room temperature. Extract 3.1 is a sample answer of a response from a candidate who scored high marks.

Extract 3.1

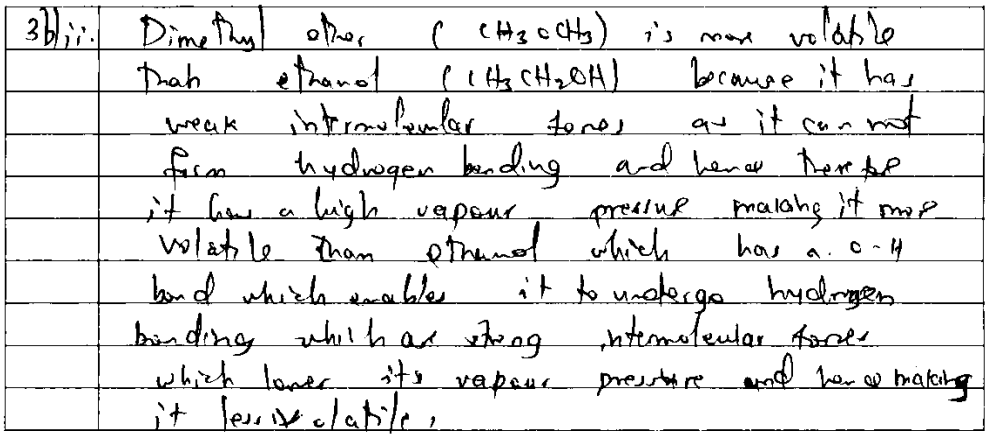
3a)	To give reasons for the given observations;
i.	Melting point of NaCl is 800°C while that of HCl is -114 because NaCl is an ionic compound while HCl is a covalent compound and hence therefore the intermolecular forces in HCl are weak Vander waal forces while those in NaCl are strong electrostatic force of attraction making it to have a very high melting point. NaCl is ionic because of the large electronegativity difference between Na and Cl atoms.
ii.	Sodium chloride is soluble in water but not in benzene because water is a polar solvent while benzene is a non polar solvent. Water being a polar solvent it can form hydrogen bonds with Na^+ and Cl^- from chlorine and hence therefore NaCl dissolves in water.
iii)	~~Here~~ H_2O is liquid while H_2S is gaseous because water has O-H bond in which hydrogen atom is bonded to O a small highly electronegative atom and hence therefore hydrogen bonding exists in water making it to have much more intermolecular forces than H_2S which has no hydrogen bonding and therefore H_2O becomes liquid while H_2S is gas due to weak intermolecular forces of attraction between its molecules.

(b) Compounds showing hydrogen bonding are given below:

Compound	Reason for having H-bonding.
NH_3	- There is a N-H in which hydrogen is bonded to a small highly electronegative atom N making the polar bond polar and hence enabling hydrogen bonding to occur.
HF	- There is a H-F in which hydrogen is bonded to a small highly electronegative atom F making the bond polar and hence enabling hydrogen bonding to occur.
$CH_3\overset{\overset{O}{\|}}{C}_{O-H}$	- There is a O-H bond in which hydrogen is bonded to a small highly electronegative O atom making the bond polarized and hence enabling hydrogen bonding to occur.

Compounds which do not contain hydrogen bonding.

Compound	Reason for not forming H-bonding
$CHCl_3$	- Chlorine is too large to allow hydrogen bonding to occur.
H_2S	- Sulphur is not highly electronegative to polarise the H_2S bond to allow H bonding to occur.

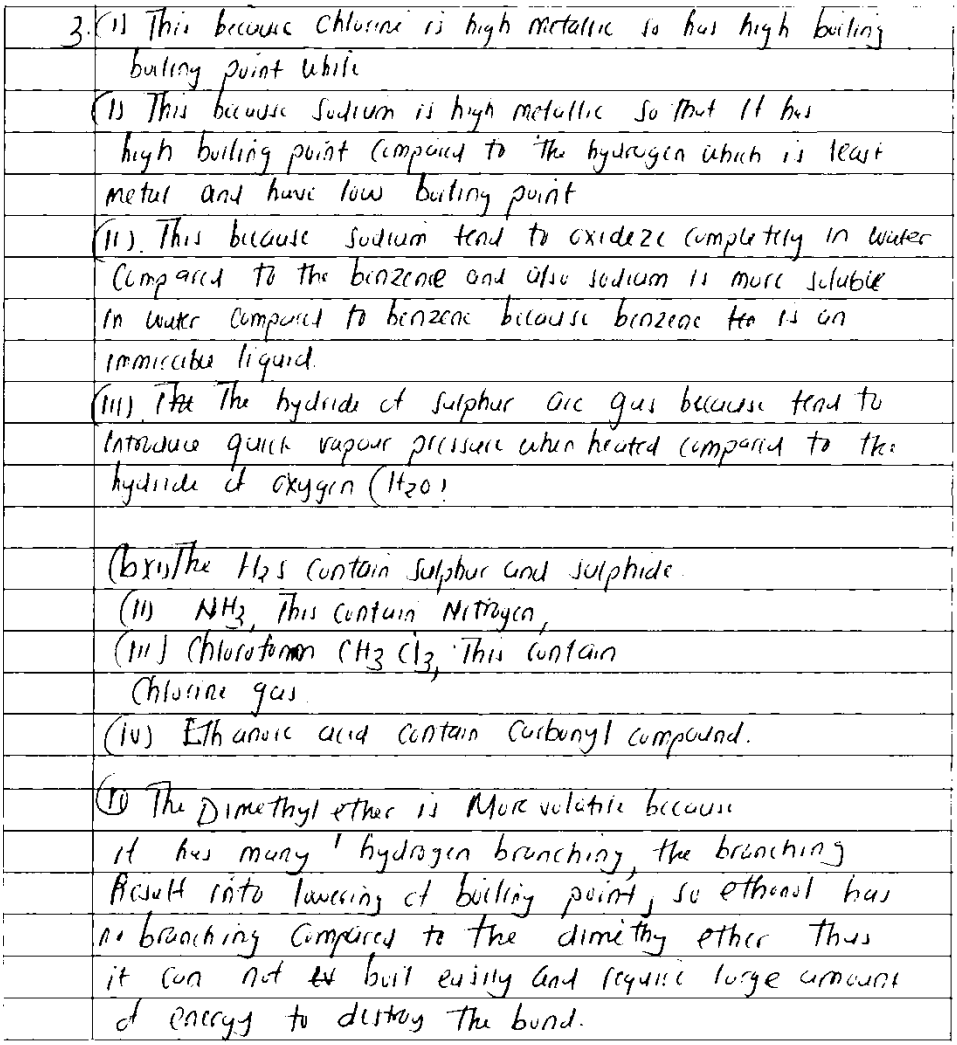


In Extract 3.1, the candidate presented correct answers to all parts of the question.

The candidates who scored low marks did not give correct reasons for the higher melting point of sodium chloride as compared to hydrogen chloride regardless of sodium and hydrogen being found in the same group (IA) of the periodic table. They also failed to understand that sodium chloride is an ionic compound, while benzene is an organic solvent which is a non-polar and hence cannot dissolve sodium chloride.

Furthermore, the candidates failed to explain the reasons why the hydride of oxygen become a liquid, while that of sulphur become a gas at room temperature, regardless occupying the same group in the periodic table. The analysis shows that the majority of the responses resulted from guess work basing on either one element is metal and another is a non-metal, or one element is higher in the group and another lower in the group. This implies that the candidates had insufficient knowledge of bonding which is the main reason for their differences. Extract 3.2 illustrates one of the poor responses.

Extract 3.2



3. (i) This because chlorine is high metallic so has high boiling
boiling point while
(i) This because sodium is high metallic so that it has
high boiling point compared to the hydrogen which is least
metal and have low boiling point
(ii) This because sodium tend to oxidize completely in water
Compared to the benzene and also sodium is more soluble
in water compared to benzene because benzene ~~he~~ is an
immiscible liquid
(iii) ~~The~~ The hydride of sulphur are gas because tend to
introduce quick vapour pressure when heated compared to the
hydride of oxygen (H_2O)

(b)(i) The H_2S contain Sulphur and sulphide
(ii) NH_3, This contain Nitrogen,
(iii) Chloroform CH_3Cl_3, This contain
Chlorine gas
(iv) Ethanoic acid contain Carbonyl compound.

(c) The Dimethyl ether is More volatile because
it has many ' hydrogen branching, the branching
Result into lowering of boiling point, so ethanol has
no branching Compared to the dimethy ether Thus
it can not ~~to~~ boil easily and require large amount
of energy to destroy the bond.

The candidate's response in Extract 3.2 did not meet the demand of the question. For example in part (b), the candidate wrote; H_2S, NH_3, $CHCl_3$, CH_3COOH contain sulphur and sulphide, nitrogen, chlorine instead of explaining with reasons the compounds which contain and those which do not contain hydrogen bond.

2.1.4 Question 4: Gases

In part (a) of the question, the candidates were required to state why was it necessary to modify the ideal gas equation, show how the modified equation looks like and define all the symbols in the equation. In part (b), the candidates were required to briefly explain why beyond certain temperatures, gases cannot be liquefied. In part (c), the candidates were

required to calculate the pressure of 1 mole of diethyl ether which occupies 1.5 litres at 227^{o}C, provided that the Van der Waals' constant for diethyl ether are: a = 17.38 atmL^{2}mol^{-1} and b = 0.134 Lmol^{-1}.

This question was attempted by 42.5 percent of the candidates, out of which 54.9 percent scored below 3.5 out of 10 marks, with 8.0 percent scoring a zero mark. The candidates who scored from 3.5 to 6.0 marks were 26.2 percent and 18.9 percent scored from 6.5 to 10 marks. It is only 0.9 percent who scored all the 10 allocated marks. Figure 3 represents these data.

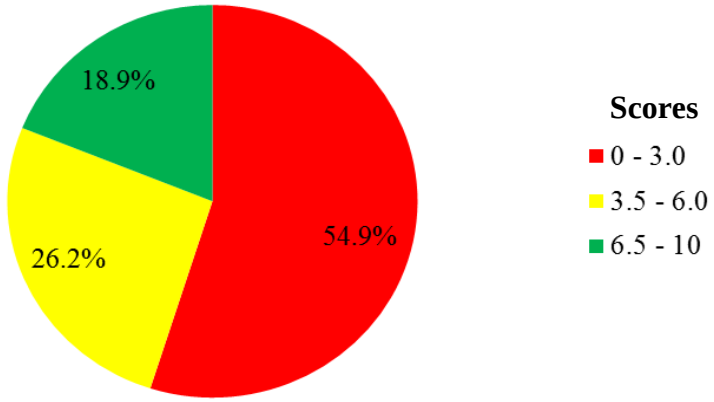


Figure 3: Performance of the candidates in question 4.

Figure 3 shows that the general performance of the candidates in this question was average as 45.1 percent of the candidates passed. Most of the candidates who scored high marks were able to state and describe the reasons which led to the modification of the ideal gas equation and clearly showed how the modified equation looks like. They were also able to define all the symbols in the equation. They explained why gases beyond certain temperatures do not liquefy. The candidates also were able to calculate the pressure of one mole of diethyl ether. Extract 4.1 displays a sample answer from one of such candidates.

Extract 4.1

4:- (a) It was necessary to modify the ideal gas equation because the force of attraction between the molecular of the gas is considered and also the volume of the molecular of the gas is not negligible.

the modified equation

$$\left(P + \frac{n^2 a}{V^2}\right)(V - bn^2) = nRT$$

Where,

P = pressure of gas in the container

n = number of mole

V = Volume of the gas in the container

a and b are the constant of the deviation from the ideal to real gas.

R =

T = Change in Temperature in the gas container.

(b) When the temperature raises also the kinetic energy of the gas molecular increases as the result the gas molecular move far apart.

From each other in the randomly motion colliding one another and with the wall of the container in that stage it is impossible for the molecules of the gas to close again and form liquid.

(c) Ans

Data given

number of mole (n) = 1

Volume (V) = 1.5 dm³.

Temperature (T) = 227°C = 500 K

a = 17.28 atm litre²mol⁻²

b = 0.134 litre mol⁻¹

R = 0.082 atm mol⁻¹ K⁻¹

Required to find pressure

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

Where $n = 1$

$$\left(P + \frac{a}{V^2}\right)(V - b) = RT$$

$$\left(P + \frac{17.38}{(1.5)^2}\right)(1.5 - 0.134) = RT$$

$$(P + 7.724)(1.366) = (0.082 \times 500)$$

$$(P + 7.724)(1.366) = 41.05$$

$$1.366P + 10.551 = 41.05$$

$$1.366P = 41.05 - 10.551$$

$$1.366P = 30.499$$

$$P = \frac{30.499}{1.366}$$

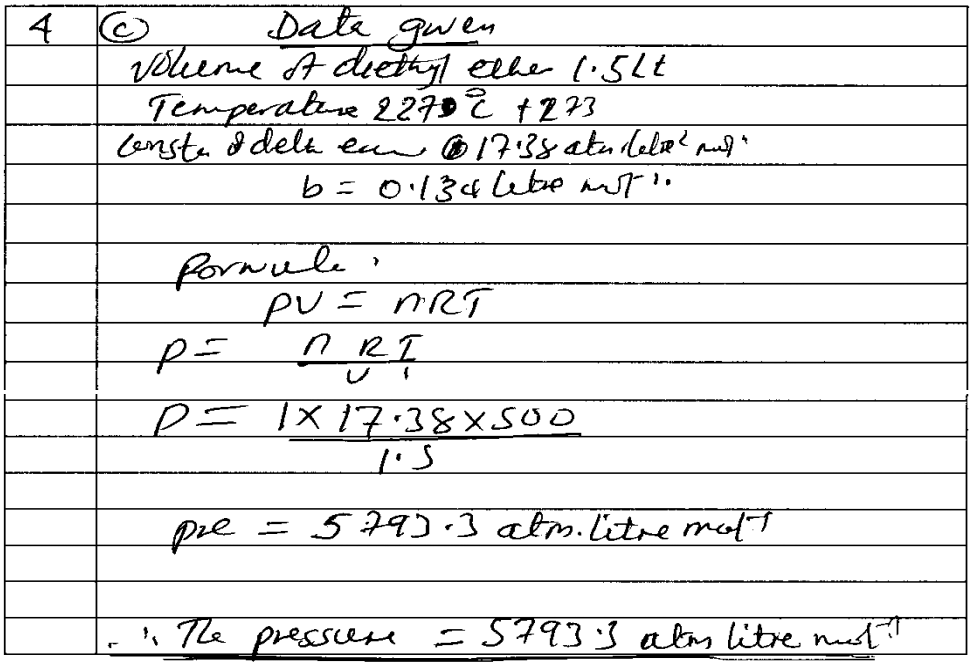
$$P = 22.327 \text{ atm}$$

∴ Pressure = 22.327 atm

In Extract 4.1, the candidate answered correctly all parts of the question but she/he presented a wrong Vander Waal's equation.

On the other hand, some of the candidates who scored low marks lacked sufficient knowledge of behaviors of gases, hence failed to describe the reasons for modification of ideal gas equation. They failed to understand that under normal conditions of temperature and pressure, there are considerable forces of attraction between the gas molecules and therefore the volume of the individual molecules should also be counted; all of which are ignored in the ideal gas equation ($PV = nRT$). As a result, they failed to write the modified equation $(P + an^2/v^2)(V - nb) = n\,RT$. However, the analysis shows that some of the candidates wrote the ideal gas equation, while others wrote the correct modified equation, but on substitution of the given data they interchanged the values of a and b, hence ended up with incorrect value of pressure of diethyl ether. Extract 4.2 shows a sample of the responses which do not meet the requirement of the question.

Extract 4.2



In Extract 4.2, the candidate was not able to answer parts (a) and (b); this could be an indication that she/he had insufficient knowledge about atomic theory and gas laws. In part (c), the candidate applied a wrong formula which led to the incorrect answer.

2.1.5 Question 5: Gases

Part (a) of this question required the candidates to define Critical temperature, Critical volume and Critical pressure, with references to gases. In part (b), they were required to derive the relationship between density of a gas in gdm^{-3}, the gas pressure in atmosphere, the temperature (T) in kelvin, the relative molecular mass of a gas (M_r) and the gas constant (R) from ideal gas equation. In part (c), they were required to find the density in gdm^{-3} at 20^oC and $98.650kNm^{-2}$ of a certain dry gas composed of 21% of oxygen, 1% of argon and 78% of nitrogen by volume.

This question was attempted by 53.4 percent of the candidates and 55.9 percent scored from 3.5 to 6.0 out of 10 marks, 3.2 percent scored from 6.5 to 10 marks. Only 2 candidates scored all 10 marks. On the other hand, 40.9 percent scored below 3.5 marks, of which 4.4 percent scored a zero mark. The pie chart in Figure 4 gives the summary of these statistics.

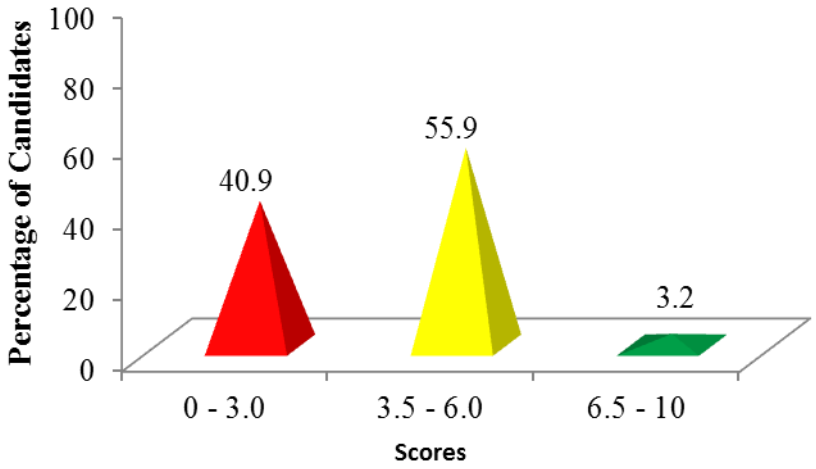


Figure 4: Performance of the candidates in question 5.

Figure 4 shows that 59.1 percent of the candidates scored from 3.5 to 10 marks, indicating an average performance in this question. Most of the candidates who scored high marks defined properly the terms, critical temperature, critical volume and critical pressure with reference to gases. The candidates derived the relationship between density of a gas in grams per dm^3, the gas pressure in atmosphere, the temperature (T) in kelvin, the relative molecular mass of a gas (M_r) and the gas constant, R. The candidates also were able to calculate the density of a dry gas in gdm^{-3} from the given information. Although a few candidates obtained all the marks, others faced difficulties to define the terms critical temperature, critical

volume and critical pressure, hence failed to score all 10 marks. Extract 5.1 shows a sample of the response of the candidate with high score.

Extract 5.1

5(a) (i) Critical temperature
- Is the temperature above which a gas cannot liquefy no matter how much pressure is applied on it.

(ii) Critical volume:
- Is the ~~temperature of~~ volume of a gas at its critical temperature.

(iii) Critical pressure:
- Is the pressure required to liquefy a gas at its critical temperature.

5(b) Recall the Ideal gas equation

$$PV = nRT$$

But $n = \frac{\text{mass}}{\text{molar mass}} = \frac{M}{Mr}$.

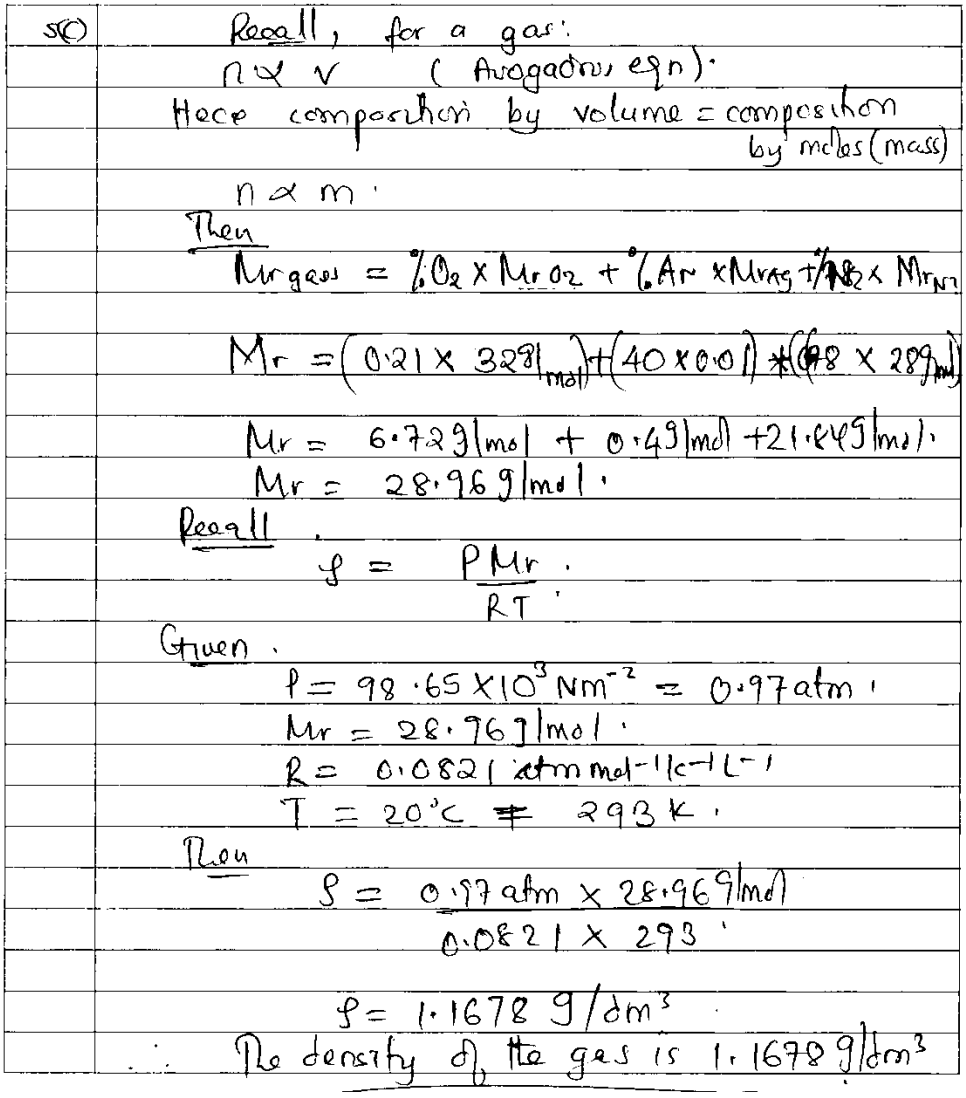
$$PV = \frac{MRT}{Mr}$$

$$P = \left(\frac{M}{V}\right)\frac{RT}{Mr} \quad \because \text{Density, } \rho = \frac{M}{V}$$

$$P = \frac{\rho RT}{Mr}$$

$$\rho = \frac{PMr}{RT}.$$

Where ρ = density of a gas in gmper dm^3 and all other symbols carry their indicated meanings

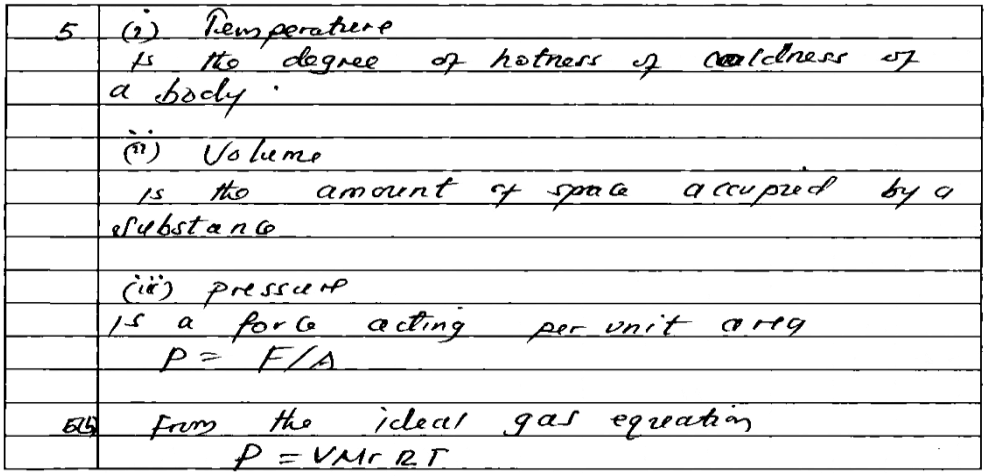


In Extract 5.1, the candidate answered correctly all parts of the question but gave an incomplete definition for critical volume and critical pressure. The candidate used correct formula and properly computed the molecular mass and the density of the gases inquired.

On the other part, the candidates who scored low marks failed to define the given terms. The analysis shows that some of them mixed up the terms, critical temperature with standard temperature; critical volume with volume, while others gave incorrect definitions. For example, one candidate defined critical temperature as 'the degree of hotness or coldness of the given substance or of a place'. Another candidate defined critical volume as 'the quantity which occupies space'.

In other cases, some of the candidates failed to derive the relationship between the density of a gas in grams per dm^3, the gas pressure in the atmospheres, the temperature (T) in kelvin, the relative molecular mass of a gas (M_r) and the gas constant R from ideal gas equation. It was observed that some of these candidates wrote incorrect ideal gas equation which was necessary for the derivation of the required relationship, hence could not proceed. Others applied correct ideal equation but failed to manipulate the data to obtain the correct relationship. In addition, others failed to apply the correct formula in calculating the density of a dry gas, while others failed to convert kNm^{-2} into Nm^{-2}, hence ended up with incorrect values. In general, the candidates lacked coverage of the subject matter of the topic and simple arithmetic skills. Extract 5.2 illustrates one of the poor responses.

Extract 5.2


5 (i) Temperature
is the degree of hotness of coldness of a body.

(ii) Volume
is the amount of space occupied by a substance

(iii) pressure
is a force acting per unit area
P = F/A

5(b) from the ideal gas equation
P = VMr RT

5(b)	Ideal gas Equation deriving
	$P = \quad V Mr RT$
	$P = \quad V = m/d\,M$
	$P = m/d\,Mr\,RT$
	but
	$Mr = M/n$
	and $m = d \times v$
	hence
	$P = dv\ M/n\ RT$
	also $M/n = Mr$
	and $d/v = m$
	from mole concept
	$n = M/Mr$
	$P = M/Mr\ V\ RT$
	where $M/Mr = n$
	$P = nRT$ derived
5(c)	Solv
	Data
	$T = (20^{\circ}C + 273K) = 298K$
	$R = 8.315 mol^{-1} k^{-1}$

In Extract 5.2, none of the items was correctly answered. The candidate gave incorrect definitions of the given terms and applied a wrong formula, hence failed to get the required relationship.

2.1.6 Question 6: Relative Molecular Masses in Solution

In Part (a), the candidates were required to give two differences between osmosis and diffusion. In part (b), they were required to calculate the freezing point depression constant for the solvent given that when 15 g of glucose ($C_6H_{12}O_6$) was dissolved in 50 g of the solvent with relative molecular mass of 180 g, the freezing point was depressed by 8.0 ^{o}C. In part (c), they were required to calculate the relative molecular mass of sugar if an aqueous solution of sugar containing 19.15 g of sugar per dm^3 has an osmotic pressure of 136,300 Nm^{-2} at 20 ^{o}C.

A total of 23,176 (87.2%) candidates attempted this question, out of which 36.4 percent scored from 3.5 to 6.0 out of 10 marks, 41.4 percent scored from 6.5 to 10 marks out of which 2 percent scored all the 10 marks. The candidates who scored below 3.5 marks were 22.2 percent of which 3.0 percent scored a zero mark. Figure 5 gives the summary of these statistics.

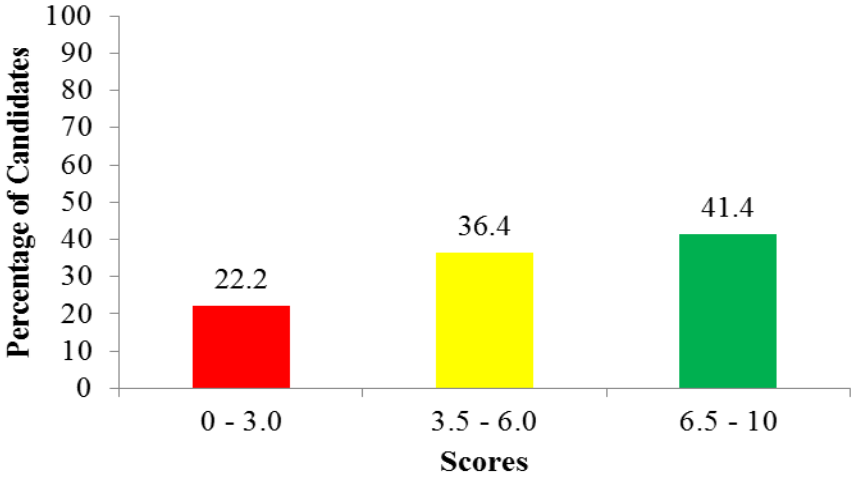
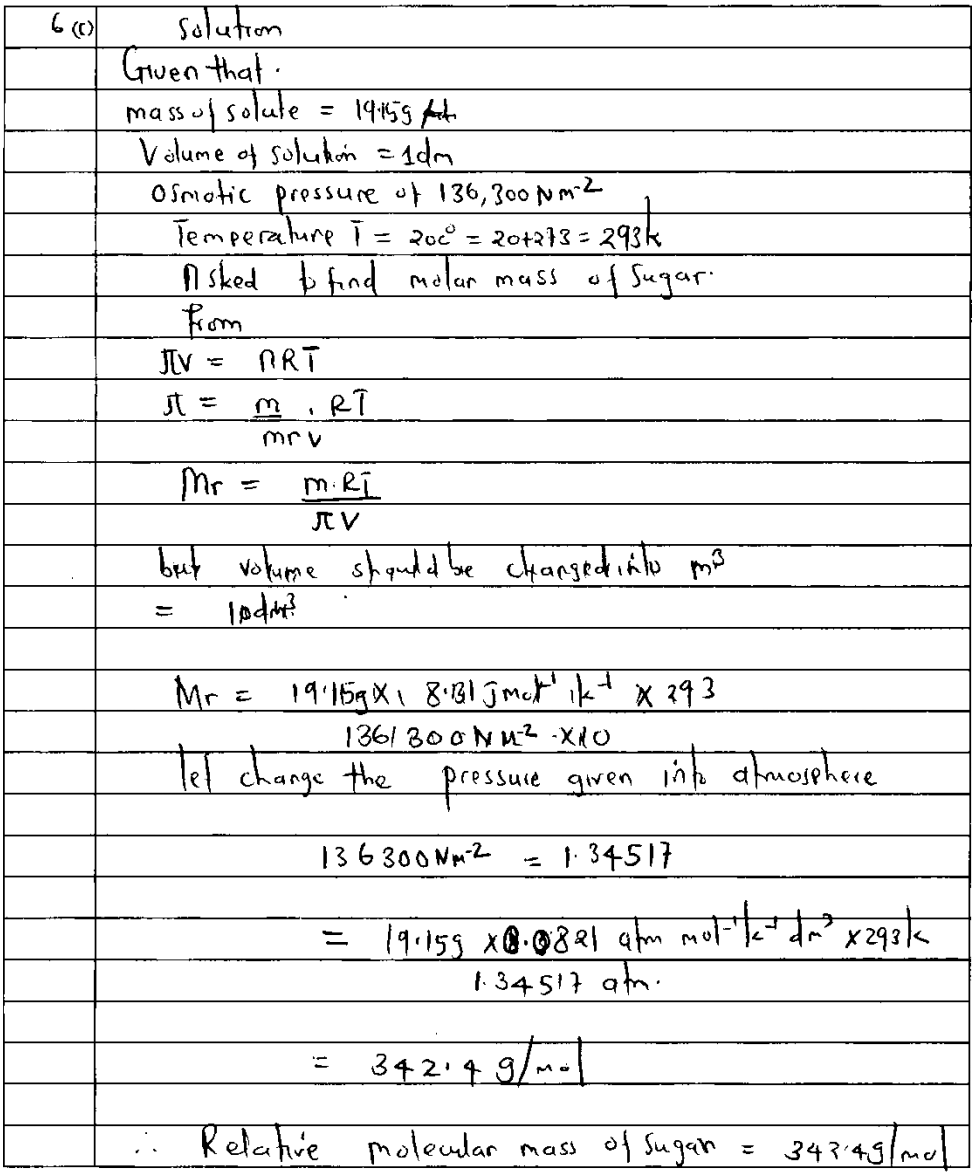


Figure 5: Performance of the candidates in question 6.

Figure 5 shows that the majority of the candidates (77.8%) scored from 3.5 to 10 marks, implying a good performance in this question. These candidates who performed well in this question, provided correct differences between osmosis and diffusion and calculated the freezing point depression constant of the given solvent. In the same way, they correctly calculated the relative molecular mass of sugar from the information provided. A sample response from one of the candidates who performed well is presented in Extract 6.1.

Extract 6.1

6(a)	Differences between osmosis and diffussion.	
	Osmosis	diffussion
	i. Is a movement of solvent molecule	i. Is the movement of gas or any substa
	from a region of high water	nce from a region of high concentration
	pontetial to the region of low	to the region of low concentration
	Wanter pontetial through a	
	Selective permeable membrane	
	ii It involves selective permea	ii It does not involve permeable
	ble membrane	membrane
(b)	Solution:	
	Given that:	
	Mass of solute (M_B) = 15g.	
	mass of solvent (M_A) = 50g	
	relative molecular mass of solvent(m_{rA}) = 180g	
	depressed freezing Point = 8.0C.	
	Asked to find freezing Point depression constant for solvent.	
	from	
	$\Delta T_f = \frac{k_f m_B \times 100}{m_{rB} m_A (kg)}$	
	but Molar mass solute = 180g/mol	
	$8.0^c = \frac{k_f \times 15g \times 1000}{180g/mol \times 50g}$	
	$k_f \cdot 15g \times 1000 = 8.0^c \times 180g/mol \times 50g$	
	$k_f = \frac{8.0^c \times 180g/mol \times 50g}{15g \times 1000}$	
	$K_f = 4.8\ c^\circ g\ mol^{-1}$	
	∴ freezing Point depression = $4.8\ c^\circ g\ mol^{-1}$	

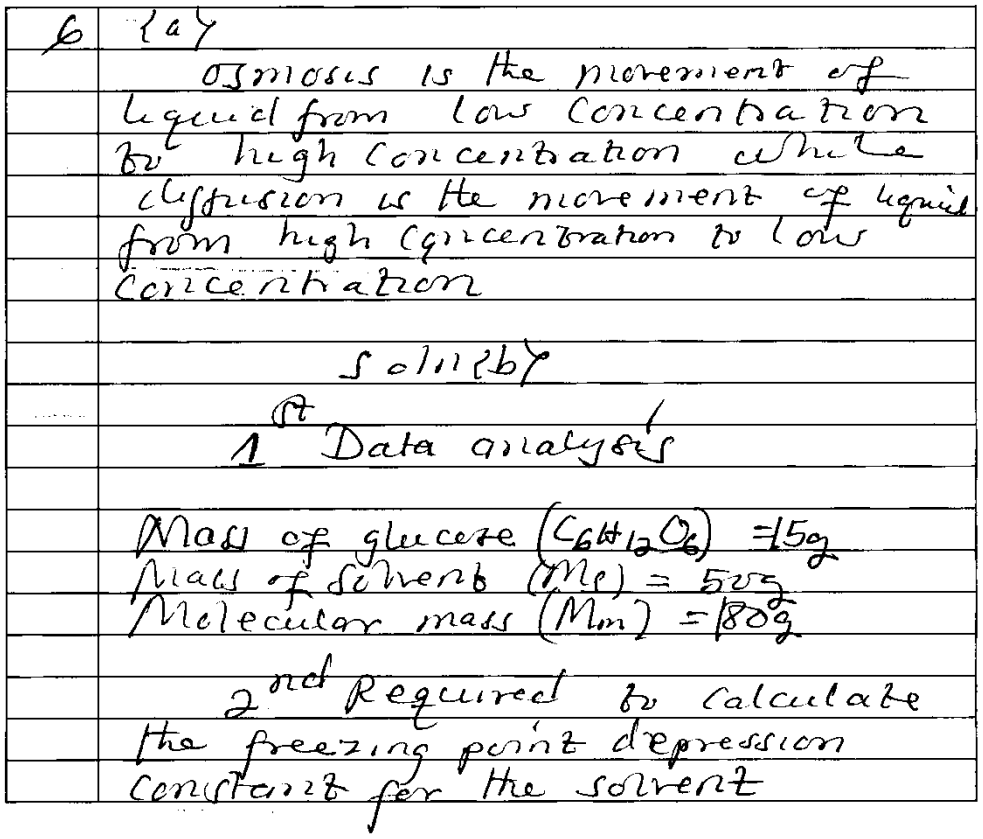


Extract 6.1 shows that the candidate was able to differentiate between osmosis and diffusion and correctly calculated the freezing point depression constant for the solvent and relative molecular mass of sugar.

On the contrary, the candidates who scored low marks were not able to differentiate osmosis from diffusion. The analysis reveals that some of the candidates mixed up the concepts of the two terms. Similarly, the candidates were not able to calculate the freezing point depression constant of the given solvent and the relative molecular mass of sugar from the given information. Further, the analysis reveals that some of them used incorrect formula while others plugged in wrong data, hence obtained wrong values. It was also

observed that, some were not able to covert Nm^{-2} to atmospheres (atm), and therefore they failed to get the correct answer while others skipped some of the steps on the calculations, resulting to low scores. Extract 6.2 demonstrates this case.

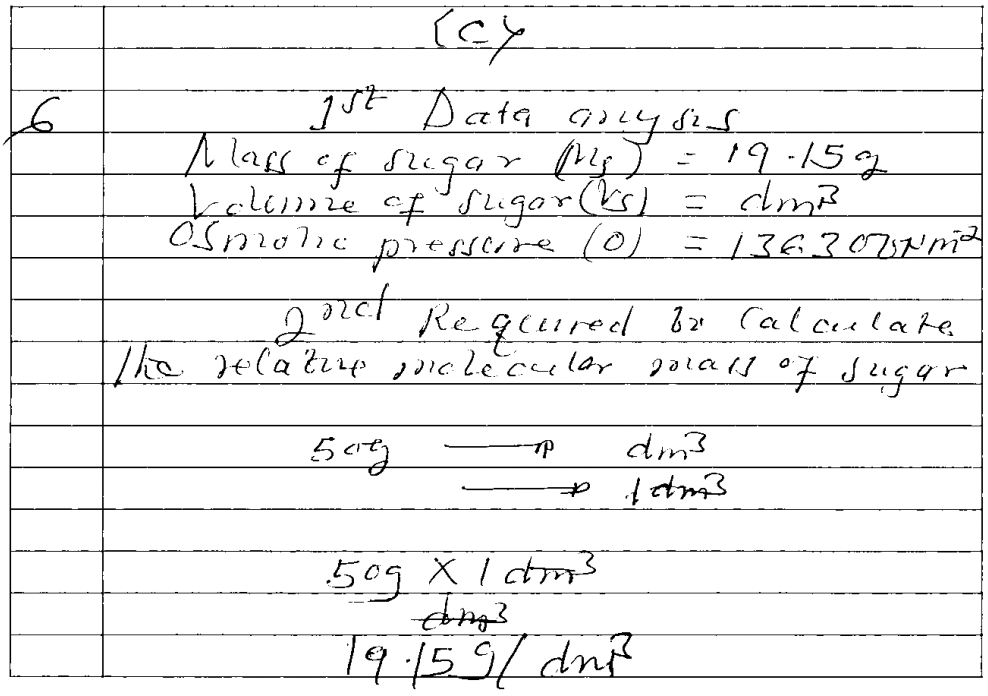
Extract 6.2


6 (a)
Osmosis is the movement of liquid from low concentration to high concentration while diffusion is the movement of liquid from high concentration to low concentration

(b)
Solution
1st Data analysis

Mass of glucose ($C_6H_{12}O_6$) = 15g
Mass of solvent (M_s) = 525
Molecular mass (M_m) = 180g

2nd Required to calculate the freezing point depression constant for the solvent



In Extract 6.2 the candidate gave insufficient explanation of the differences between osmosis and diffusion. She/he used a wrong approach in the calculation of molecular formula of compound X.

2.1.7 Question 7: Two-Component Liquid Systems

In Part (a), the candidates were required to give a brief molecular explanation of positive and negative deviation from Raoults' law for non-ideal binary solutions. In part (b), they were required to state the differences in the lowering of vapour pressure expected for 1M aqueous solutions of $CaCl_2$, KBr and Na_3PO_4 and give justification on their answers. In part (c), they were provided with the information that Benzene (C_6H_6) and Toluene ($C_6H_5CH_3$) form ideal solution and the vapour pressure of pure benzene at 333K was 53.3kPa, while that of pure toluene was 26.7kPa. Then, they were asked to:

(i) Find the partial pressure of each component in the vapour phase in equilibrium with this solution at 333K.

(ii) Calculate the total vapour pressure of the solution.

(iii) Explain which substance will be collected from the top of the distillation column when the mixture containing 2 moles of benzene and 3 moles of toluene was distilled.

More than half (55.6 %) of the candidates opted for the question, out of which 51.2 percent scored from 3.5 to 6.0 out of the 10 marks. The

candidates who scored from 6.5 to 10 were 1,183 (8%), with 13 candidates scoring all the10 marks. On the other hand, 40.8 percent scored below 3.5 marks, with 6.0 percent scoring a zero mark.

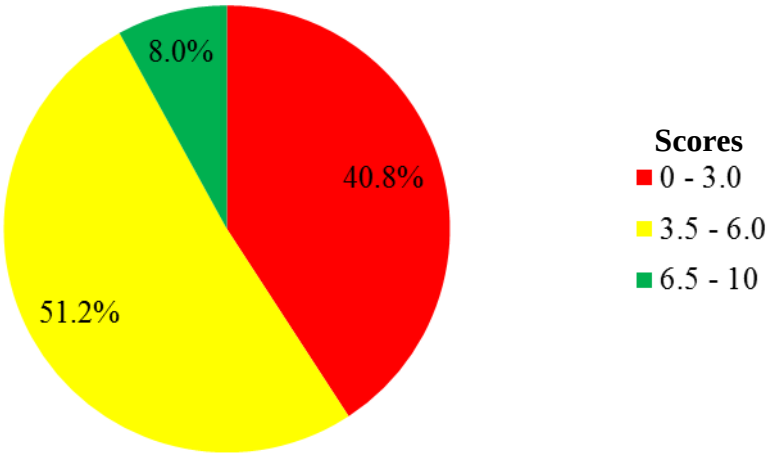


Figure 6: Performance of the candidates in question 7.

The candidates who scored high marks managed to apply the concept of inter and intra molecular forces of attraction to explain the positive and negative deviations from Raoult's law for non-ideal binary solutions. In part (b), they managed to write balanced dissociation equations of the given compounds, from which they made correct justification of the vapour lowering differences. They correctly calculated the partial pressure of each component in the vapour phase in equilibrium with the solution at 333K and the total vapour pressure of the solution. From the calculated values, they correctly explained that benzene was collected from the top of the distillation column. Extract 7.1 illustrates the case.

Extract 7.1

7 (a) - Positive deviation from Raoult's law occurs when intermolecular forces of attraction of solution becomes less than either of intramolecular forces of attraction in pure components.

- Negative deviation from Raoult's law occurs when intermolecular forces of attraction of solution is greater than intramolecular forces of attraction in pure liquids.

(b) . The lowering of vapour pressure follows this trend

$$Na_3PO_4 > CaCl_2 > KBr$$

Decrease in lowering in vapour pressure.

- This difference is due to dependency on lowering of vapour pressure with amount of solute added. Since Na_3PO_4 dissociates to give four moles of ion it lowers vapour pressure of solution much than all other solutes given. Also since $CaCl_2$ dissociates to give three moles of ions it will lower vapour pressure at high amount than KBr which gives only two ions upon

7 (b) Dissociation

(c) Given:

- Vapour pressure of pure benzene, $P_B^\circ = 53.3$ kPa
- Vapour pressure of pure toluene, $P_T^\circ = 26.7$ kPa.
- Number of moles of benzene, $n_B = 2$
- Number of moles of toluene, $n_T = 3$

(i) From: Raoult's law, $P_{soln} = P_B^\circ X_B + P_T^\circ X_T$.

But $n_T = n_B + n_T = 2 + 3 = 5$.

$X_B = 2/5 = 0.4$

$X_T = 3/5 = 0.6$

Then, Partial pressure of benzene, $P_B = P_B^\circ X_B$.

$P_B' = P_B^\circ X_B = 53.3\text{kPa} \times 0.4$

$\therefore P_B' = 21.32$ kPa

Also, Partial pressure of toluene, $P_T' = P_T^\circ X_T$

$P_T' = 26.7\text{kPa} \times 0.6$

$\therefore P_T' = 16.02$ kPa.

∴ Partial pressure of Benzene is 21.32kPa

Partial pressure of ~~toluene~~ is 16.02 kPa

(ii) From: $P_{soln} = P_B' + P_T'$

$= 21.32\text{ kPa} + 16.02\text{kPa}$.

∴ Total vapour pressure of solution is 37.34 kPa

7 (c) (iii) Benzene will be collected from the top of the distillation flask since it have has higher partial vapour pressure compared to toluene.

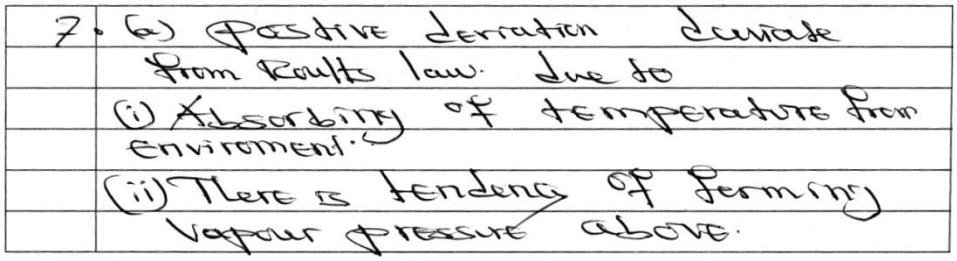
In Extract 7.1 the candidate properly explained positive and negative deviations from Raoults law for non-ideal binary solutions and correctly differentiated the vapour pressure lowering differences for 1M solution of the given compounds. The candidate also correctly

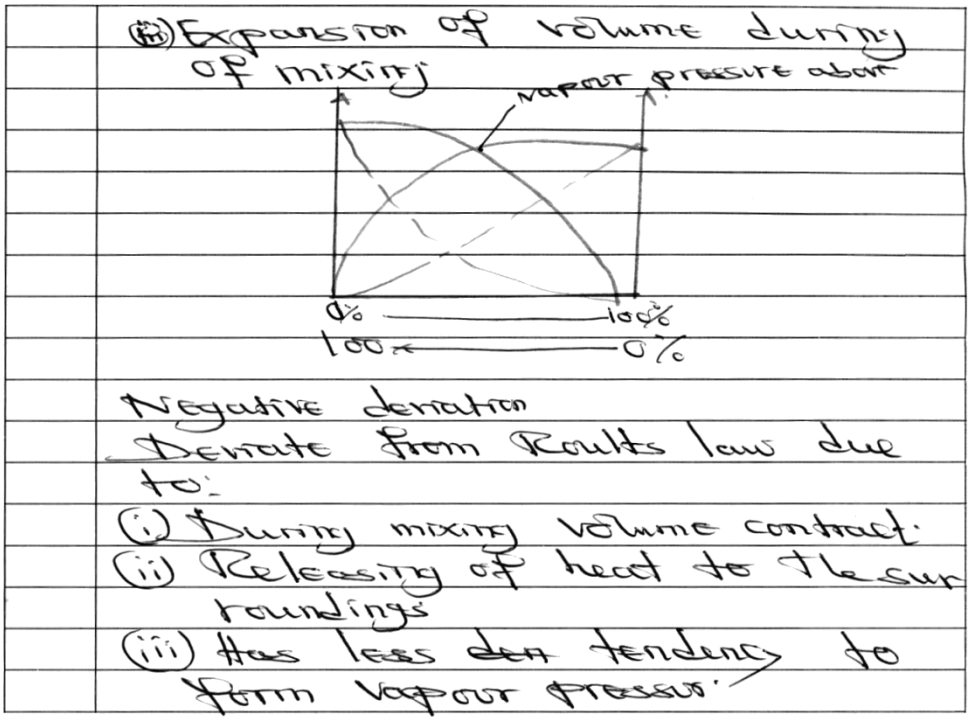
calculated the required answers for the items of part (c) and finally concluded that benzene will be collected from the top.

However, the candidates who scored low marks failed to relate inter and intra molecular forces of attraction with positive or negative deviation from Raoult's law for non-ideal binary solutions. It was observed that some of the candidates associated positive and negative deviations with the release or absorption of heat from the environment and others associated it with contraction of the volume of the solution without explaining the cause of the contraction. The analysis also shows that other candidates failed to understand that lowering vapour pressure is a colligative property that depends on the concentration of solute. This property could enable them to recognize that on dissociation, Na_3PO_4 produces high concentration of solute followed by $CaCl_2$ and then KBr.

Furthermore, others faced difficulties in writing the correct equations of finding the partial pressure of each component and the total vapour pressure of the solution. This failure had adverse effect, since they could not justify the substance that could be collected from the top of the distillation column. This implies that the candidates had insufficient knowledge of mole concept and colligative properties. Extract 7.2 is a sample answer from a script of a candidate whose performance was poor.

Extract 7.2





Extract 7.2 is a response from a candidate who failed to explain the given terms in part (a) of the question.

2.1.8 Question 8: Relative Molecular Masses in Solution

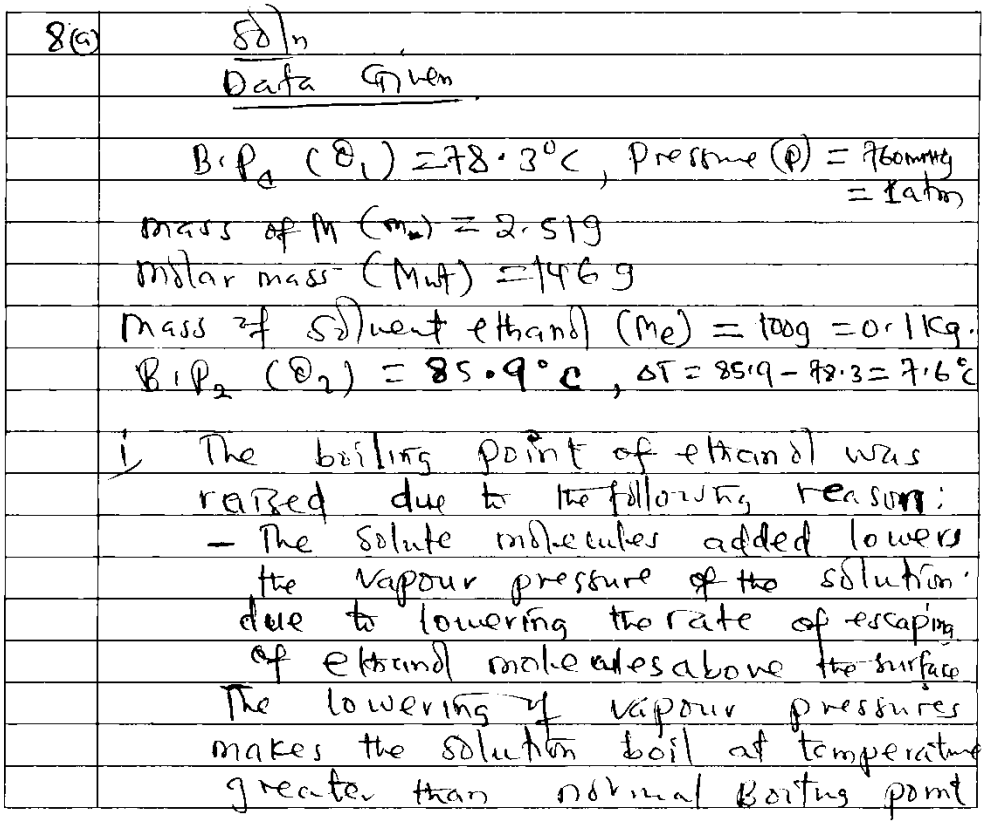
In part (a) of the question, the candidates were required to give reasons for the rise of boiling point of ethanol from 78.3^{o}C at 760 mmHg to 85.9^{o}C at 760 mmHg, when 2.51g of an organic compound M (Mwt = 146g) was dissolved in 100 g of ethanol. They were also asked to calculate the molal boiling point, K_b for ethanol. In part (b), they were required to calculate the boiling point of the solution prepared by dissolving 2.40 g of biphenyl ($C_{12}H_{10}$) in 75.00 g of benzene, given that K_b = 2.53^{o}C/m; K_f = 5.12^{o}C/m; boiling point of pure benzene = 80.1^{o}C and freezing point of pure benzene = 5.5^{o}C.

The question was attempted by 69.8 percent of the candidates and 28.8 percent scored from 3.5 to 6.0 out of 10 marks. The candidates who scored from 6.5 to 10 marks were 32.6 percent of which 7.4 percent scored all the 10 marks. Besides, 38.6 percent scored below 3.5 marks with 10.7 percent scoring a zero mark. In this question, 61.4 percent of the candidates scored from 3.5 to 10 marks and therefore, the question was well performed.

Most of the candidates who scored high marks in this question were able to explain the reasons for the rise of the boiling point of ethanol and correctly

calculated the molal boiling point of ethanol and freezing point of pure benzene. Extract 8.1 illustrates this case.

Extract 8.1


8(a) Soln

Data Given

B.P$_1$ (θ_1) = 78.3°C, Pressure (P) = 760mmHg = 1atm

mass of M (m_M) = 2.51g

Molar mass (Mwt) = 146 g

Mass of solvent ethanol (m_e) = 100g = 0.1Kg.

B.P$_2$ (θ_2) = 85.9°C, ΔT = 85.9 − 78.3 = 7.6°C

i. The boiling point of ethanol was raised due to the following reasons:

- The solute molecules added lowers the vapour pressure of the solution due to lowering the rate of escaping of ethanol molecules above the surface. The lowering of vapour pressures makes the solution boil at temperature greater than normal boiling point

8(a) ii) required: K_b = ?

But $\Delta T \propto$ molality (m).

$\Delta T = K_b m_2$, $m = \frac{n}{\text{Mass of solvent in kg}}$

$m_2 = \frac{m}{M_r \times \text{mass of solvent kg}}$

$\Delta T = \frac{m}{M_r \times M_v \text{ in kg}} K_b$.

$K_b = \frac{\Delta T \times M_r \times M_v \text{ in kg}}{m}$.

$K_b = \frac{(7.6) \times 146 \times 0.1}{2.51} = 44.2 \text{ kmol}^{-1}\text{kg}$

$K_b = 44.2 \text{ K mol}^{-1}\text{kg}$.

∴ The molal boiling point $K_b = 44.2 \text{ K mol}^{-1}\text{kg}$.

8(b) Data Given.

Mass of $C_{12}H_{10}$ (m) = 2.46g.

Molar mass (M_r) = (12 × 12 + 10) = 154 g/mol.

Mass of solvent benzene (m_v) = 75g = 0.075kg

B.P (θ) = ?, $K_b = 2.53°C/m$, $K_f = 5.12°C$

$\Delta T = \frac{K_b \times m}{M_r \times M_v \text{ in kg}} = \frac{2.53 \times 2.4}{154 \times 0.075} = 0.526°C$

$\Delta T = 0.526°C$

$\theta - 80.1 = 0.526°C$

8(b) $\theta = 80.68°C$.

∴ The Boiling point of solution is 80.68°C

Extract 8.1 shows a response from the candidate who performed well in this question. All workings are correct and clearly shown.

However, some of the candidates who scored low marks failed to give reasons for the rise of the boiling point of ethanol. For example, one

candidate wrote *it was due to the addition of the impurities of an organic compound M* without explaining how it lowers the vapour pressure. It was also noted that the candidates applied incorrect formula to calculate the K_b of the solution, hence achieving the wrong answer. In other cases, some of the candidates used the formula for calculating freezing point depression and others calculated the freezing point of a solution instead of the boiling point. In general, these candidates had insufficient knowledge on the topic of Relative Molecular Masses in Solution. Extract 8.2 illustrates this case.

Extract 8.2

8. a) Data given:
Boiling point of ethanol (C_2H_5OH) = 78.3°C
Pressure = 760 mm Hg
Mass of Compound M = 2.51 g
Molecular weight of M = 146 g
Mass of ethanol = 100g
Boil point of the Solution = 85.9°C at 760 mm Hg

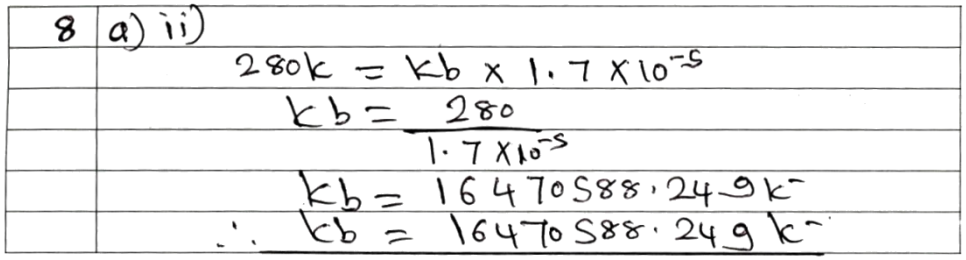
i) The boiling point of the ethanol raised because due to the dissolving of the Compound M which elevate the boiling point to be high. The Compound M elevate the boiling point of ethanol.

ii) Data given:
Boiling point of ethanol (C_2H_5OH) = 78.3°C
Pressure = 760 mm Hg
Mass of Compound M = 2.51g
Molecular mass of Compound M = 146g
Mass of ethanol = 100g
Boiling point of the Solution = 85.9°C at 760 mm Hg
$\therefore$ K_b = ?
ΔT = 85.9°C − 78.3°C = 7.6°C
ΔT = 7.6°C + 273°C = 280.6K

$\Delta T = K_b \times w/m \times 1/W$

280K = $K_b \times \frac{2.51}{146} \times \frac{1}{100g}$

280k = $K_b \times 0.017 \times 0.001$
280 k = $K_b \times 1.7 \times 10^{-5}$



In Extract 8.2, the candidate failed to explain the cause of boiling point elevation of ethanol after the addition of organic compound. Likewise, he/she failed to apply the correct formula in calculating the molal boiling point of ethanol. Apart from that, part (b) was left unanswered, which is an indication of lack of knowledge in Relative Molecular Masses in Solution topic.

2.1.9 Question 9: Chemical Equilibrium

In part (a), the candidates were required to briefly explain the dynamic nature of equilibrium reactions. They were also required to illustrate the dynamic nature of equilibrium reactions using the reaction between H_2 and I_2 gas to produce HI gas. In part (b), they were required to mention the four stresses explained by Le Chatelier's principle to help maximization of ammonia gas in the Haber process. Finally, they were required to use the equation: $N_{2(g)}+3H_{2(g)} \rightleftharpoons 2NH_{3(g)} \quad \Delta H^o = -92.6kJ$ to explain how maximum yield of ammonia can be achieved.

The question was attempted by 72.8 percent of the candidates, of which 54.7 percent scored from 3.5 to 6.0 out of 10 marks, 19.5 percent scored from 6.5 to 10 marks with 4 candidates scoring all the 10 marks. The candidates who scored below 3.5 marks were 25.8 percent of which 1.6 percent scored a zero mark. This question had good performance, as 74.2 percent scored above 3 out of 10 marks.

The majority of the candidates who scored high marks were able to correctly explain the dynamic nature of equilibrium reaction and used hydrogen, iodine and hydrogen iodide gases to illustrate the concept of forward and backward reaction. They also mentioned the four common stresses explained by Le Chateliers' principle to help maximize the yield of ammonia gas in the Haber process. Extract 9.1 shows a sample of a correct response to this question.

Extract 9.1

9(a)(i) The reaction is said to have dynamic nature of equilibrium reaction if the rate of forward and backward reaction are equal but there is continual constant interchange of particles between product side and reactant side.

9(a)(ii)

$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$$

$$R_f = k_f[H_2][I_2]$$

and $R_b = k_b[HI]^2$

at equilibrium

$$R_f = R_b$$

$$k_f[H_2][I_2] = k_b[HI]^2$$

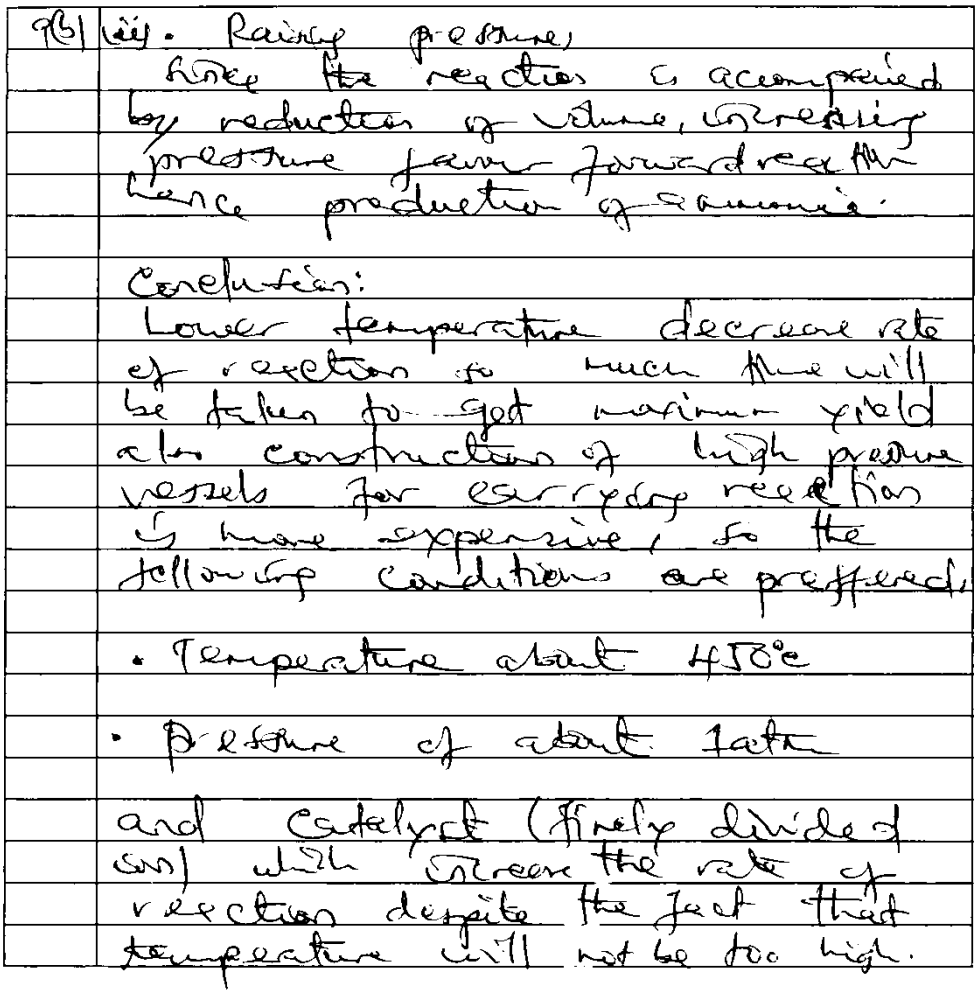
$$\frac{k_f}{k_b} = \frac{[HI]^2}{[H_2][I_2]}$$

$$\Downarrow$$

$$K_c = \frac{[HI]^2}{[H_2][I_2]}$$

The reaction appears static externally but in reality

9(a)	(ii) the rate of combination of H_2 and N_2 is equal to rate of decomposition of NH_3, and the mixture of colour of I_2 and HI is observed at equilibrium.
9(b)	(i) • Lowering temperature of surroundings. • Increasing pressure of the system. • Using catalyst which is finely divided iron. • Increasing concentration of H_2 and N_2.
9(b)	(ii) • Lowering temperature. The reaction being exothermic, to lowering in temperature will favour production of more ammonia. (forward reaction will be favoured).



In Extract 9.1, the candidate correctly explained the dynamic nature of equilibrium reaction and the concept of forward and backward reaction. The candidate mentioned the four common stresses which maximize the yield of ammonia gas in the Haber process.

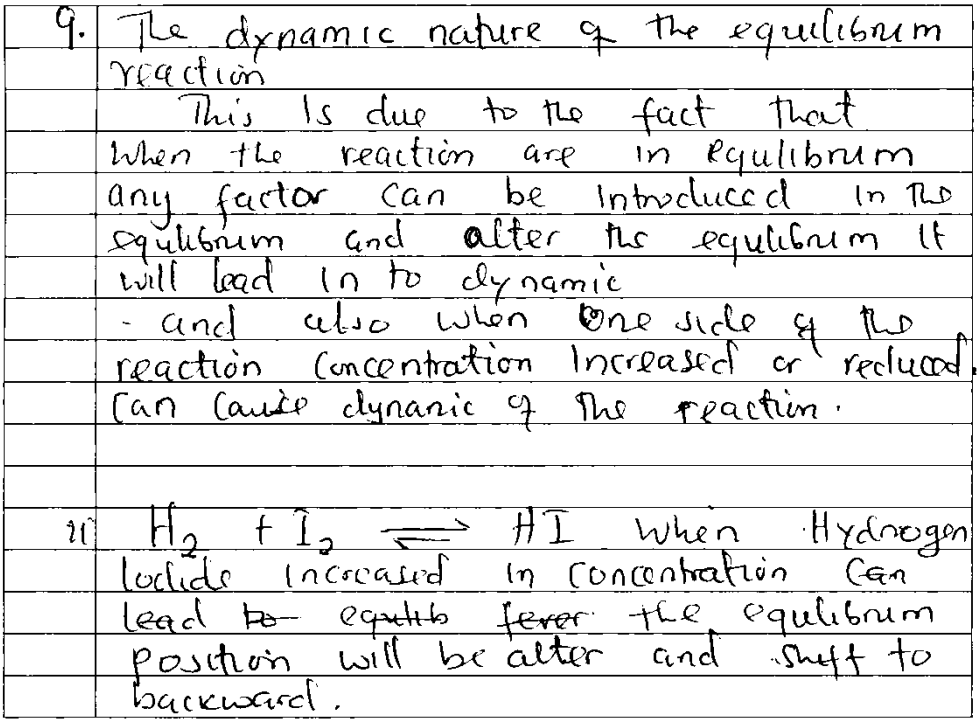
However, the candidates who scored low marks in this question failed to present the concept of forward and backward (reverse) reaction to explain the dynamic nature of equilibrium reaction. For example in one script, the candidate wrote:

> *9(a)(i) "dynamic nature of equilibrium reaction is the situation at which the equilibrium point occurs in the equation which may product on both sides it known as reversible reaction. This reversible reaction is the type of dynamic reaction which product can be in either forward or backward reaction".*

Such incorrect and unclear answers are among the examples which show that the candidates lacked knowledge of the concept of reversible reactions.

In other cases, some candidates explained reversible reaction instead of dynamic equilibrium. Not only that, others failed to mention the four common stresses explained by Le Chateliers' principle which help to maximize the yield of ammonia gas in the Haber process. Instead they explained the factors affecting chemical equilibrium rather than the dynamic equilibrium. Extract 9.2 shows a sample of poor responses.

Extract 9.2



In Extract 9.2, the candidate failed to explain the dynamic nature of equilibrium reaction and to use the concept of reversible reaction to illustrate it. Above all, part (b) and (c) was left unanswered, an indication of lack of knowledge on the concept tested.

2.1.10 Question 10: Energetics

In part (a), the candidates were asked to define the following: heat of reaction, exothermic reaction and endothermic reaction. In part (b), they were required to explain whether the change in temperature from 22.7^{o}C to 19.4^{o}C after the addition of 1.5 g of ammonium nitrate (NH_4NO_3) to 35.0 g of water, was endothermic or exothermic. Finally, they were required to calculate the heat of solution of NH_4NO_3 in kJ/mol, given that, the specific heat capacity of water was 4.184J/g^{o}C.

The question was attempted by 83.5 percent of the candidates and 50.7 percent scored below 3.5 out of 10 marks, with 2.2 percent scoring a zero mark. The candidates who scored from 3.5 to 6.0 marks were 42.6 percent and from 6.5 to 10 marks were 6.7 percent. Only a few candidates (0.1%) scored all the10 marks. These data signify that the question was averagely performed.

The majority of the candidates who scored high marks were able to state the given terms. They also explained, with reasons, why the dissolution of 1.5 g NH_4NO_3 in 35 g of water which caused a drop of temperature from 22.7^0C to 19.4^0C was an endothermic process. Additionally, the candidates accurately calculated the heat of solution of NH_4NO_3 in the given units. Extract 10.1 is one example of such good responses.

Extract 10.1

10a) i) Heat of reaction is the heat change when the certain stoichometric of reactants has completely reacted.

ii) Exothermic reaction is the reaction which proceeds with the evolution of heat to the surrounding.

iii) Endothermic reaction is the reaction which proceeds with the absorption of heat from the surrounding.

b) Given:

$M_{NH_4Cl} = 1.5g$.

$M_w = 35.0g$

$T_1 = 22.7°C$.

$T_2 = 19.4°C$.

$T_2 - T_1 = -3.3°C$.

i) The process is endothermic. This is because the decrease in temperature shows that the process proceeds with absorption of heat.

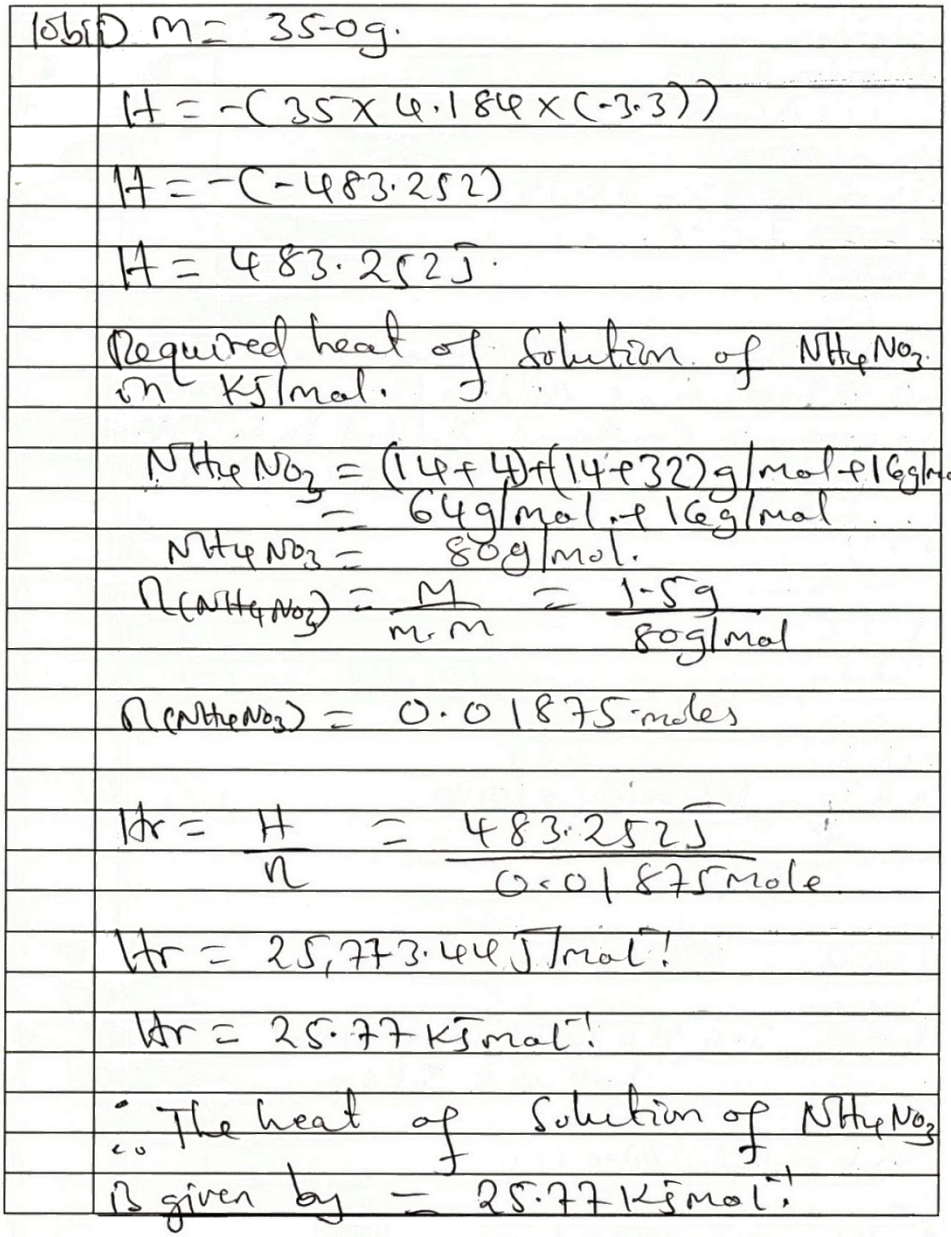
ii) Heat of solution:

$C = 4.1845 J/g°C$.

Soln

$H = -(mc\Delta T)$.

$M = \rho V$.

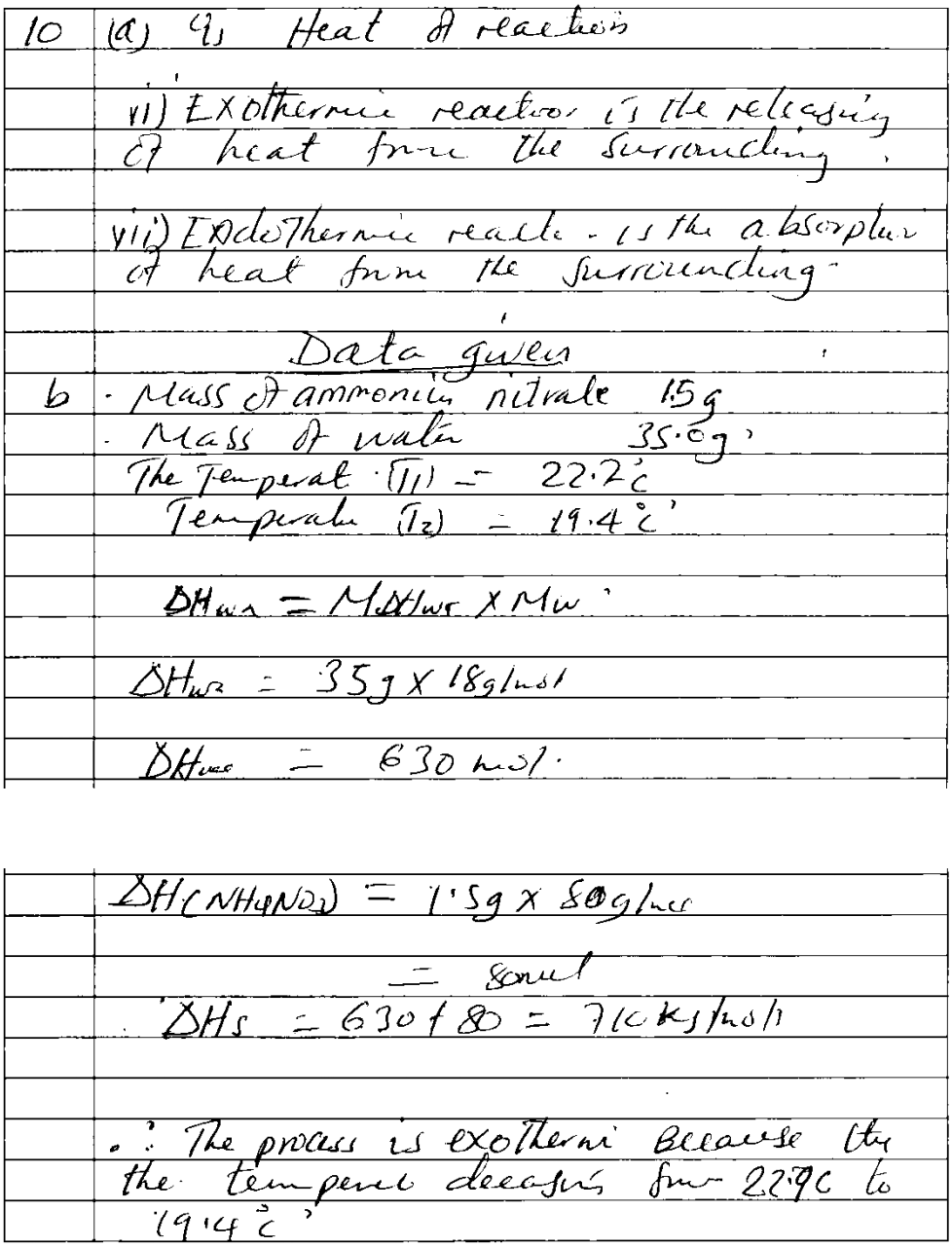


In Extract 10.1, the candidate wrote correct definitions and formulae with all the symbols. Eventually, the candidate managed to do the related calculations correctly.

However, the candidates who scored low marks failed to define the given terms. Some of them interchanged the definition of exothermic and endothermic reaction. As a result, they failed to determine whether the reaction was exothermic or endothermic. In other cases, some of the candidates failed to calculate the heat of the solution of NH_4NO_3. This was due to the wrong approach of using the summation of mass of solvent and

solute instead of using the mass of solvent in the calculation. This indicates that the candidates had inadequate knowledge of the topic of Energetics. Extract 10.2 illustrates one of the poor responses.

Extract 10.2



In Extract 10.2, the candidate attempted all parts of the question, but made some mistakes in stating the given terms. For example in part 10 (a) (i), he/she stated exothermic as the releasing of heat from

the surroundings and used a wrong approach in calculating the heat of solution.

2.1.11 Question 11: Aliphatic Hydrocarbons

In part (a), the question required the candidates to explain briefly the terms; hydrocarbon, saturated hydrocarbon and unsaturated hydrocarbon. The candidates were also enquired to give an example of the family of organic compound in each case. In part (b), the candidates were given the following information:

10 cm^3 of a gaseous hydrocarbon Q required 45 cm^3 of oxygen for complete combustion. Q reacts with 1 mole of bromine gas to form a brominated compound of relative molecular mass of 200.02 which contained 79.2% bromine.

(i) Determine the molecular formula of Q.

(ii) Give the structural formula of Q.

The question was attempted by 77.8 percent of the candidates, out of which 84.0 percent scored below 3.5 out of 10 marks, with 3.9 percent scoring a zero mark. The candidates who scored from 3.5 to 6.0 marks were 11.7 percent, 4.3 percent scored from 6.5 to 10 marks of which 0.4 percent of the candidates scored all the 10 marks. Figure 7 gives a summary of the performance of the candidates in this question.

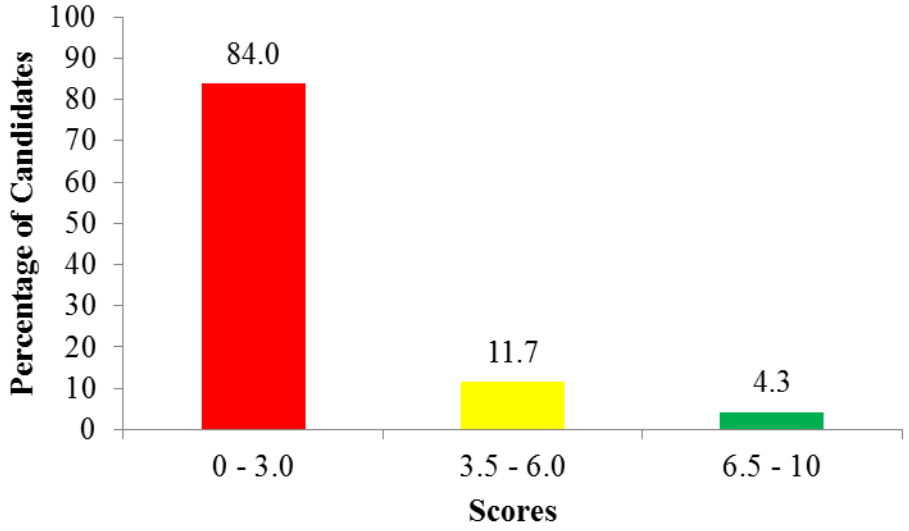
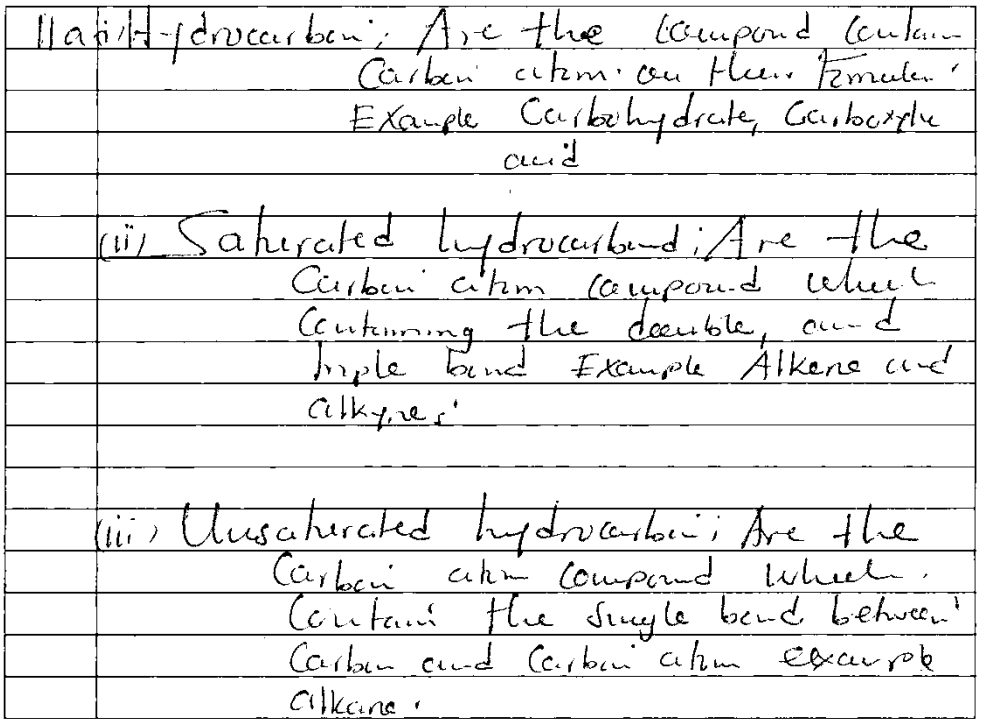


Figure 7: Performance of the candidates in question 11.

Figure 11 shows that the general performance of the candidates in this question was poor as only 33.9 percent of them passed. As for the candidates who scored low marks, some of them failed to correctly explain

the given terms. For example, one candidate wrote "unsaturated hydrocarbons are the organic compounds which have only three hydrogen atoms", and gave an example of "CH_3 methyl". This is wrong, since unsaturated hydrocarbons contain multiple bonds in their carbon atoms. In other cases, some of the candidates gave wrong examples of different families. The candidates also failed to calculate the molecular formula of Q since they failed to formulate the respective equations from the given information. As a result, they were not able to give correct structural formula of Q. Extract 11.1 is a sample answer from a script of a candidate whose performance was poor.

Extract 11.1


Hahi-hydrocarbon; Are the compound contain Carbon atom on their formula' Example Carbohydrate, Carboxylic acid

(ii) Saturated hydrocarbon; Are the Carbon atom compound which Containing the double, and triple bond Example Alkene and alkyne'

(iii) Unsaturated hydrocarbon; Are the Carbon atom compound which. Contain the single bond between Carbon and Carbon atom example alkane'

What is written in Extract 11.1 is an indication that the candidate had insufficient knowledge about the basic terms in organic chemistry. All of the given terms are not correct.

However, most of the few candidates who scored high marks, properly explained the given terms and gave correct examples of organic compounds. They also correctly calculated the molecular and structural formulae of Q. A sample response from one of the candidates who performed well is presented in Extract 11.2.

Extract 11.2

11 (a) (i) Hydrocarbon is the organic compound formed by Hydrogen and Carbon only.
Forexample Alkane ⇒ CH_4 (methane)

(ii) Saturated hydrocarbon is the type of hydrocarbon which consists of single bond between carbon atoms (C-C)
Example. Alkane ⇒ H_3C-CH_3.

(iii) Unsaturated hydrocarbon is the type of hydrocarbon which consists of multiple bonds between carbon atoms.
Example Alkenes contain double bonds $H_2C=CH_2$
Alkynes contain triple bonds $HC\equiv CH$.

11 (b) Solution

Data given.

Volume of hydrocarbon Q = 10cm³
Volume of Oxygen = 45cm³.
Molecular mass of brominated compound = 200.02.
Percentage of bromine = 79.2%
Moles of bromine = 1 mole.

Reaction of Q with 1 mole of bromine indicates that the hydrocarbon Q is alkene.

Reaction: $C_nH_{2n} + Br_{2(g)} \xrightarrow[\text{light}]{U.V} C_nH_{2n}Br_2$

But Br_2 has 79.2% 200.02.

Molecular mass of $Br_2 = \frac{79.2}{100} \times 200.02 = 158.42$.

Molecular mass of Q = 200.02 − 158.42 = 41.6

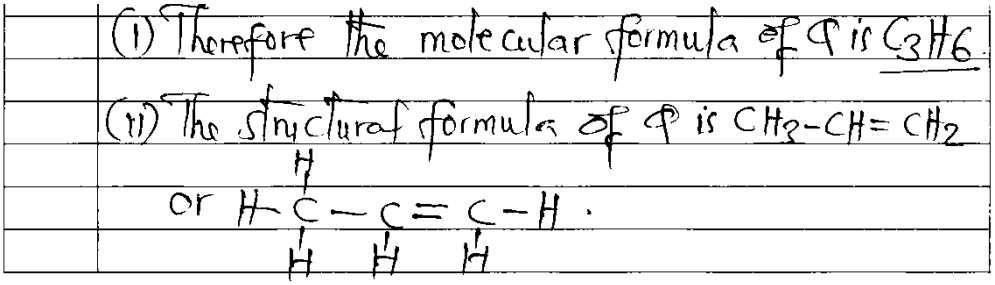
Then

$C_nH_{2n} = 41.6 \simeq 42$.

$12n + 2n = 42$.

$\frac{14n}{14} = \frac{42}{14}$

$n = 3$. C_3H_6



In Extract 8.2, the candidate explained correctly the terms hydrocarbon, saturated hydrocarbon and unsaturated hydrocarbon, and gave correct examples in each case. The candidate also correctly calculated the molecular formula and presented well the structural formula of hydrocarbon Q.

2.1.12 Question 12: Aliphatic Hydrocarbons

In part (a), the candidates were required to define isomers and isomerism. In part (b), they were required to write the structural formula of 3-methly-1pentene; 2-methyl-2-pentene; 2,2-dimethylpentane and 4-methylpent-2-yne. In part (c) of the question, the candidates were required to identify a simple chemical test that could be used to distinguish 1-butyne from 2-butyne and butane from butene.

The question was attempted by many candidates (97.9%), of which 34.4 percent scored from 3.5 to 6.0 out of 10 marks, 48.4 percent scored from 6.5 to 10 marks. The candidates who scored from 0 to 3.0 marks were 17.2 percent of which 3.9 percent scored a zero mark. Figure 8 shows the distribution of the candidates' scores.

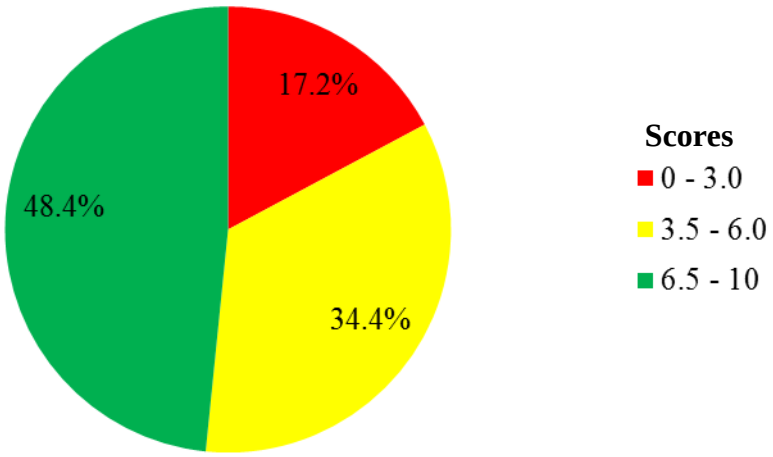


Figure 8: Performance of the candidates in question 12.

Figure 12 shows that 82.8 percent of the candidates scored from 3.5 to 10 marks implying a good performance in this question. The candidates who scored all 10 marks were able to define well the terms isomers and isomerism. The candidates also wrote a correct structural formula of the given organic compounds and correctly identified simple chemical tests used to distinguish 1-butyne from 2-butyne and butane from butene. Extract 12.1 displays a sample answer from one of the candidates.

Extract 12.1

12a) To define

i) Isomers: Are organic compounds which have the same molecular formula but different structural formula.

ii) Isomerism: Is the tendency of organic compounds to have the same molecular formula but different structural formula.

b) Structural formulae of the named compounds are as follows

i) 3-methyl-1 pentene.

$CH_2 = CH\,CH(CH_3)\,CH_2CH_3$

ii) 2-methyl-2 pentene.

$CH_3\,C(CH_3) = CH\,CH_2CH_3$

iii) 2,2-dimethyl pentane.

$CH_3\,C(CH_3)_2\,CH_2CH_2CH_3$

iv) 4-methyl pent-2-yne.

$CH_3\,C\equiv C\,CH(CH_3)\,CH_3$

12c) Distinguishing Tests for

i) $CH_3CH_2C\equiv C-H$ and $CH_3C\equiv CCH_3$

⇒ $CH_3CH_2C\equiv C-H$ has acidic terminal hydrogen and hence it will react with Toller's reagent to form white ppt while $CH_3C\equiv CCH_3$ has no reaction with Toller's reagent.

$CH_3CH_2C\equiv C-H + [Ag(NH_3)_2]NO_3 \rightarrow CH_3CH_2C\equiv CAg + 2NH_3$ (white ppt) $+ HNO_3$

$CH_3C\equiv CCH_3 + [Ag(NH_3)_2]NO_3 \rightarrow$ No reaction.

ii) $CH_3CH_2CH_2CH_3$ and $CH_3CH_2CH=CH_2$

- $CH_3CH_2CH_2CH_3$ is saturated and hence it can't decolourize bromine while since $CH_3CH_2CH=CH_2$ is unsaturated it decolourizes bromine as per;

$CH_3CH_2CH=CH_2 + Br_2 \xrightarrow{CCl_4} CH_3CH_2CH(Br)CH_2Br$

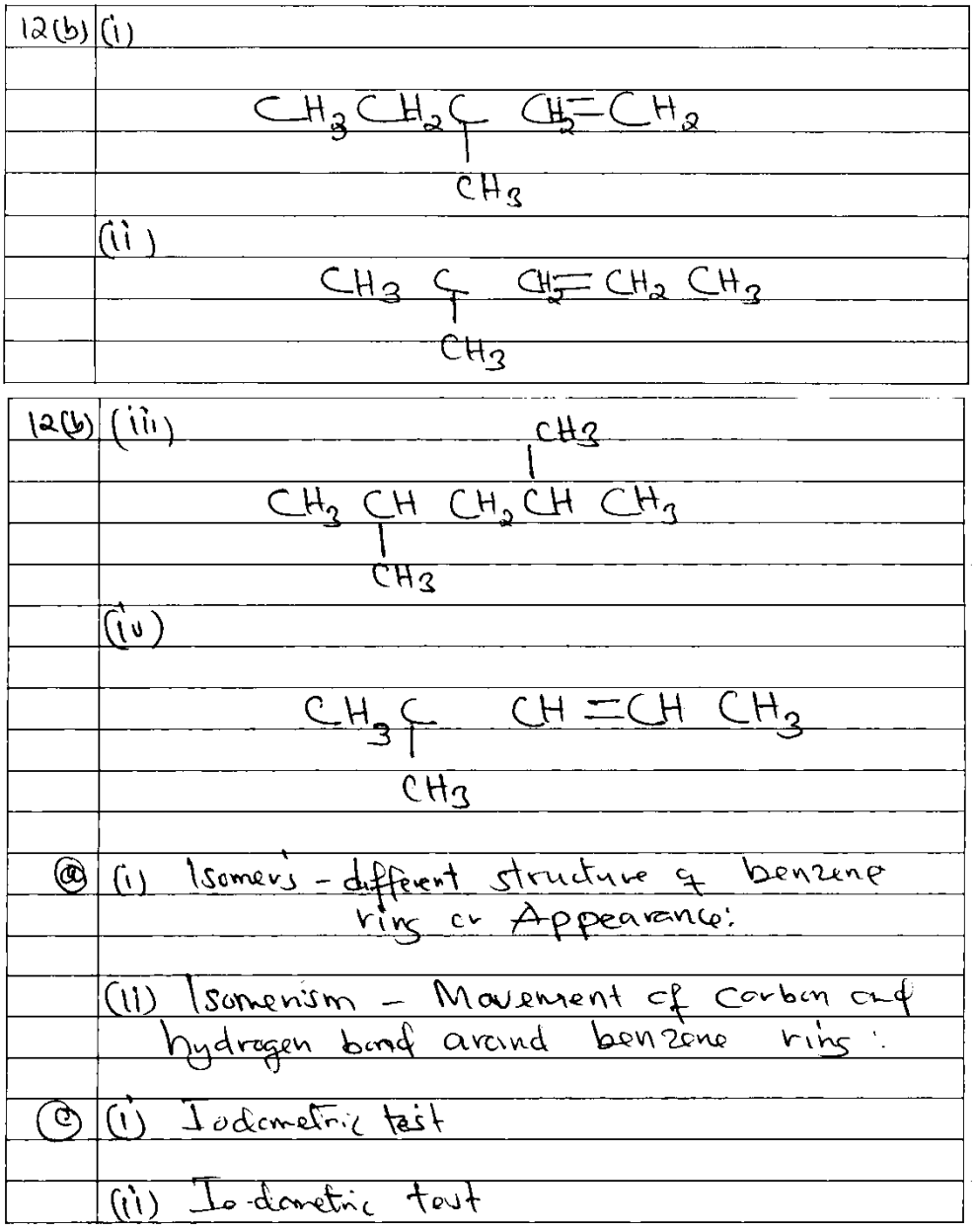
(Brown) (colourless)

$CH_3CH_2CH_2CH_3 + Br_2 \xrightarrow{CCl_4}$ No reaction.

In Extract 12.1, the candidate gave the correct definition of isomers and isomerism. Structural formula of the given organic compounds was correctly written. The candidate also presented correct chemical tests that could be used to distinguish the given organic compounds.

Some of the candidates who scored low marks, specifically those who scored zero, were not able to define isomers and isomerism. The candidates also failed to write correct structural formulae of the given organic compounds and they did not manage to identify the tests that could be used to distinguish 1-butyne from 2-butyne and butane from butene. Extract 12.2 shows a sample of responses of a candidate who failed to meet the requirement of the question.

Extract 12.2



In Extract 12.2, the candidate presented a wrong structural formula, definition and incorrect chemical tests of the given compounds.

2.1.13 Question 13: Halogen Derivatives of Hydrocarbons

In part (a) of the question, the candidates were required to outline the stages in the formation of chloromethane from methane and chlorine at 450^0C. They were also required to give reason for the obtained chloromethane being not so pure. In part (b) of the question, the candidates were given a

statement that: “bromoalkanes may react with alcoholic potassium hydroxide solution to form alkenes”. Basing on the statement, the candidates were required to:

(i) Mention the type of organic reaction.

(ii) Write an equation for the reaction between 1-bromobutane and alcoholic potassium hydroxide, showing all the reaction mechanisms.

(iii) Draw the structural formula of the alkene obtained from the reaction between 2-bromobutane and alcoholic potassium hydroxide.

Two-thirds (66.7%) of the candidates attempted this question, of which 39.6 percent scored from 3.5 to 6.0 out of 10 marks. The candidates who scored from 6.5 to 10 marks were 11.8 percent with 0.1 percent scoring all the 10 marks. On the other hand, 48.6 percent scored below 3.5 marks with 10.4 percent scoring a zero mark. These data indicate an average performance in this question.

The majority of the candidates who performed well were able to outline the stages in the formation of chloromethane from methane and chlorine, which are; initiation, propagation and termination. The candidates also gave reason for the chloromethane obtained not being pure. In responding to part (b), the candidates managed to mention the type of organic reaction wrote an equation for the organic reaction and showed the mechanisms involved in the reaction. Finally, the candidates drew the structural formula of the obtained alkene from the reaction between 2-bromobutane and alcoholic potassium hydroxide. Extract 13.1 illustrates the case.

Extract 13.1

12(a)(i) Chloromethane from Methane and chlorine at 450°C.

Eqn.

$$CH_4 + Cl_2 \xrightarrow[450^\circ C]{u.v} CH_3Cl.$$

This process involve three stages

1st stage: Chain initiation.

In the stage involve the formation of two radicals

$$Cl_2 \xrightarrow{u.v} Cl\overset{\cdot}{-}\overset{\cdot}{Cl} \longrightarrow Cl^{\cdot} + Cl^{\cdot}$$

2nd stage: Chain propagation.

In the stage involve the following:

Cl· react with CH_4 and to form the CH_3

$$CH_4 + Cl^{\cdot} \longrightarrow \dot{C}H_3 + HCl.$$

3rd stage: Chain termination.

In this stage the two radical combine to form compound

$$\dot{C}H_3 + \dot{C}H_3 \longrightarrow CH_3CH_3$$

$$\dot{C}H_3 + \dot{C}l \longrightarrow CH_3Cl$$

$$\dot{C}l + \dot{C}l \longrightarrow Cl_2.$$

12(a) (ii) The reason for the chloromethane obtained in the reaction to not be pure.

This is because at the chain termination step there is production of different compounds as it involves the reaction of free radicals.

That is

$CH_3 + CH_3 \longrightarrow CH_3CH_3$

$Cl_2 + Cl \longrightarrow Cl_2$

$CH_3 + Cl \longrightarrow CH_3Cl$

both CH_3CH_3 and Cl_2 remain as the impurities.

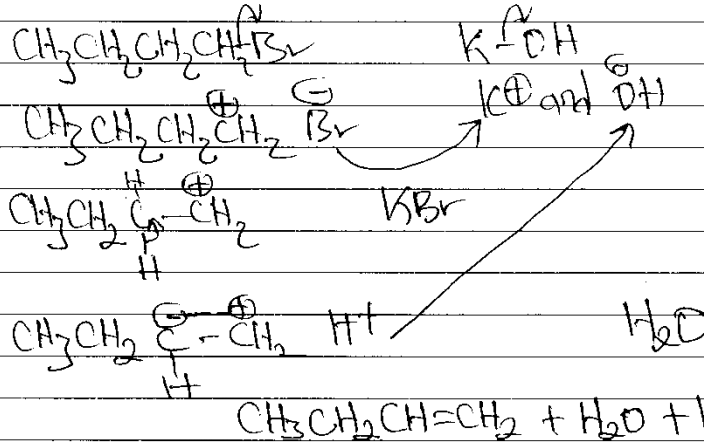
13(b) Soln.

$CH_3CH_2CH_2Br + Alc.\ KOH \longrightarrow CH_3CH=CH_2$.

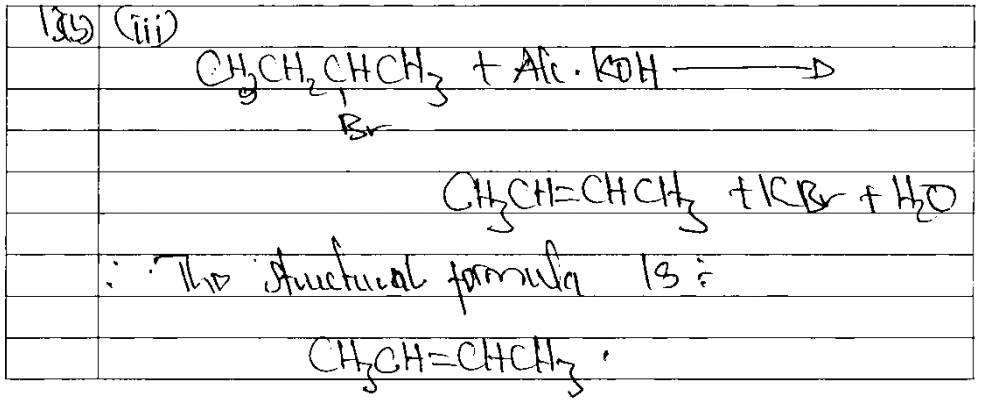
(i) It is an Elimination reaction

(ii) Reaction

$CH_3CH_2CH_2CH_2Br + Alc.\ KOH \longrightarrow$



$CH_3CH_2CH=CH_2 + H_2O + KBr$.



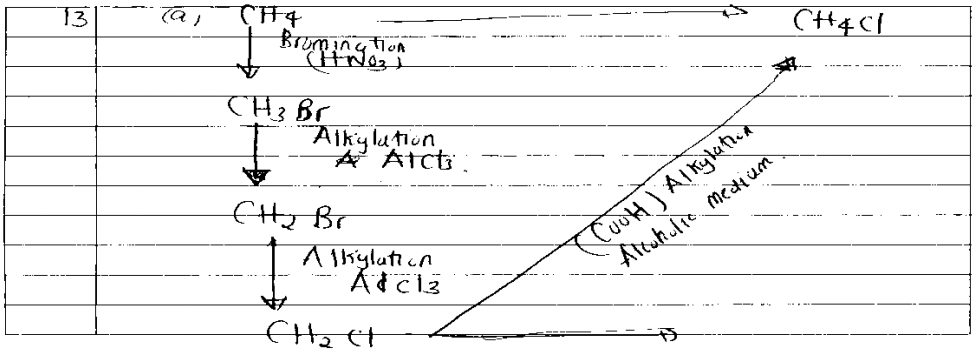
In Extract 13.1, the candidate correctly answered all the parts of the question. All mechanisms for the reactions are clearly shown.

However, the candidates who scored low marks failed to outline the stages in the formation of chloromethane from methane and chlorine. They failed to understand that the given temperature facilitates the chlorine molecule to break into free radicals which are very reactive. In other cases, some of the candidates failed to give reasons for the chloromethane obtained not being pure. This is an indication of insufficient knowledge of free radical substitution reaction.

The analysis also reveals that a few candidates were able to mention the type of organic reaction which took place, but failed to show the mechanisms involved. Moreover, they failed to draw the structural formula of the alkene obtained by reaction between 2-bromobutane and alcoholic potassium hydroxide. This is an indication of insufficient knowledge of the reactions of the aliphatic hydrocarbons. Extract 13.2 illustrates one of the poor responses.

Extract 13.2

13 (a)



13 (b) The Chloromethane is obtained is not pure because the methane tend to form many precipitates which are not dissolved in solution Thus cause it to be impure at all

(b) (i) The type of reaction is addition reaction

(ii) $CH_2 - CH - CH - CH - CH_2 + KOH$

Br^-

$CH_3^+ - CH - CH - CH - CH_2 + K^+ + OH^-$

Br^-

$OH - CH_2 - CH - CH - CH - CH_2 + KBr$

$OH - CH_2 - CH - CH - CH - CH_2 + KBr$

$O^+ - H^- - CH_2 - CH - CH - CH + HKBr$

$O - CH_3 = CH - CH - CH + KBr$

(iii) $CH_2O - CH = C - CH_2$

$\Rightarrow CH_2\bar{O} - C\overset{+}{H} = C^+ = CH_2$

$CH_2 = CHO + CH_3$

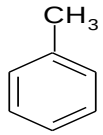
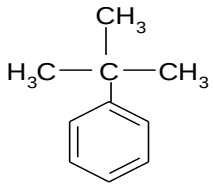
$CH_2^+ - CH^- + CH_3O$

$CH_3 + CH_3 = CH + CH_3COOH$

In Extract 13.2 the candidate gave incorrect stages of formation of chloromethane and provided irrelevant explanations about the purity of chloromethane. She/he failed to show the mechanisms for the reaction between bromoalkane and alcoholic potassium hydroxide.

2.1.14 Question 14: Aromatic Hydrocarbons

In part (a), the candidates were required to briefly explain on the observation that, C-C bonds are all equal and intermediate in length between a single and a double bond in benzene. They were also required to explain why dry ether is necessary in the preparation and the use of Grignard reagent. In part (b) of the question, the candidates were provided with the information that: "chlorination of methyl benzene and 1,1-dimethylethyl benzene, yield the following isomers:

	2	3	4
	60%	0.5%	39.5%
	22%	8%	70%"

The candidates were required to study the produced isomers and explain the observed different product ratio.

A total of 7,067 candidates, equivalent to 26.6%, attempted this question, out of which 87.5 percent scored below 3.5 out of 10 marks, with 15.9 percent scoring a zero mark. The candidates who scored from 3.5 to 6.0 marks were 11.9 percent, 0.6 percent scored from 6.5 to 10 marks. However, there was no candidate who scored all the allocated marks. Figure 9 gives a summary of the performance of the candidates in this question.

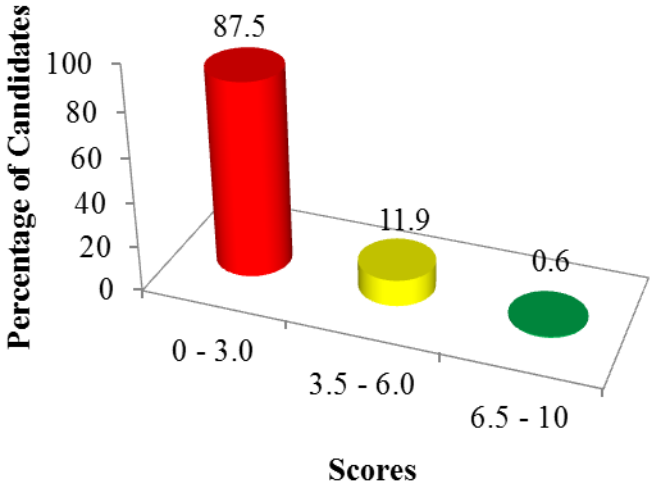
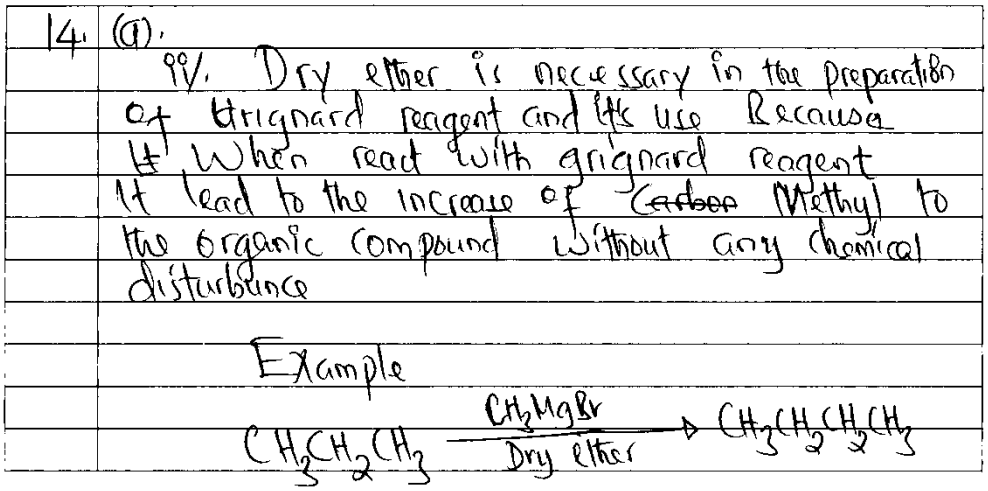


Figure 9: Performance of the candidates in question 14.

Figure 10 shows that, the general performance of the candidates in this question was poor as many candidates (87.5%) scored low marks (0 – 3). These candidates failed to explain that the C-C bonds are equal and intermediate in length between a single and double bond in benzene. Others failed to explain the reason which makes dry ether necessary in preparation and use of the Grignard reagent. It was also noted that some of the candidates did not understand the requirements of the question and some provided the reaction for the preparation of alcohols by using Grignard's reagent, which was wrong. They failed to explain that chlorination of methyl benzene and 1, 1-dimethylethylbenzene could yield the isomers 2, 3 and 4. They also failed to interpret the use of percentages (%) provided in the question as some of them used them to calculate the empirical formula of the compounds. Extract 14.1 shows a sample answer from the script of a candidate whose performance was poor.

Extract 14.1



Extract 14.1 shows the candidate's wrong responses. The candidate provided insufficient explanation on the necessity of dry ether in the preparation and use of Grignard reagent. Apart from that, he/she did not attempt part (b).

However, a few candidates (12.5%) who performed well explained with reasons that, C-C bonds are equal and intermediate in length between a single and double bond in benzene. They were also able to explain well the reasons why dry ether is necessary in the preparation of the Grignard reagent. The candidates correctly explained the chlorination of methyl benzene and 1,1-dimethylethylbenzene to yield the isomers observed. Extract 14.2 shows good responses from one of the candidates.

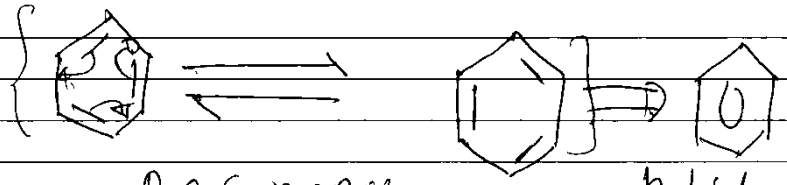
Extract 14.2

14. (a) C – C in bond all equal and intermediate in length between single and double bond

14(a) (i) This is due to delocalization of the lone pair in the benzene make the electron charge density around the C-C bond to be of equal length.

- i.e Delocalization lead to spread of the charge density to all C-C single bond and also C=C double bond thus making to have same length.

- This can be shaw by resonance below



Resonance hybrid structure

(ii) Dry ether is necessary in preparation of ~~Dry ether~~ Grignard reagent

Grignard reagent is prepared by reaction between alkyl halide and magnesium in presence of dry ether

ie RMg + Cl $\xrightarrow{\text{dry ether}}$ RMg

~~If the~~ The ether must be dry in preparation to prevent the hydrolysis of the grignard reagent to form the alkane. thus we they employ dry ether to get the required reagent.

Also in the use of grignard reagent, Dry ether must be present to prevent the hydrolysis of grignard reagent.

14 (b)

In methylbenzene the isomer of 2 is 60% because the ~~ortho~~ methyl is ortho-para director, but the higher yield in ortho is due to small in size of methyl group thus exert weak steric hindrance.

In ~~1,1-methyl~~ 1,1-dimethylethylbenzene In the ortho carbon there is large steric hindrance this due to large nature of alkyl group hence lower yield in isomer (2) thus it prefer to attach in para carbon which is isomer 4 thus higher yield

In both case methylbenzene and 1,1-dimethyl ~~ben~~ ethylbenzene the meta carbon which is isomer 3 is less deactivated thus gave lower yield in both cases.

In Extract 14.2 the candidate gave the correct explanation on the delocalization of 6π electrons around the benzene ring. In the same way, he/she appropriately explained the ratio of the product based on the concept of ortho-para director and steric hindrance.

2.2 132/2-CHEMISTRY 2

This paper had a total of ten (10) questions. Each question carried 20 marks.

2.2.1 Question 1: Chemical Kinetics; Chemical Equilibrium

The question was:

(a) Derive an expression relating Kc and Kp for the decomposition of phosphorous pentachloride. $PCl_{5(g)} \leftrightharpoons PCl_{3(g)} + Cl_{2(g)}$.

(b) The equilibrium constant for the reaction $2HCl_{(g)} \leftrightharpoons H_{2(g)} + Cl_{2(g)}$ is $K_1 = 4.17x10^{-34}$ at 25^oC and the equilibrium constant for the reaction $I_{2(g)}+Cl_{2(g)} \leftrightharpoons 2ICl_{(g)}$ is $K_2 = 2.1\ x10^5$ at 25^oC. Calculate the equilibrium constant for the reaction. $2HCl(g) + I_{2(g)} \leftrightharpoons 2ICl_{(g)} + H_{2(g)}$.

(c) Briefly explain five factors that affect the rate of chemical reaction.

The question was opted by 78.7 percent of the candidates. The data indicate that10.5 percent of the candidates scored 0 to 6.5 marks, 31.8 percent scored 7.0 to 11.5 marks and 57.7 percent scored 12.0 to 20 marks. The pie chart (Figure 10) gives a graphical presentation of these data.

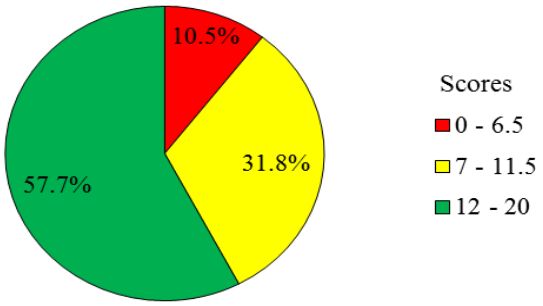


Figure 10: Performance of the candidates in question 1.

Figure 10 shows that 89.5 percent of the candidates scored above 6.5 marks, an indication of good performance in the question. The majority of the candidates who scored high marks, managed to derive an expression relating Kc and Kp. Similarly, they were able to calculate the equilibrium constant in part (b) by combining the two given reactions to obtain the require equation, hence, correctly calculated its equilibrium constant. They also managed to explain five factors that affect the rate of chemical reaction. Extract 15.1 is one of the good responses for part 1(a) from one of the candidates.

Extract 15.1

1. (a) Required to derive an expression relating K_c and K_p for;

$$PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}.$$

1st Case

Write K_c expression in terms of concentration.

$$K_c = \frac{[Products]}{[Reactants]}.$$

$$K_c = \frac{[PCl_3][Cl_2]}{[PCl_5]}. \quad \text{——(i)}$$

2nd Case

Find K_p expression in terms of Partial Pressure

$$K_p = \frac{(P'PCl_3)(P'Cl_2)}{(P'PCl_5)} \quad \text{——(ii)}$$

3rd Case;

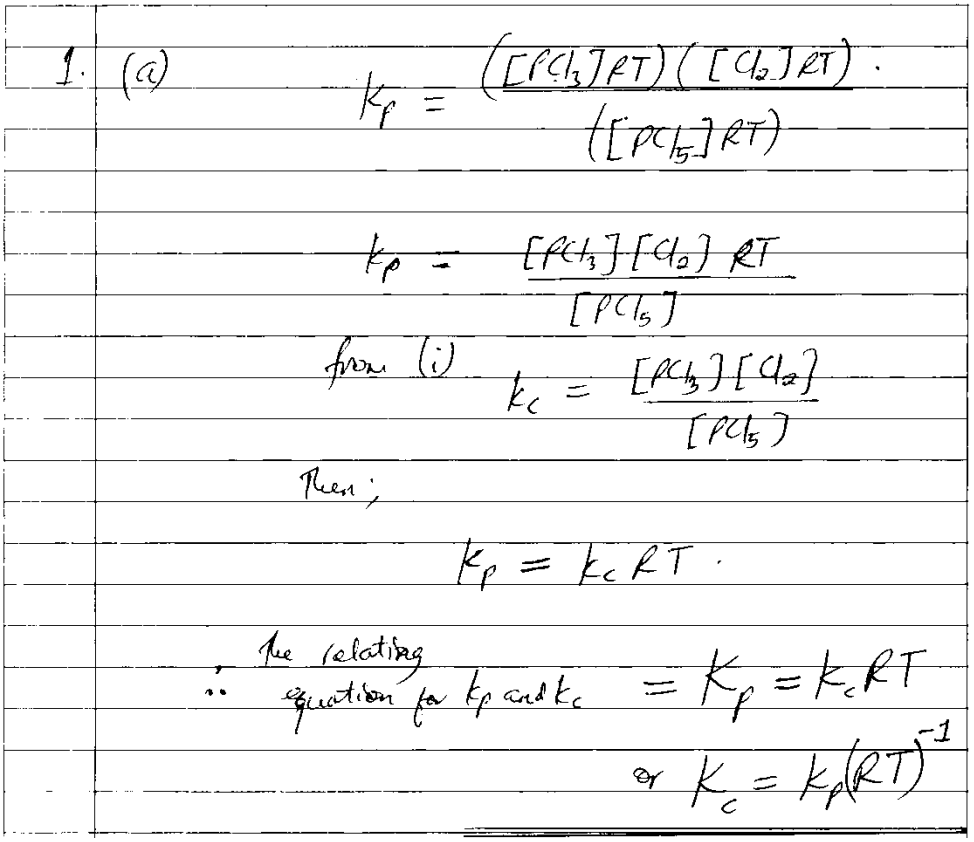
Relate partial pressures in terms of other variables from the Ideal gas equation.

$$PV = nRT$$

$$P = \left(\frac{n}{V}\right)RT \quad \text{where } \frac{n}{V} = [\ ], \text{ concentration}$$

$$P = [\ ]RT \quad \text{——(iii)}$$

Introduce (iii) to (ii)



In Extract 15.1 the candidate correctly showed all the necessary steps in the process of deriving the expression relating Kc and Kp.

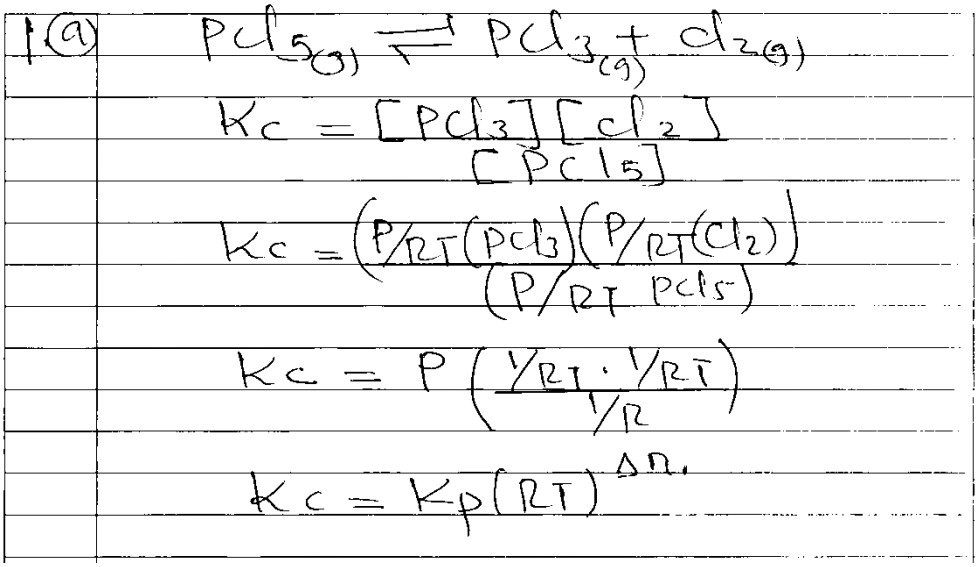
On the other hand, the candidates who scored average marks were able to do well in some parts of the question. For instance, instead of deriving the expression relating Kc and Kp, some of them used the general formula as $Kp = Kc(RT)^{\Delta n}$ which was a short cut, hence they scored low marks. This implies that these candidates lacked practice on deriving the expression. On responding to part (c), some of the candidates only listed the factors that affect the rate of chemical reaction without giving any explanation, while others managed to describe only a few factors, and therefore could not score high marks in this part.

The candidates who scored low marks, specifically, those who scored zero, faced difficulties in all parts of the question. For instance in part (b), the candidates failed to establish the required reaction equation from the reactions 1 and 2, therefore they failed to determine the value of K_3. These candidates lacked the basic mathematical skills which could have enabled them to manipulate the two reactions so as to come up with the required reaction. In the other cases it was noted that some of the candidates

incorrectly wrote Kp expression as Kp = $\frac{[P'_{PCl_3}][P'_{Cl_2}]}{[P'_{PCl_5}]}$. These candidates did not understand that partial pressures cannot be expressed in square brackets.

In part (c), some of the candidates failed to distinguish the factors affecting the rate of chemical reactions and those affecting the position of equilibrium, hence responded wrongly by writing the factors affecting the position of equilibrium. This is an indication that the candidates were unable to identify the requirement of the question. Extract 15.2 is one of weak responses to part 1(a) of the question.

Extract 15.2



Extract 15.2 shows part (a) of the candidate's response in which he/she wrongly expressed Kc as $\frac{[P_{PCl_3}][Cl_2]}{[P_{PCl_5}]}$, hence could not derive the required expression.

2.2.2 Question 2: Electrochemistry

This question consisted of five parts, namely; (a), (b), (c), (d) and (e). In part (a) the candidates were asked to define the following terms: Standard electrode potential, Redox reaction and Corrosion. Part (b) required the candidates to briefly explain how voltaic cells differ from electrolytic cells. Part (c) required them to write a balanced ionic equation and identify the oxidants and reductants in each of the following reactions:

(i) Iron(II) sulphate solution reacts with an acidified potassium dichromate solution.
(ii) Iodine and sodium thiosulphate solution react together.
(iii) Copper(II) sulphate solution and potassium iodide solution react together.

In part (d), the candidates were asked to give explanation on the function of moisture in the rusting process. Lastly in part (e), the candidates were provided with half reactions and their standard electrode potentials as follows:

$Au^{3+} + 3e^- \rightarrow Au$ $\quad E^o = 1.50$ v

$NO_3^- + 4H^+ + 3e^- \rightarrow NO + 2H_2O$ $\quad E^o = 0.96$ v

The candidates were then asked to use the provided half reactions to predict whether 1M HNO_3 will dissolve gold metal to form a 1 M Au^{3+} solution.

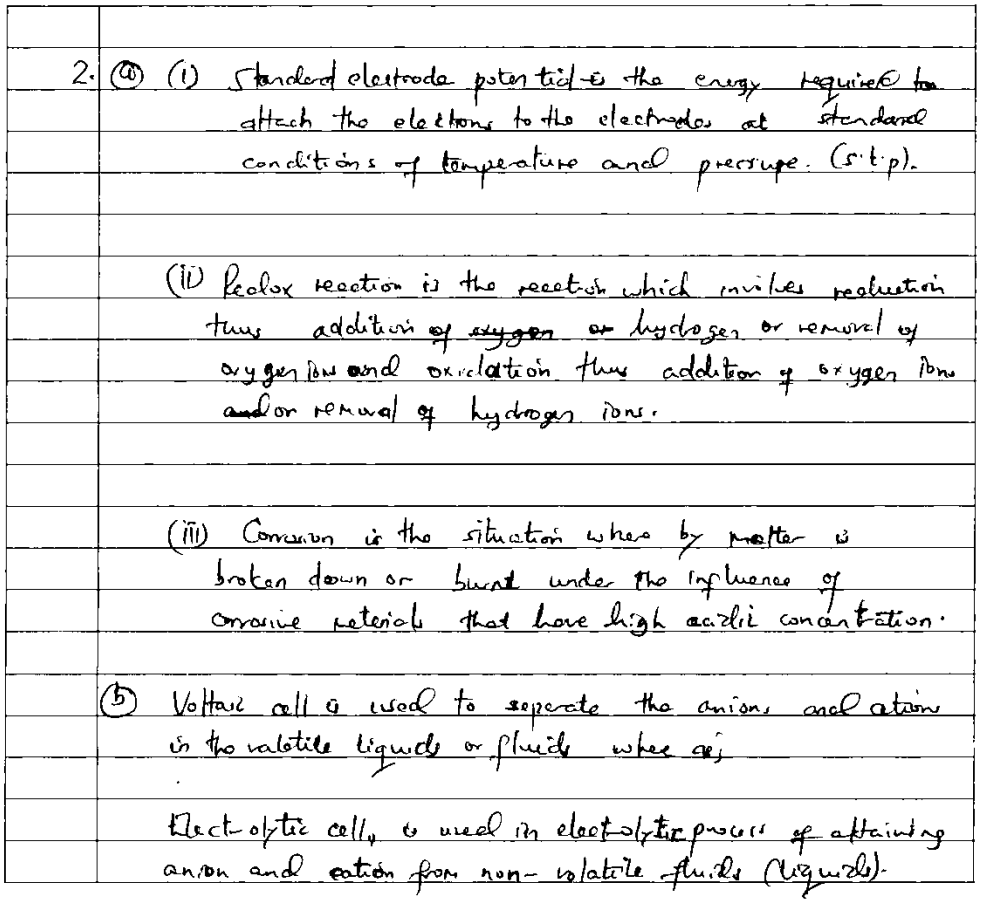
The data indicate that about two-thirds (66.0%) of the candidates who opted for the question scored from 00 to 6.0 marks, 24.0 percent scored 7 to 11 marks and 10.0 percent scored from 12 to 20 marks. These data reveal the general poor performance in this question.

The analysis of the candidates' responses shows that the candidates who performed poorly failed to give correct definitions of the terms in part (a), particularly in part (iii). Most of them defined rusting instead of corrosion. Moreover, they mixed up the concepts of voltaic cell and electrolytic cell, while differentiating the two cells in part (b). The analysis shows that, in part (c), the majority of the candidates failed to form and write the chemical formulae of the given compounds of the reacting species. As a result they were unable to write the correct ionic equations and could not identify the oxidants and reductants. For instance, in c (iii) they considered Cu_2I_2 as aqueous solution instead of a solid; hence some of them wrongly obtained the ionic equation as $2Cu^{2+}_{(aq)} + 2I^-_{(aq)} \rightarrow 2Cu^{+}_{(aq)} + I_2$ instead of $Cu^{2+}_{(aq)} + 4I_{(aq)} \rightarrow Cu_2I_{2(s)} + I_2$.

In order to correctly answer part (e), the candidates needed to have a thorough knowledge of application of electrode potentials on the feasibility of a redox reaction. It was noted that some of the candidates failed to combine the two equations with their respective electrode potentials to obtain a single equation and resultant e.m.f. Thus, they could not comment on the feasibility of 1M HNO_3 to dissolve gold metal to form 1 M Au^{3+}. This shows that the candidates had insufficient knowledge of merging the

concepts of redox reactions and electrochemistry. Extract 16.1 illustrates how the candidates failed to provide correct responses in question 2.

Extract 16.1


2. (a) (i) Standard electrode potential is the energy required to attach the electrons to the electrodes at standard conditions of temperature and pressure. (s.t.p).

(ii) Redox reaction is the reaction which involves reduction thus addition of ~~oxygen~~ or hydrogen or removal of oxygen ion and oxidation thus addition of oxygen ion and/or removal of hydrogen ions.

(iii) Corrosion is the situation where by matter is broken down or burnt under the influence of corrosive materials that have high acidic concentration.

(b) Voltaic cell is used to seperate the anions and cations in the volatile liquids or fluids where as;

Electrolytic cell, is used in electrolytic process of attaining anion and cation from non-volatile fluids (liquids).

In Extract 16.1, the candidate wrote incorrect definitions of the terms in part (a) and incorrect differences of voltaic cells and electrolytic cells in part (b).

However, the candidates who performed well in this question, particularly those who scored 20 marks, managed to define the given terms in part (a). They were also able to distinguish between voltaic cells and electrolytic cells in part (b). In part (c), the candidates wrote appropriate balanced ionic equations and identified the oxidants and reductants for each of the provided chemical reactions. Likewise, they provided adequate responses to parts (d) and (e). Extract 16.2 illustrates one candidate's appropriate answers.

Extract 16.2

2(a) Solution

i) Standard electrode potential → Is the potential different of the electrode measure relative to the standard hydrogen electrode at the Concentration of 1M, Pressure of 1atm and temperature of 25°c

2(a) ii) Redox reaction → Is the chemical reaction in which both oxidation and reduction reaction occurs simultaneously.

2(c) iii) Corrosion → Is the deterioration/decay of the metal surface due to the chemical reaction occurring on its surface.

2(b) Voltaic cells → These are the cells which use the chemical reaction of the chemical solution to generate the electric power example the daniel cell but;

Electrolytic Cells → These are the cell which use the electric power to allow the chemical reaction to take place.

2(e) i) Iron (II) sulphate and $K_2Cr_2O_7$

Half reactions

$$Fe^{2+} \longrightarrow Fe^{3+} + e^-$$

$$Cr_2O_7^{2-} \longrightarrow Cr^{3+}$$

2(c) ii) $Cr_2O_7^{2-} \longrightarrow 2Cr^{3+} + 7H_2O$

1 | $Cr_2O_7^{2-} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O$

6 | $Fe^{2+} \longrightarrow Fe^{3+} + e^-$

$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

$6Fe^{2+} \longrightarrow Fe^{3+} + 6e^-$

Overall reaction

$Cr_2O_7^{2-} + 6Fe^{2+} + 14H^+ \longrightarrow 2Cr^{3+} + 7H_2O + 6Fe^{3+}$

Oxidant from Potassium dichromate ($Cr_2O_7^{2-}$)

Reductant from Iron(ii) Sulphate (Fe^{2+})

2(c) ii) Iodine and Sodium thiosulphate

I_2 and $NA_2S_2O_3$

Half reaction

$I_2 + 2e^- \longrightarrow 2I^-$

$2S_2O_3^{2-} \longrightarrow S_4O_6^{2-}$

Overall reaction

$I_2 + 2S_2O_3^{2-} + 2e^- \longrightarrow 2I^- + S_4O_6^{2-}$

Oxidant . Iodine (I_2)

Reductant from sodium thiosulphate ($S_2O_3^{2-}$)

2(c) iii) Copper (II) Sulphate and Potassium Iodide

$CuSO_4$ (Cu^{2+}) and KI (I^-)

Half reaction

$2 \times Cu^{2+} + e^- \longrightarrow Cu^+$

$1 \times 2I^- \longrightarrow I_2 + 2e^-$

$2Cu^{2+} + 2e^- \longrightarrow 2Cu^+$

$2I^- \longrightarrow I_2 + 2e^-$

Overall reaction

$2Cu^{2+} + 2I^- \longrightarrow 2Cu^+ + I_2$

Oxidant; From Copper (II) sulphate (Cu^{2+} ion)

Reductant From Potassium iodide (I^- ion)

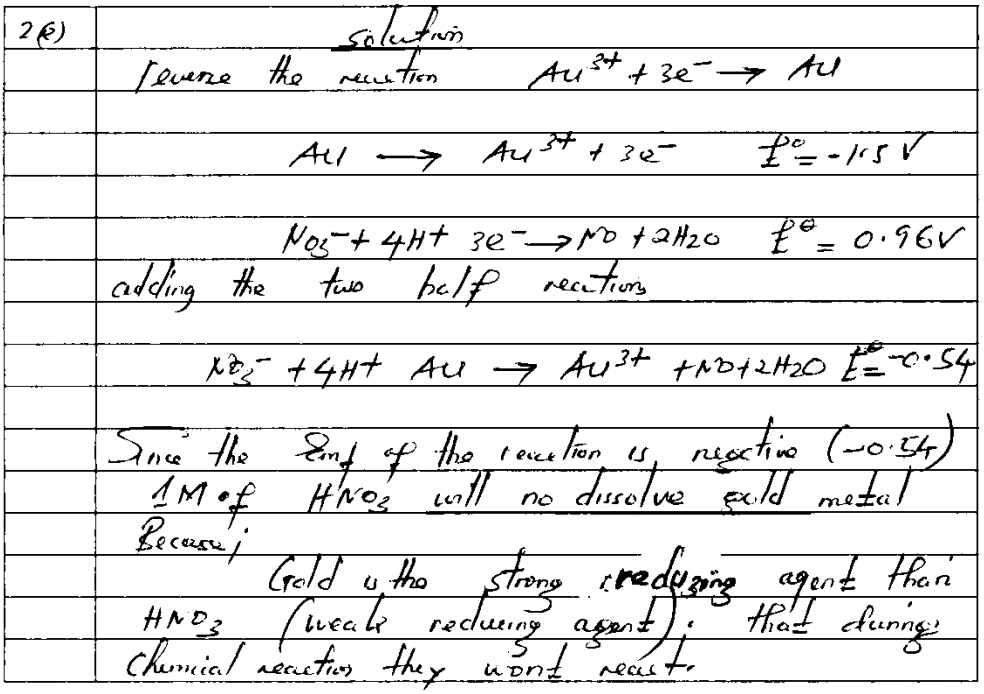
2(d) The Function of Manstire in the rusting process is to provide the water and oxygen which are the meyor components taking chemical reaction at the Cathode reaction during rusting Process

$2H_2O + O_2 + 4e^- \longrightarrow 4OH^-$

2(e) Cathod; selection

$Au^{3+} + 3e^- \rightarrow Au$ $E^\ominus = 1.5V$

$NO_3^- + 4H^- + 2e \rightarrow NO + H_2O$



In Extract 16.2, the candidate correctly responded to all the parts of the question. She/he gave correct definitions and formulated the required equations and then substituted the appropriate data, and finally obtain the required solution.

2.2.3 Question 3: Acids, Bases and Salts; Solubility, Solubility Product and Ionic Product

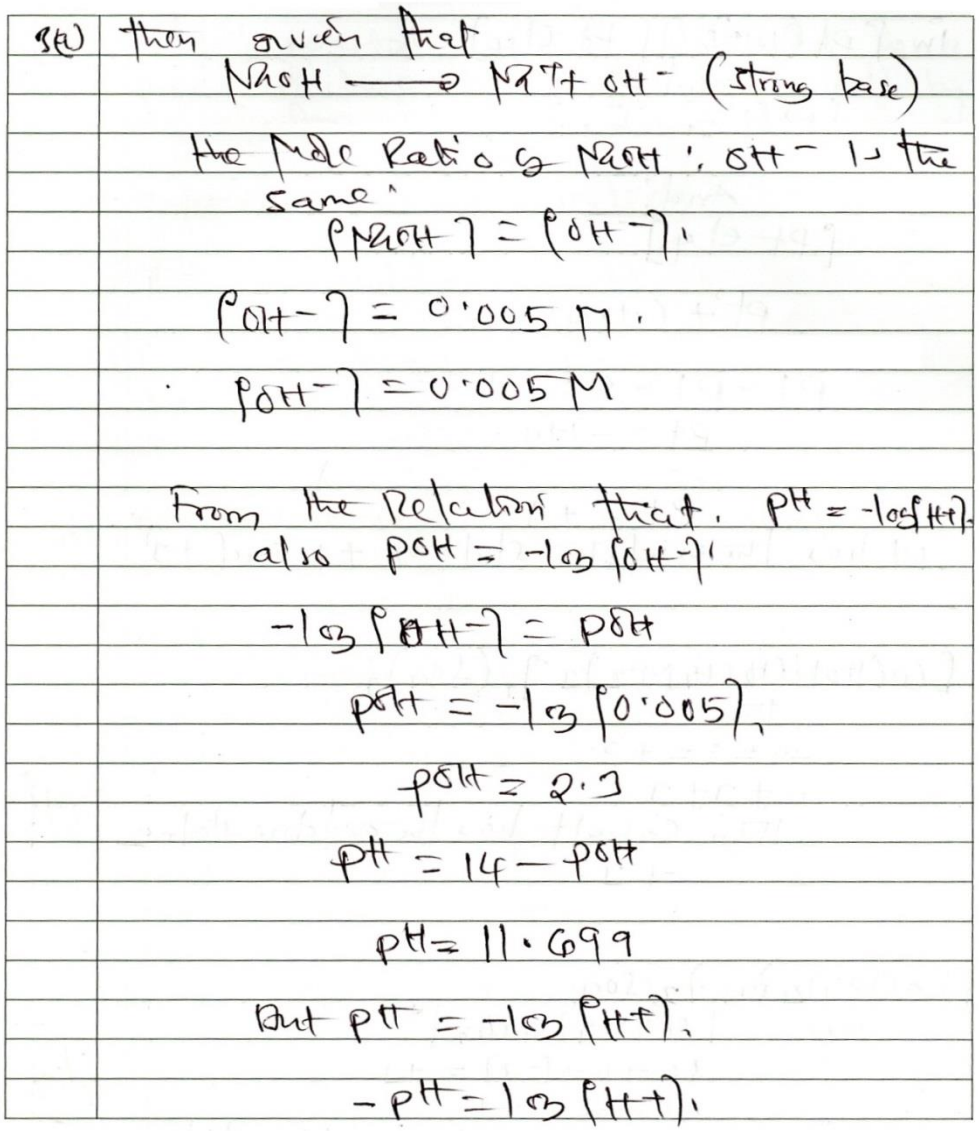
In part (a), the candidates were asked to calculate the values of $[H^+]$ and $[OH^-]$ in a 0.005 M solution of NaOH. In part (b), they were asked to calculate the ionization constant of a weak base, whose concentration was 0.1M and its pH was 10.6. Part (c) of the question, required the candidates to calculate the number of grams of sodium acetate (CH_3COONa) which were to be added to 500 cm^3 of 012 M acetic acid (CH_3COOH) to give a buffer solution of pH = 4.60 given that $k_a = 1.8 \times 10^{-5}$. In part (d), the candidates were given the solubility product of lead(II) chloride ($PbCl_2$) at 298 K as 1.6×10^{-5} Mol^3dm^{-9} and asked to calculate the solubility of lead chloride at 298 K. Lastly, in part (e) the candidates were asked to give the differences between solubility and solubility product, reaction quotient and equilibrium constant.

This question was the most opted for by the candidates and performance was good. The statistics show that 74.5 percent of the candidates answered the question, out of which 19.1 percent scored from 0.0 to 6.5 marks, 27.8

percent scored from 7.0 to 11.5 marks and the majority, 53.1 percent, scored from 12.0 to 20 marks.

The candidates who scored high marks applied appropriate formulae and used correct data, hence correctly calculated the values in part (a) through (d). They also gave the correct explanation to differentiate solubility from solubility product as well as reaction quotient from equilibrium constant. This is an indication that these candidates had acquired sufficient knowledge and skills on acids, bases, buffers and solubility. Extract 17.1 illustrates the responses from the script of a candidate who performed well in the question.

Extract 17.1



3a	~~[H+] = -pH~~ $[H^+] = \log^{-1}[-pH]$. $\log^{-1}[11.6997]$. then $[H^+] = 2 \times 10^{-12}$ M.
3b	Given the Molality of the weak base $= 0.1$ M. pH = 10.6 then the ionisation constant of the base From $pH = -\log[H^+]$. Also $pOH = -\log[OH^-]$. $pH + pOH = 14$. $pOH = 14 - pH$ $= 14 - 10.6$ $pOH = 3.4$. $-\log[OH^-] = 3.4$. $[OH^-] = \log^{-1}[-3.4]$.

3(b) then $[OH^-] = 3.98 \times 10^{-4} M$.

then From the Relation that

$$\frac{Kb[Base]}{[Base]} = \frac{[OH^-]^2}{[Base]}$$

$$Kb = \frac{[3.98 \times 10^{-4}]^2}{[0.1]}$$

$$Kb = 1.585 \times 10^{-6} mol/dm^3$$

then the value of the $Kb = 1.585 \times 10^{-6} mol/dm^3$

3e Data Given:

pH = 4.6

$K_a(C_6H_5COOH) = 1.8 \times 10^{-5}$

Molarity of the acid = 0.12 M

from the Relationship that

$$pH = pK_a + \log \frac{[Salt]}{[Acid]}$$

$$pH - pK_a = \log \frac{[Salt]}{[Acid]}$$

$$\frac{[Salt]}{[Acid]} = \log^{-1}(pH - pK_a)$$

$$[Salt] = [Acid] \times 10^{-1}[pH - pKa]$$

$$pKa = -\log Ka$$

$$= 4.745$$

$$[Salt] = 0.12 \times 10^{-1}[4.6 - 4.745]$$

$$[Salt] = 0.086\,M$$

e) then Molar concentration
$= 0.086\,M$

Mass Concentration = Molarity × Molar Mass

$= 0.086 \times 82$

$= 7.052\ g/dm^3$

then $7.052 \longrightarrow 1000$
$X \longrightarrow 500$

$$= \frac{500 \times 7.052}{1000 \times 2}$$

$= 3.526\,g$

then the Mass Required
$= 3.526\,g$

3(d) Data Solubility product $= 1.6 \times 10^{-5}\ mol^3 dm^{-9}$
then To Calculate the solubility of
$PbCl_2$ at 298K

3q

then $PbCl_2 \rightleftharpoons Pb^{2+} + 2Cl^-$

$$K_{sp} = [Pb^{2+}][Cl^-]^2 \quad \text{---(1)}$$

$$K_{sp} = [Pb^{2+}][Cl^-]^2$$

let that the solubility of lead is equal to x.

$$K_{sp} = [x][2x]^2$$

$$K_{sp} = 4x^3$$

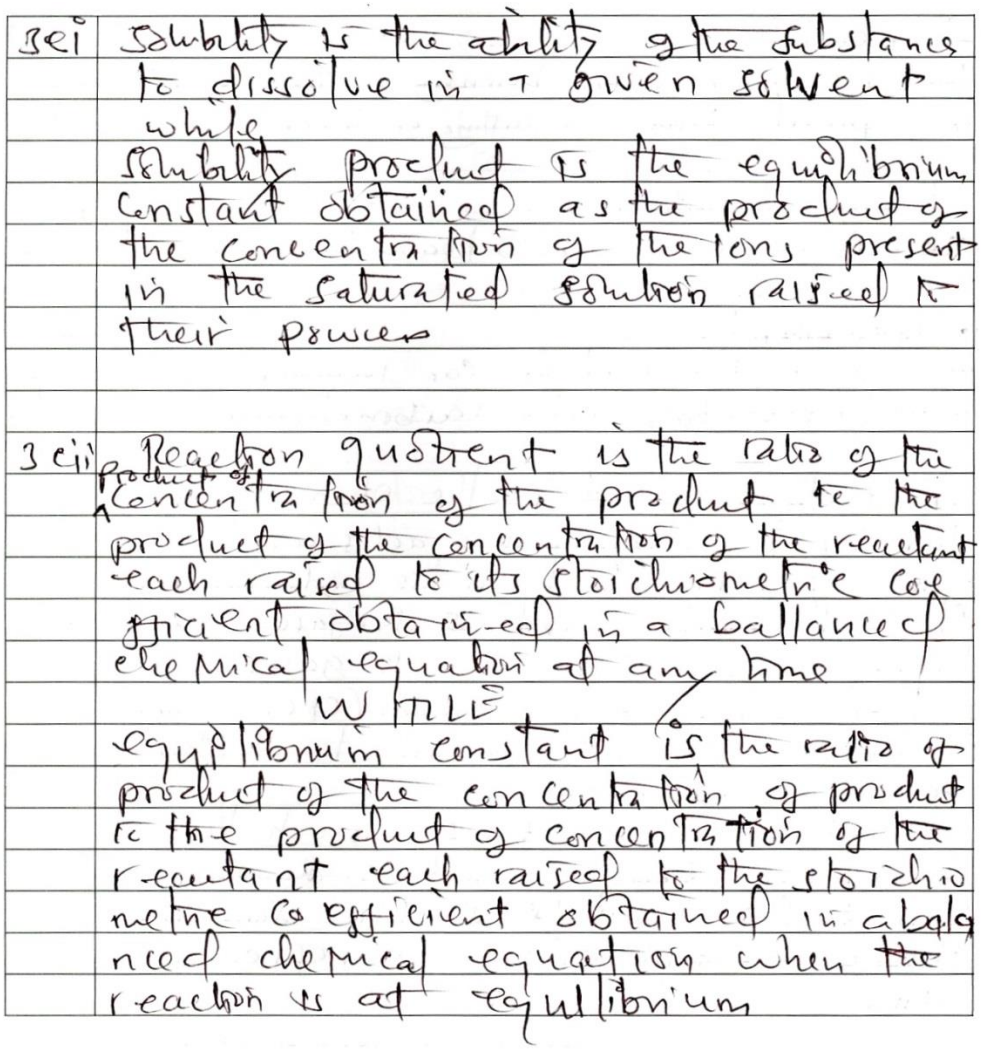
$$\frac{K_{sp}}{4} = x^3$$

$$x = \sqrt[3]{\frac{K_{sp}}{4}}$$

$$= \sqrt[3]{\frac{1.6 \times 10^{-5}}{4}}$$

$$x = 0.016\ M$$

solubility of $Pb(II)$ $PbCl_2 = 0.016\ M$



In extract 17.1, the candidate used correct formulae and data to all calculation parts of the question. He/she appropriately manipulated the data and eventually obtained the required solution. Finally, the candidate correctly differentiated the terms asked in part 3(e).

On the other hand, some of the candidates who scored low marks failed to apply appropriate formulae in the calculations, hence failed to obtain the required answers. The analysis indicates that other candidates were able to remember some of the formulae but failed to work on the given data. This shows that the candidates lacked the basic principles of calculations in buffer concept, solubility and solubility product.

The analysis further shows that some of the candidates mixed up the terms reaction quotient and equilibrium constant; and solubility and solubility product, while some could not clearly differentiate the terms. For example, one candidate wrote the following as the difference between solubility and

solubility product: *solubility is the reaction between salt and water to produce or form acid and base while solubility product is the product of concentration of water and salt concentration to form concentration of acid and that of base*. Such responses show that the candidates lacked sufficient knowledge on the terms. Extract 17.2 illustrates poor responses given by one of the candidates.

Extract 17.2

3. (a)

Given that

Concentration (C) = 0.005 M.

from

$\alpha K_a = \sqrt{K_a / C}$

$[H^+] = \alpha [OH^-]$

$NaOH = 40$

$40/0 \quad H = M_r / C$

$[H^+] = \frac{40}{0.005}$

$[H^+] = 8 \times 10^3$

$[8 \times 10^3] = \alpha [3 \times 10^2]$

$\alpha = \frac{[8 \times 10^3]}{3 \times 10^2}$

$\alpha = 2.6 \times 10^7$

3. (b)

Given that.

Concentration (c) = 0.1M

pH = 10.6

Then

$pH = -\log k_a$

$pH = -\log c$

$10.6 = -\log$

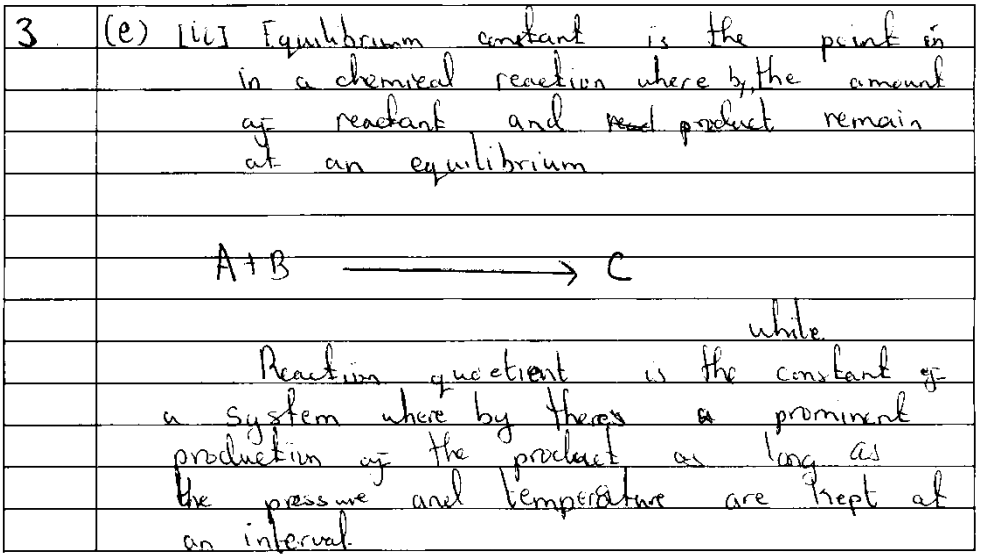
$= 80.6$

∴ The ionization energy of the base is 80.6

(c) (i) Solubility is the ability of a substance to dissolve something else either partially or completely wh

white.

Solubility product is the ∫ solution in a system which contains the solute together with the solvent



It is obvious that the answers of the candidate illustrated by Extract 17.2 indicate lack of knowledge of the asked terms. The candidate applied incorrect formulae in parts (a) and (b). Similarly, the differences given in part (e) are not correct. The candidate skipped parts (c) and (d).

2.2.4 Question 4: Transition Elements

In part (a) the candidates were asked to write the chemical formulae for the compounds potassium hexacyanocobaltate (III) and potassium hexacyanoferrate (II). In part (b), the candidates were instructed to observe the complex ion $[Co(NH_3)_3(H_2O)_2Cl]^+$, then they were asked to identify the ligands and the charge on each ligand as well as to write the geometry of the complex ion. Part (c) required the candidates to give a brief explanation on why bivalent titanium ion $[Ti^{2+}]$ is paramagnetic. In part (d) the candidates were required to give the IUPAC names of the following compounds:

(i) $Cu_2[Fe(CN)_6]^{2-}$
(ii) $[Cu(NH_3)_4SO_4]$
(iii) $Ag(NH_3)_2Cl$
(iv) $[Ni(NH_3)_6]Cl_2$
(iv) $[Cr(en)_2Cl_2]^+NO_3^-$.

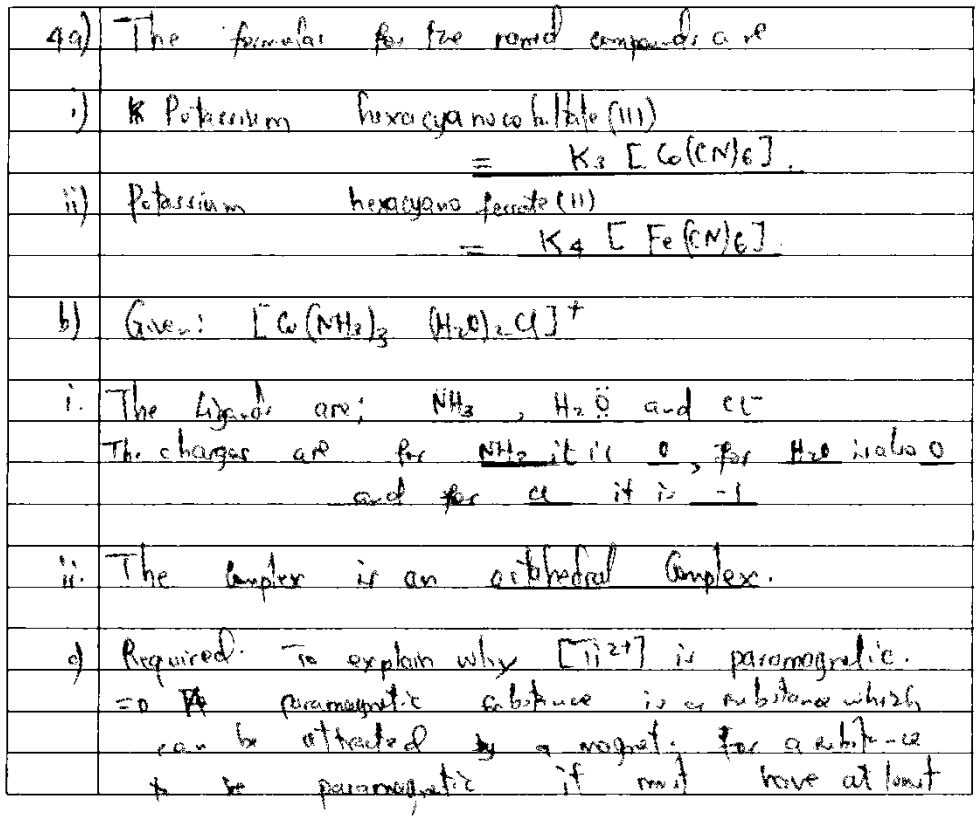
Part (e) enquired the candidates to determine the oxidation state of the central metal ion or atom in the following compounds:

(i) $KMnO_4$
(ii) $[Pt(NH_3)_4][PtCl_4]$
(iii) $[Co(H_2NCH_2CH_2NH_2)_3]_2(SO_4)_3$
(v) $[Co(NH_3)_4Br_2]_2SO_4$.

This question was chosen by many candidates (68.6%) and the performance was good. Statistics show that about one-third (32.9%) of the candidates scored from 0.0 to 6.5 marks, 39.1 percent scored from 7.0 to 11.5 marks and 28.0 percent scored from 12 to 20 marks.

The majority of the candidates who performed well (28.0%) managed to write the correct formula for the given complex compounds, identify the ligands and their respective charges and write the geometry of the complex ions. They also managed to give an explanation as to why $[Ti^{2+}]$ is paramagnetic. Similarly, they gave correct IUPAC names for the given compounds and finally, correctly calculated the oxidation state of the central metal ion for the given compounds in part (e) of the question. Extract18.1 is an example of the good response given by one of the candidates.

Extract 18.1



c) One unpaired electron in one of it's orbitals. Ti^{2+} is paramagnetic as it has two unpaired electrons in its d orbital as evidenced by its electronic configuration given below.

$[Ti^{2+}] = [Ar]\,3d^2$

The electrons in d orbital are unpaired as shown in the orbital diagram below;

1	1				

- The two unpaired electrons make Ti^{2+} paramagnetic.

d) The IUPAC names for the given compounds are as follows;

i) Copper (II) hexacyanoferrate (II).

ii) Tetraammine sulphato copper (II).

iii) ~~Diammine silver~~ Diamminesilver (I) chloride.

iv) Hexaammine nickel (II) chloride.

v) Dichloro bis (ethylenediamine) chromium (III) nitrate.

e) Oxidation state.

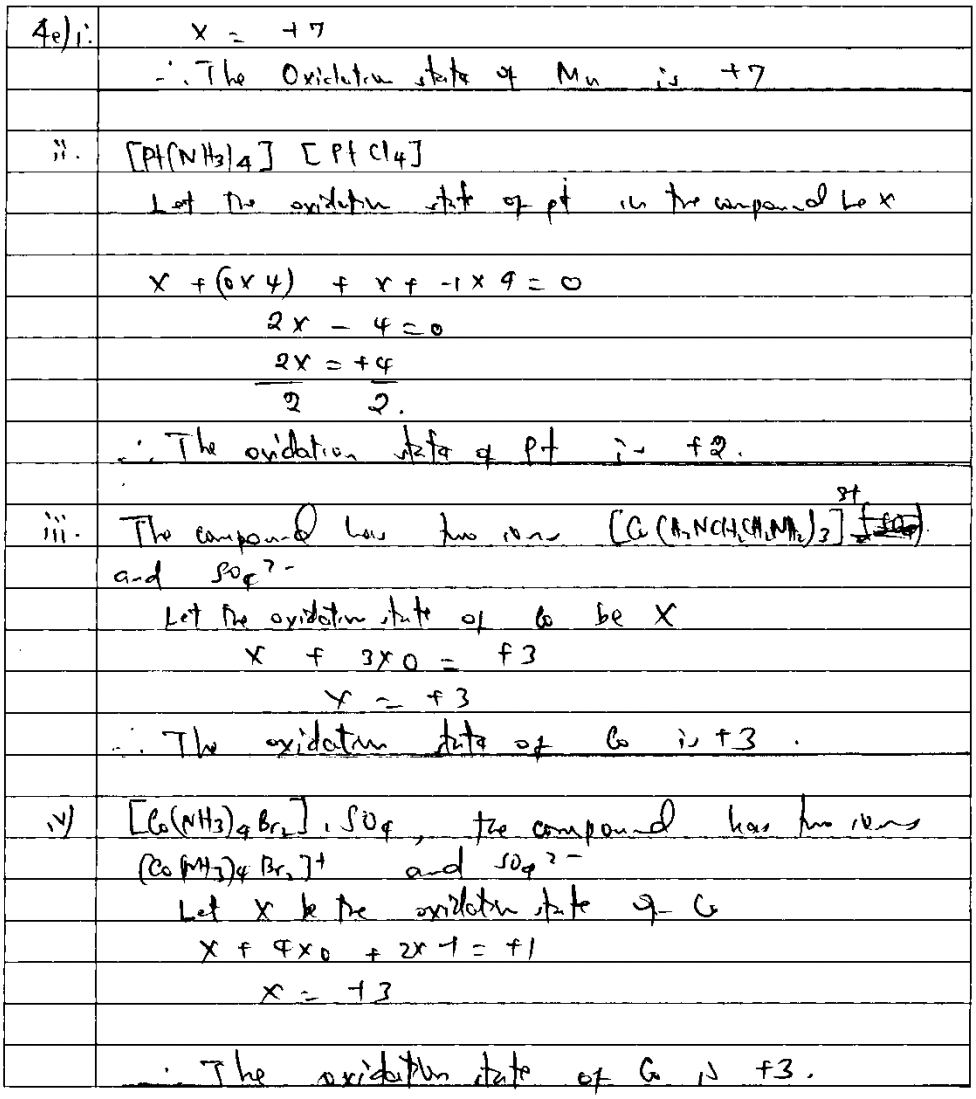
∴ $KMnO_4$

The compound has two ions K^+ and MnO_4^-

The oxidation state of K^+ is +1

For Mn in MnO_4^- can be found as per

$x + (4x - 2) = -1$



In Extract 18.1, the candidate wrote correct chemical formulae of the asked compounds, identified the ligands and their charges, correctly explained why [Ti^{2+}] is paramagnetic, gave correct IUPAC names of compounds and finally computed the correct oxidation states of the central metal ion as required.

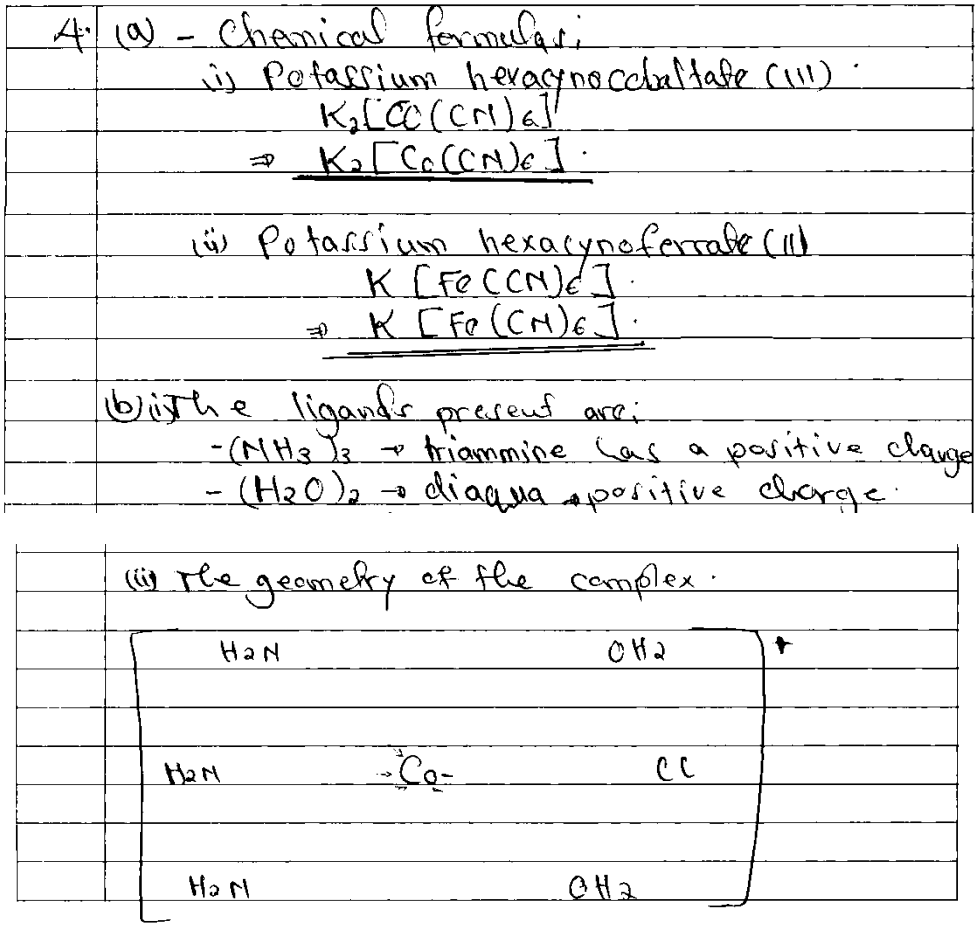
The candidates who scored low marks had insufficient knowledge on the concept of complex compounds. The analysis shows that some of the candidates failed to apply the rules for naming complex ions, hence were unable to write the correct formula for potassium hexacyanocobaltate (III) and potassium hexacyanoferrate (II). In naming the given compounds using IUPAC system, it was observed that some of the candidates could not differentiated names for ligands and groups (radicals) in or out of

coordination sphere. For instances, one of the candidates on naming item (d) (v), named NO_3^- outside the coordination sphere as "nitrato" instead of nitrate. Other candidates on naming (d) (iv), named Cl outside the coordination sphere as "Chloro", instead of chloride. Also other candidates, on naming (d) (ii) named SO_4^{2-} which was inside the coordination sphere as "sulphate" instead of sulphato. This implies that they lacked practice on naming complex compounds as per IUPAC system of naming.

The analysis further shows that some of the candidates could not differentiate central metal ion/atom from ligands hence failed to compute the oxidation state of the central metal ion/atom, while some neglected the + sign after calculation hence got a wrong answer. This indicates that they lacked sufficient knowledge on the concepts of complexes ions and calculation of oxidation state.

Extract 18.2 is a response of a candidate who performed poorly.

Extract 18.2



4. (d) IUPAC names:

(i) $Cu_2[Fe(CN)_6]^{2-}$

Cuprate hexacynoferrate(IV)

(ii) $[Cu(NH_3)_4SO_4]$

Tetraammine sulphotate Copper (I)

(iii) $Ag(NH_3)_2Cl$

Chlorodiammine silver(I)

(iv) $[Ni(NH_3)_6]Cl_2$

hexaammine nickel (VI)

(v) $[Cr(en)_2Cl_2]^+ NO_3^-$

(e) Finding the oxidation state of the central atom:

$KMnO_4$

$K + (-1 \times 1) + (-2 \times 4) = 0$

$K = 0 + (9)$

$K = +9$

4e (ii) $Pt(NH_3)_4][PtCl_4]$

$Pt(NH_3)_4 = 0 + 1$

$[Pt(NH_3)_4]^+$

$Pt + (-4 \times 4) + (1 \times 4) = 1$

$Pt = 1 + 16 - 4$

$Pt = 17 - 4$

$Pt = +13$

(iii) $[Co[H_2NCH_2CH_2NH_2]_3]_2(SO_4)_3$

$Co[H_2NCH_2CH_2NH_2]_3 = 3$

$Co + 6 + (\cdot \times 3) + (4 \times 3)(1 \times 3)(\cdot 4 \times 3)(1 \times 3) + (8 \times 3)$

+

In Extract 18.2, the candidate systematically attempted all the items of the question except item (c), but failed to give correct answers to all parts.

2.2.5 Question 5: Periodic Classification

The question was:

Study a portion of periodic table indicated below then answer questions in part (a) and (b).

s – Block p-block

GROUP	I	II										III	IV	V	VI	VII	VIII
Period 1	**M**																
Period 2			← d - block →														
Period 3	**G**														**J**		
Period 4	**H**																

(a) (i) Identify with reason the block in which elements A, C, D and E are to be found if their electronic configurations are as follows:
A:$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^1$
C:$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$
D:$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^5$
E:$1s^2 2s^2 2p^6 2s^2 2p^6 4s^2 3d^{10} 4p^6 5s^2$.

(ii) Write the molecular formula of a compound formed when D combines with E.

(b) (i) Justify that, the first ionization energy of J is larger than that of G although both are found in the same period.

(ii) Account for the increase of metallic nature from M to H.

(c) Briefly explain each of the following trends:

(i) Some members in the periodic table are said to be diagonally related.

(ii) Fluorine is more reactive than other members of the halogen group.

(d) Describe how hydrides of the elements in period 3 react with water.

The question was chosen by the majority (79.4%) of the candidates. The scoring of the candidates in the question was as follows: 37.6 percent scored from 0.0 to 6.5 marks, 42.2 percent scored from 7.0 to 11.5 marks and 20.2 percent scored from 12.0 to 20 marks. These data suggest good performance in this question.

The candidates who performed well were conversant with the knowledge on periodicity, periodic trends in physical and chemical properties and diagonal relationship, hence managed to perform most items of the question well. Extract 19.1 illustrates this case.

Extract 19.1

5 (a)	
(i)	A : S - block.
	reason :- valence electrons enter the s-orbital (5s¹).
	- it can't be d-block since it doesn't have $ns^{1-2}(n-1)d^{1-10}$ structure
(ii)	C : d - block.
	reason: - Its valence electronic configuration is $4s^2 3d^8$
	which corresponds to general formula $ns^{1-2}(n-1)d^{1-10}$
	of d-block elements
	- its d-orbital is partially filled unlike the rest.
(iii)	D : p - block.
	reason: - valence electrons enter the p-block with all
	other lower orbitals filled.
(iv)	E : S - block.
	reason - valence electrons are in its 5s orbital
	- other lower orbitals are all filled.
	- it can't be transition d-block since it doesn't
	have $ns^{1-2}(n-1)d^{1-10}$ configuration.

5 (a)	
(ii.)	D ion most probable ion : D^{-1}
	E most probable ion : E^{2+}.
	Now: $2D^{-1} + E^{2+} \longrightarrow ED_2$.
	∴ Molecular formula : ED_2
5 (b)	
(i.)	J is has got more protons than G, with the two having the same number of shells. As a result, J has got a higher ~~and~~ electronegativity than G. Due to higher electro-negativity, J has got higher ability to hold on to its valence electrons hence higher ionization energy is needed to remove valence electrons from J than from G.
(ii.)	from M to H, number of shells increases. Increase in number of shells ~~decrease~~ increases screening ~~effective~~ effect which reduces ability of nucleus to hold on to its ~~charges~~ valence electrons. As a result, from M to H, there is an increased tendency to loose electrons which accounts for ~~high metallic~~ increase in metallic nature from M to H.
5 (c)	
(i)	The first member of a group has got similar properties with second member of next group in terms of its ~~their~~ chemistry and physical properties. This is due to similar ionization energy, similar atomic and ionic radius and similar electronegativity. Eg. Li and Mg, Be and Al have diagonal relationship.

5 (c)

(ii) Aff of all the halogens, flourine is the smallest making it have a high charge density and highest electronegativity.

5 (d) Being the most electronegative halogen, it has the highest ability to oxidize other molecules. Hence, flourine is the most reactive halogen.

Hydrides of period 3 are as follows.

- NaH, MgH_2, AlH_3, SiH_4, & PH_3, H_2S, HCl.

- Argon being noble gas doesn't form hydride.

→ NaH, MgH_2 react with water to form basic solution.

$NaH + H_2O \longrightarrow NaOH + H_2$

$MgH_2 + H_2O \longrightarrow Mg(OH)_2 + H_2$

→ Aluminium hydride forms amphoteric hydroxide

$AlH_3 + H_2O \longrightarrow Al(OH)_3 + H_2$

→ SiH_4 and PH_3 being highly covalent show no reaction with water.

$SiH_4 + H_2O \longrightarrow$ no reaction

$PH_3 + H_2O \longrightarrow$ no rxn.

5 (d) → H_2S and HCl dissociate in water to form acidic solution.

$H_2S + H_2O \rightleftharpoons H_3O^+ + HS^-$: weak acid.

* $HCl + H_2O \longrightarrow H_3O^+ + Cl^-$: strong acid

In Extract 19.1, the candidate was able to answer all parts of the question.

However, the analysis of the responses from the candidates who scored low marks reveals insufficient knowledge of the concepts tested. For instance, in part (a) the candidates failed to recognize that, the last valence orbital filled

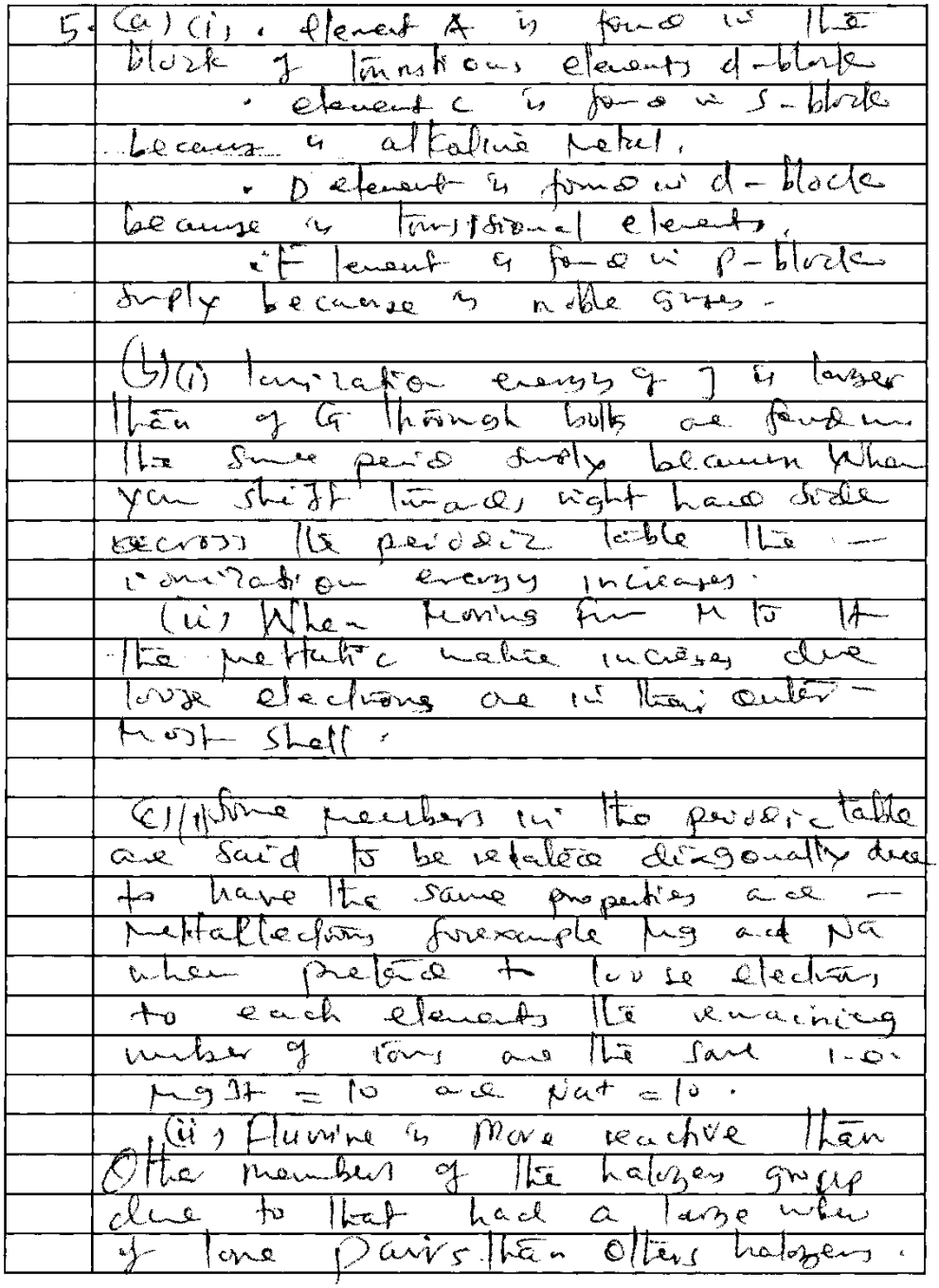
of the provided electronic configurations represented the block in which the elements A, C, D and E are found. It was revealed that most of the candidates' responses in this part resulted from guess work.

In writing the molecular formula of the compound formed when D combines with E, some of the candidates mistakenly used the actual chemical symbols of the elements while others failed to identify the valency of D and E, thus wrote a wrong chemical formula. Moreover, they failed to explain diagonal relationship between members in the periodic table and that fluorine is more reactive than other members of the halogen group. It was revealed that, on the part of diagonal relationship, some of the candidates were defining the term instead of explaining and relating between the members prescribed.

The analysis also indicates that some of the candidates were not able to give proper description of the reaction of the hydrides of the elements in period 3 with water while others failed to properly write their chemical formula, hence failed to write the chemical reaction. It was also noted that some of the candidates wrongly comprehended the term hydrides as hydroxides, as one of them listed Mg(OH), NaOH, Si(OH), Ar(OH), P(OH), Al(OH) as hydrides. The candidate further wrote the chemical equation between Mg(OH) and water as $Mg\ (OH)_{(aq)} + H_2O_{(l)} \rightarrow MgO\ _{(aq)} + H_2O_{(l)}$ and that of NaOH as $NaOH + H_2O_{(l)} \rightarrow NaO_{(aq)} + H_2O_{(l)}$. The typical responses reveal that the candidates lacked skills for reading and understanding the question; also lacked knowledge of hydrides and hydroxides; chemical formulae and chemical equations.

Extract 19.2 represents one of the responses given by one of the candidates who performed poorly in this question.

Extract 19.2



In Extract 19.2, the reasons given by the candidate in attempting part (a) signify that the candidate did not understand what validates the placement of an element in a certain block in the periodic table. The same applies to part (b), he/she could not point out why ionization energy increases from left to right and metallic character increases down the group of periodic table.

2.2.6 Question 6: Selected Compounds of Metals

This question consisted of three parts, namely; (a), (b) and (c). In part (a) the candidates were required to briefly explain and support with equations where applicable, the following observations:

(i) Anhydrous magnesium chloride cannot be prepared by heating the hydrated crystals of $MgCl_2.6H_2O$.

(ii) Most metal carbonates are prepared by precipitation method but aluminium carbonate has never been prepared by this method.

(iii) Aqueous aluminium nitrate turns blue litmus red.

(iv) Zinc oxide is amphoteric.

(v) Lead (II) chloride is soluble in concentrated hydrochloric acid.

(vi) Addition of ammonia solution to aqueous copper(II) sulphate gives pale blue precipitates initially and deep blue solution when more ammonia is used.

In part (b), the candidates were required to write the chemical formulae of three oxides of lead and give their uses. Finally, in part (c) they were asked to give two importance and two hazards of lead in life.

This question was the least chosen and most poorly performed by the candidates. It is only10.5 percent of the candidates who selected it and very few (6.5%) passed, i.e. scored from 7 to 18 marks. No candidate who scored all (20) marks allocated to the question. The graphic presentation of these data is shown in Figure 11.

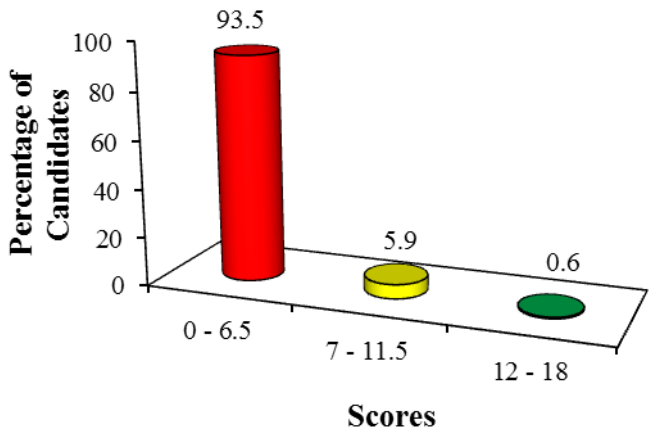


Figure 11: Performance of the candidates in question 6.

As indicated in the Figure 11, very few (0.6%) candidates performed well, ie scored from 12 to 18 marks. The analysis shows that the question was the least opted and most poorly performed by the candidates because of the following reasons:

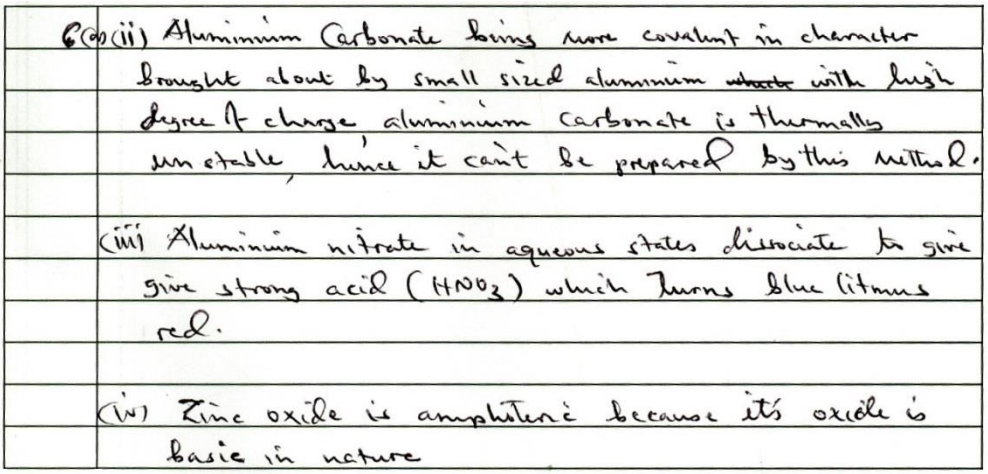
(i) Inadequate learning of the topic. This is associated by the few candidates who opted for the question. It was noted that the concepts tested were not popular in the examinations for the past few years; therefore, students might have given it little attention during learning.

(ii) Lack of practice: For the candidates to grasp the concepts in part (a) which was based on properties and preparation methods of selected metal compounds, learning should be practical. Unfortunately, it appears as if the teaching of these concepts was theoretical to both high performing and low performing schools. As a result, the candidates failed to clearly understand the metal compounds in the question.

(iii) Lack of exercises: The analysis of the candidates' responses reveals insufficient explanation and incorrect writing of the equations to support the explanation. This was also observed in writing chemical formulae of the three oxides of lead.

Extract 20.1 is a poor response from one of the candidates.

Extract 20.1


6(a)(ii) Aluminium Carbonate being more covalent in character brought about by small sized aluminium ~~atom~~ with high degree of charge, aluminium carbonate is thermally unstable, hence it can't be prepared by this method.

(iii) Aluminium nitrate in aqueous states dissociate to give give strong acid (HNO_3) which turns blue litmus red.

(iv) Zinc oxide is amphoteric because its oxide is basic in nature

Extract 20.1 is a response of a candidate to part (a). The explanation given does not show whether the candidate had ever come across the terms. In addition, he/she did not write any equation to support the explanation.

On the other hand, the analysis indicates that, a few candidates who scored high marks in this question managed either to explain some of the stated observations and support with or without equation. They correctly wrote the chemical formulae of three oxides of lead and gave their uses. Finally, they gave the importance and hazards of lead in life as the question required.

Extract 20.2 is a sample answer from one of the candidates who scored high marks.

Extract 20.1

6. (a)(i) This is because the hydrated crystals of $MgCl_2 \cdot 6H_2O$ ~~undergo~~ undergo hydrolysis leading to the formation of basic hydroxide of magnesium

$$MgCl_2 \cdot 6H_2O_{(s)} \longrightarrow Mg(OH)Cl_{(aq)} + HCl_{(aq)} + H_2O_{(l)}$$

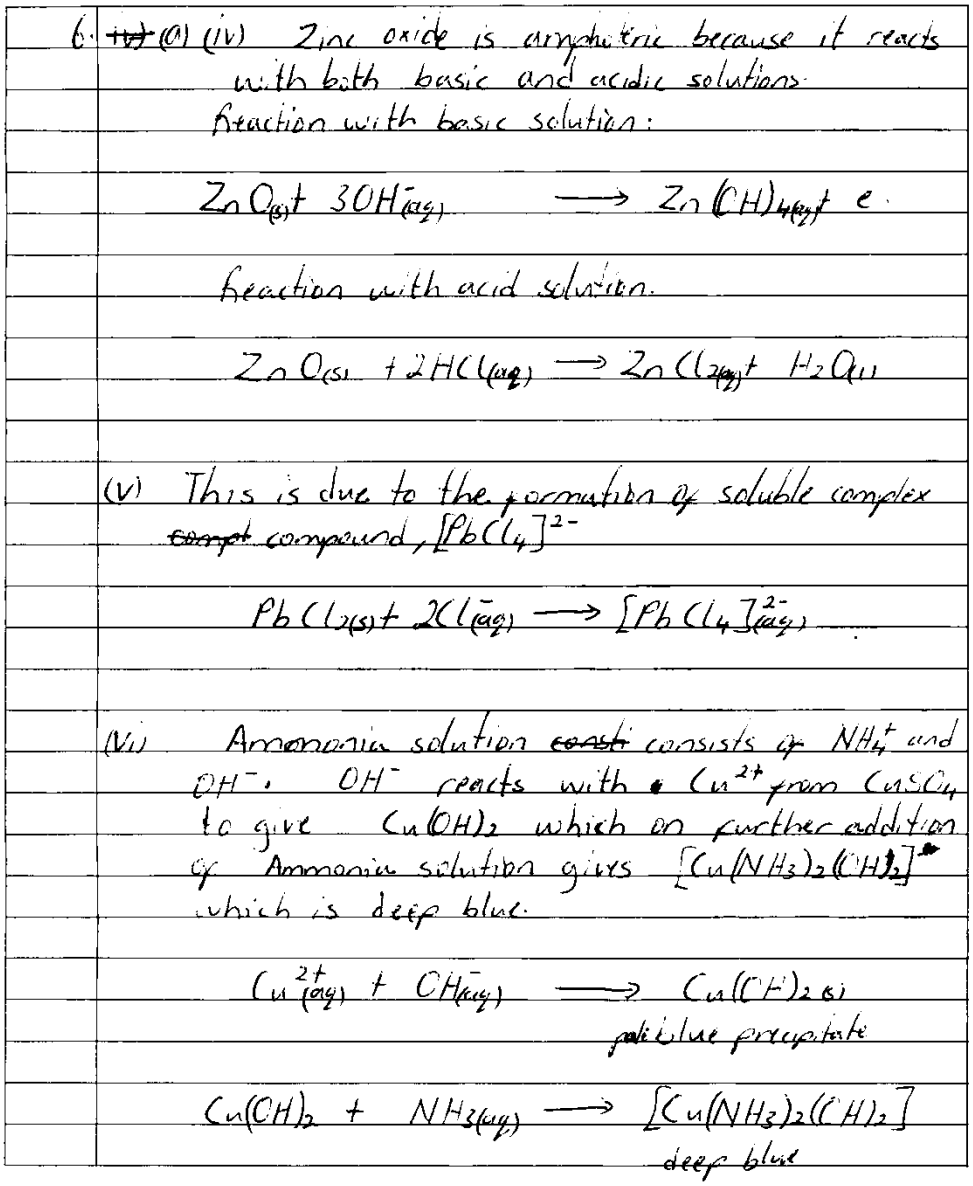
(ii) This is due to the high polarising power of Al^{3+} due to its small size and high charge, hence polarises more the CO_3^{2-}. Thus Aluminium carbonate has never been prepared by precipitation method.

(iii) This is due to the high hydration energy of Al^{3+} in water, leading to the production of H_3O^+ ions that make solution acidic hence turn blue litmus red.

$$Al(NO_3)_{3(s)} \longrightarrow Al^{3+}_{(aq)} + NO_3^-{}_{(aq)}$$

$$Al^{3+}_{(aq)} + H_2O_{(l)} \longrightarrow [Al(H_2O)_6]^{3+}$$

$$[Al(H_2O)_6]^{3+} + H_2O \longrightarrow [Al(H_2O)_5OH]^{2+} + H_3O^+$$



Extract 20.2 shows part (a) of the candidate's response whereby he/she managed to give the correct explanation and chemical formula for most items except item (ii) and one equation of item (iv).

2.2.7 Question 7: Extraction of Metals

The question was:

(a) Briefly explain the following:
   (i) Metals do not occur as nitrate in nature.
   (ii) Activity series of metals.

(iii) A metal A is found in free state in nature, while metal B is found in the form of its compound. Which of the two metals will be nearer to the top of the activity series of metals?

(iv) Aluminium cannot be extracted by reducing alumina with carbon.

(v) Limestone is added to the blast furnace in the extraction of iron from hematite. Support with equation.

(b) Describe the methods that are applied in extracting metals which are:

(i) very reactive

(ii) less reactive.

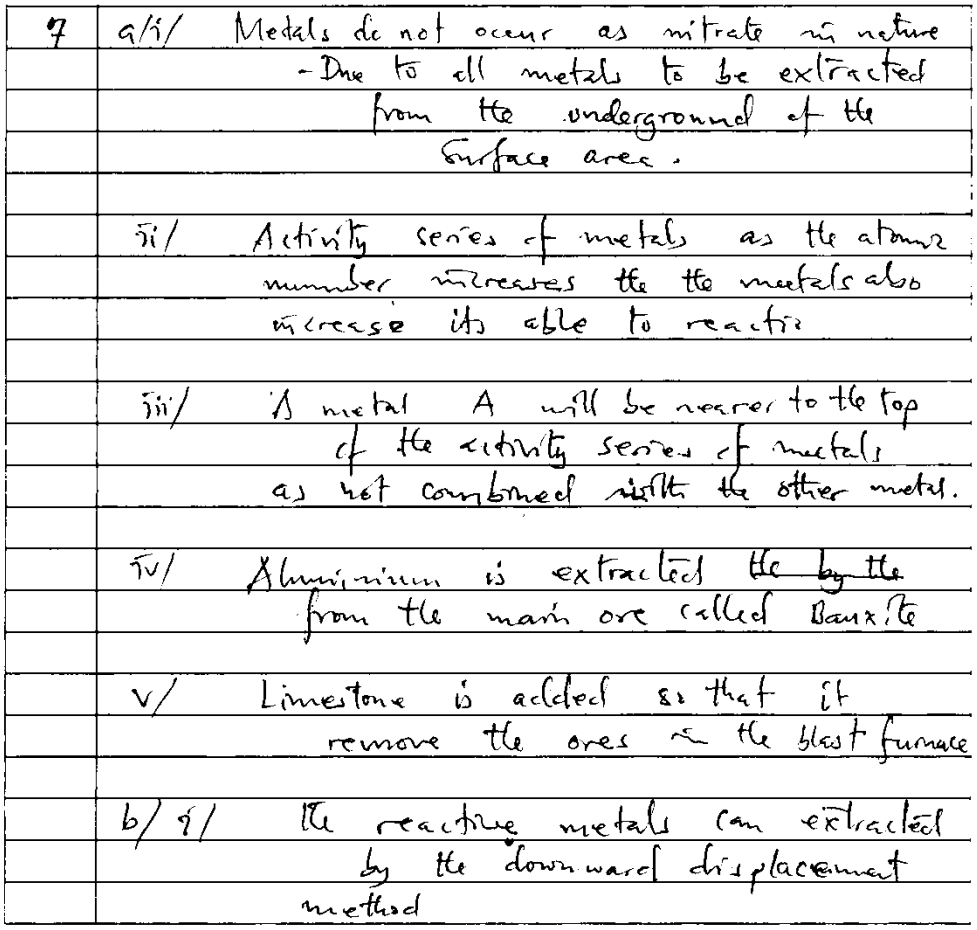
The question was the second least opted for by the candidates and the performance was poor. The statistics show that only 11.9 percent of the candidates chose this question. The majority (67.2%) of the candidates scored from 0.0 to 6.5 marks, 25.2 percent scored from 7.0 to 11.5 marks and a few (7.6%) scored from 12.0 to 18.0 marks.

Most of the candidates lacked sufficient knowledge of the concepts of extraction of metals including; occurrence of metal ores, reactivity series of metals and the function of limestone in the extraction of iron, hence they failed to provide correct responses to most of the items.

It was also noted that some of the candidates did not understand the requirement of the question, for example in part (a) (v), instead of explaining and writing the supportive equation, some of the candidates drew the blast furnace and showed the addition of $CaCO_3$ into the furnace. Similarly, instead of explaining the methods for extraction of very reactive and less reactive metals, they explained the steps for extraction of metals. In the same case, some of the candidates mixed up very reactive and less reactive metals, hence described wrong methods of extraction of such metals.

Extract 21.1 illustrates one of the poor answers.

Extract 21.1



In Extract 21.1, the candidate wrongly responded to all the items in part (a) of the question and also failed to describe the methods applied in the extraction of very reactive and less reactive metals in part (b).

However, the candidates who scored reasonably high marks, managed to give a correct explanation of most of the items in part (a), except item (v). In item (v) the candidates failed to apply the knowledge acquired at the Ordinary Level, particularly, the reactions taking place in the blast furnace in the extraction of iron, therefore they did not score good marks in this item. In the case of the methods applied in extracting metals which are very reactive and less reactive, most of the candidates gave correct descriptions and therefore scored good marks. Extract 7.2 is a sample of the good responses from one of the candidates.

Extract 21.2

7a (i) Metal do not occur as nitrate in nature This is because nitrates are unstable such that can not exist under ordinary condition.

(ii) Activity series of metal Is the arrangement of metal in order of increasing or decreasing reducing power.

(iii) Metal B will be nearer to the top of the activity series since it is more reactive.

(iv) Aluminium can not be extracted by reducing alumina with Carbon this is because Aluminium is very reactive thus reacts with Carbon to form aluminium Carbide instead of Aluminium metal.

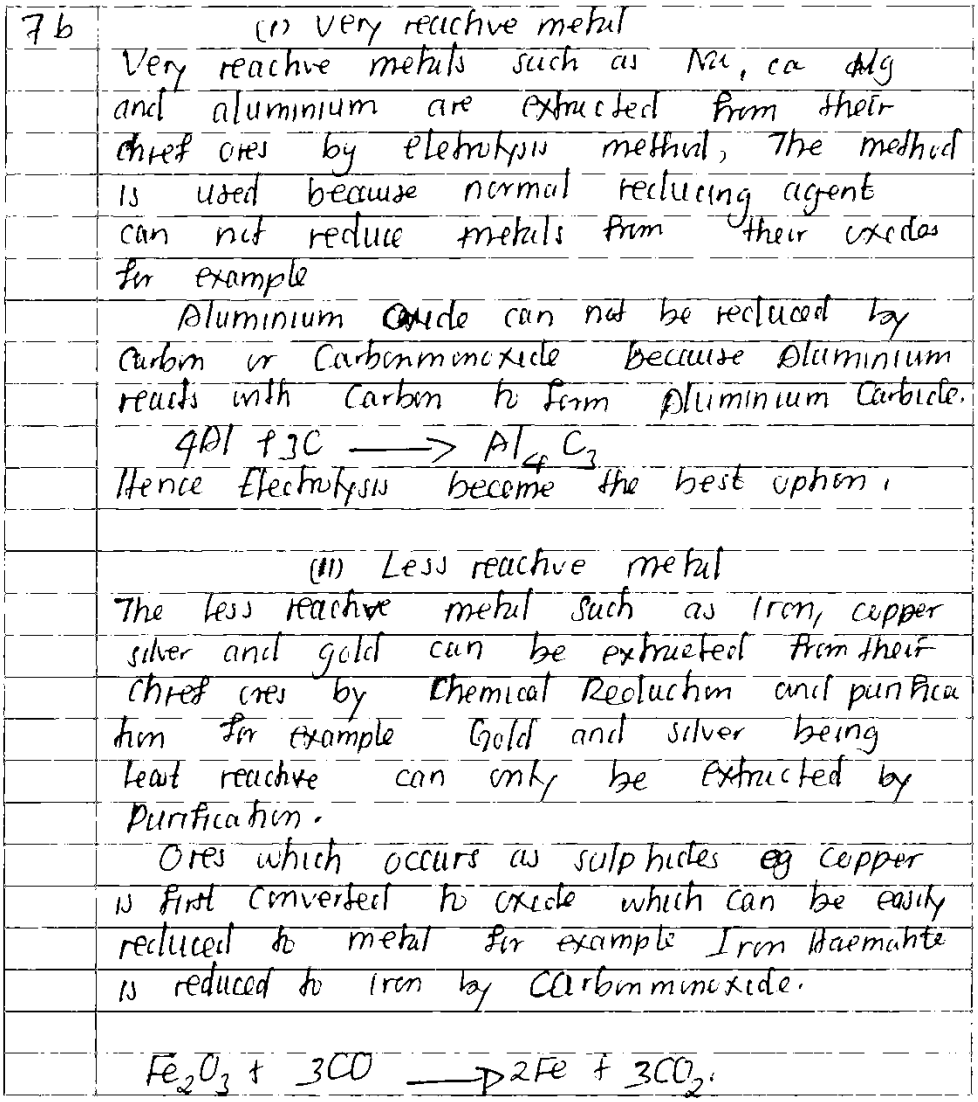
(v) Lime stone is added in the blast furnance in order to form CaO which will then used to form slage ie $CaSiO_3$.

$CaCO_3 \longrightarrow CaO + CO_2$

$CaO + SiO_2 \longrightarrow CaSiO_3$

slag

b Extraction of metal is the process of obtaining pure metal from it's ore, the choice of method of extraction depends on the position of the metal in activity series. This is explained as follows



In Extract 21.2, the candidate correctly responded to all the items in part (a) except item (i). Similarly, he/she gave correct descriptions of the methods that are applied in extracting metals which are very reactive and less reactive.

2.2.8 Question 8: Environmental Chemistry; Soil Chemistry

The question was:

(a) (i) Name three human activities which increase amount of CO_2 in the atmosphere.

(ii) Describe greenhouse effect.

(iii) List three climatic effects caused by rise in temperature due to greenhouse effect.

(b) (i) Define cation exchange capacity of a soil sample.
(ii) Briefly explain how cation exchange capacity of a soil sample is measured.

(c) A certain soil contains the following cations in meq/100g of oven-dry soil: Na^{+} = 2.00; K^{+} = 3.00; Mg^{2+} = 10.00; Ca^{2+} = 15.00; Al^{3+} = 4.00 and H^{+} = 5.50. Calculate the
(i) percentage base saturation
(ii) quantity in grams of sodium present in 100g of oven-dry soil.

(d) A certain soil has been identified to have a pH < 5. Identify two major ions which prevail in this soil and two compounds which can be used to raise the pH of this soil.

Many (64.2%) candidates opted for this question. The data show that 43.0 percent of these candidates scored from 0.0 to 6.5 marks, out of which 0.1 percent scored 0.0 marks. The data further indicate that 40.4 percent scored from 7.0 to 11.5 marks, while 16.6 percent scored from 12.0 to 20 marks. These data suggest average performance in this question.

The analysis reveals that part (a) of the question which was based on the Environmental Chemistry topic was better performed as compared to the rest of the questions which were based on the Soil Chemistry topic. The majority of the candidates who scored high marks, correctly named three human activities which increase the amount of carbon dioxide in the atmosphere, well described the greenhouse effect and listed three climatic effects caused by the rise in temperature due to greenhouse effect.

In part (b) of the question, the candidates also managed to define the cation exchange capacity of the given soil sample and correctly explained how cation exchange capacity of the soil sample is measured. Moreover, in part (c), they appropriately calculated the percentage base saturation and quantity of sodium present in 100g of oven dry soil. Finally, the candidates identified the major ions which prevailed in the soil and the compounds which could be used to raise the pH of the soil whose pH < 5 as demanded by part (d) of the question. Extract 22.1 presents a response of a candidate whose performance was high.

Extract 22.1

8 (c) i) While total Basic cation exchange capacity

Basic cations are Na^+, K^+, Mg^{2+}, Ca^{2+}

So

Total Basic cation Exchange capacity

$= (2 + 3 + 10 + 15)$ meq/100g

$= 30$ meq/100g

Then P.B.S $= \frac{30 \text{ meq}/100g}{39.5 \text{ meq}/100g} \times 100\%$

Percentage base saturation $= 75.95\%$ Ans.

ii) quantity in grams of sodium in 100 g of dry oven soil

From. 100g $\longrightarrow$ 2.00 meq of Sodium (Na^+)

But 1 eq of sodium $= \left(\frac{23\,g}{1}\right)$.

Then:

If. 1eq $\longrightarrow$ 23grams

2.0meq $\longrightarrow$? y

$y = 0.046$ grams

∴ Then. the quantity of sodium in 100 of oven dry soil is 0.046 grams Ans

8 (d) given soil pH < 5

this means the soil is acidic

The major ion ions that prevail in Acidic soils are

- ~~M^{2+}~~ (soda)
- Al^{3+} (Aluminium ions)
- H^+ (Hydrogen ions)

Two compounds that can cause pH (can facilitate liming are)

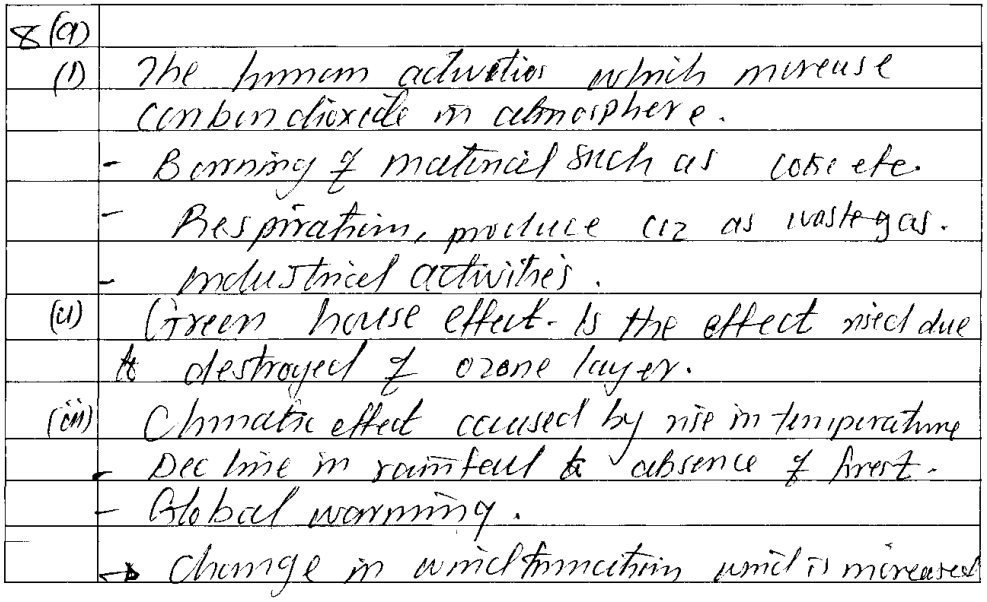
- CaO (Calcium oxide)
- $Ca(OH)_2$ (Calcium hydroxide)

Extract 22.1 is a sample answer from one of the candidates who managed to answer all the parts of the question. For instance, in part (d), he/she recognized that the soil with pH < 5 is acidic, hence the prevailing ions are likely Al^{3+} and H^{+} and therefore the soil needs CaO and $Ca(OH)_2$ as liming materials.

On the other hand, the analysis shows that some of the candidates who scored low marks mixed up the greenhouse effect and the effects of global warming, as a result they failed to describe the greenhouse effect. Furthermore, they could not list three climatic effects caused by rise in temperature due to greenhouse effect. This indicates that the candidates had inadequate content knowledge of these terms **(**refer Extract 22.2).

In part (b) of the question, some of the candidates failed to give the correct definition of the cation exchange capacity of the soil sample and to explain how to measure cation exchange capacity of the soil sample. For example, one of the candidates incorrectly stated that, *pH is used to measure cation exchange capacity of the soil sample*. In parts (c) and (d) some of the candidates failed to appropriately calculate the percentage base saturation and quantity in grams of sodium present in 100g of oven dry soil. It was also observed that although the candidates were given information that, the identified soil had a pH < 5, they failed to recognize that the soil was acidic, which could be improved by using liming materials. This shows that the candidates lacked knowledge of the soil reactions.

Extract 22.2



In Extract 22.2, the candidate scored some marks in item (a)(i) but failed the rest of the items. The candidate defined wrongly greenhouse effect as *the effect rised due to destroyed of ozone layer.*

2.2.9 Question 9: Amines; Polymers

The question was:

(a) Arrange the following compounds in the order of decreasing basic strength: NH_3, $C_6H_5NH_2$, $CH_3CH_2NH_2$, $(CH_3)_3N$, and $(CH_3)_2NH$.

(b) (i) Give the structural formulae of hexane-1,6-dioic acid and 1,6-diaminohexane.

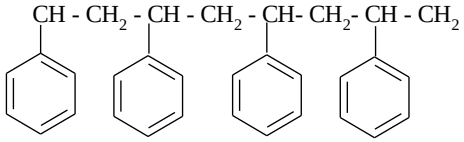
(ii) Explain why the pair of molecules in (i) is suitable for polymerization.

(iii) Give the structure of the polymer which might be formed by the pair of molecules in (i).

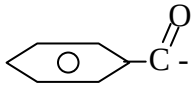
(iii) Show the repeating unit of the polymer formed by this pair of compounds.

(c) Indicate the monomer and the polymerization method which are likely to be used in making each of the provided commercial polymers:

(i) $–CF_2\text{-}CF_2\text{-}CF_2\text{-}CF_2\text{-}CF_2\text{-}CF_2\text{-}$

(ii) 

(iii) $NH\text{-}(CH_2)_5\text{-}CO\text{-}NH\text{-}(CH_2)_5\text{-}CO\text{-}NH\text{-}(CH_2)_5CO_2$.

(d) State why  and $HOCH_2CH_2OH$ cannot form a polymer.

The question was chosen by 47.6 percent of the candidates. The scoring in this question was as follows: 31.3 percent of the candidates scored from 0.0 to 6.0 marks, 37.4 percent scored from 7.0 to 11.0 marks and 31.3 percent scored from 12.0 to 20 marks. These statistics suggest good performance in this question.

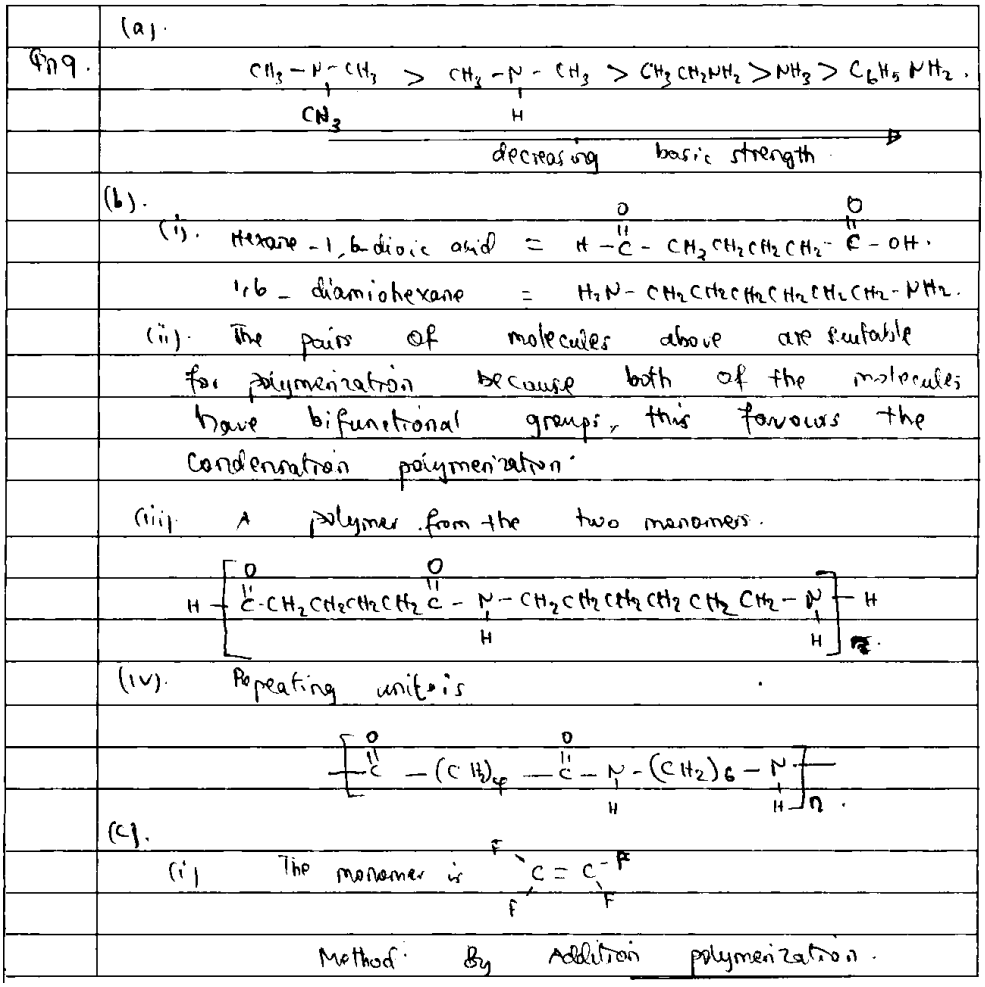
Most of the candidates whose performance was high were able to arrange the provided compounds in part (a) in the order of decreasing basic strength. They correctly wrote the structural formula of hexane-1,6-dioic acid and 1,6-diaminohexane. They managed to recognize that each molecule has two functional groups that can be involved in a condensation

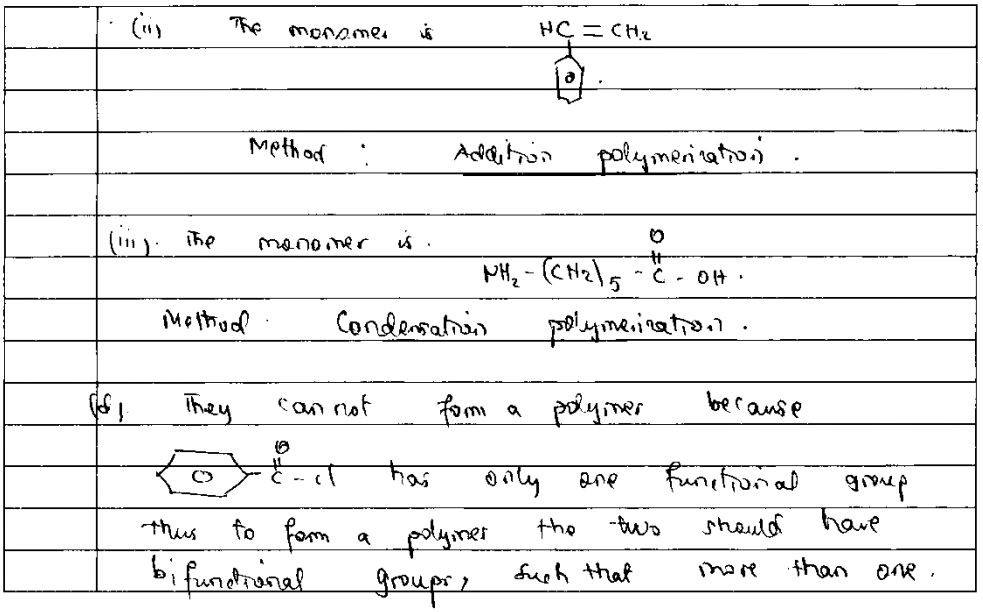
polymerization, hence they correctly commented that the pairs are suitable for polymerization. Likewise, they managed to show the repeating unit of the polymers formed by the pairs of the compounds.

Most of the candidates also managed to indicate the monomer and polymerization method used when making each of the provided commercial polymers in part (c). Finally, in part (d) they precisely stated that the pair cannot form a polymer because one of the molecules (C_6H_5COCl) is not bifunctional or polyfunctional.

Extract 23.1 shows a sample answer from one of the candidates who answered well all the parts of the question.

Extract 23.1





The work in Extract 23.1 indicates that the candidate had adequate knowledge of amines and polymers as he/she accurately answered all the items.

On the contrary, the few candidates who scored low marks were unable to arrange the given compounds in the order of decreasing basic strength. In this particular item, they lacked sufficient knowledge of hydration effect (solvation effect) and inductive effect on the determination of basic strength of amines. However, some of the candidates did not realize that C_6H_5- is a phenyl group, hence failed to place $C_6H_5NH_2$ in its correct position in the order of decreasing basic strength.

Moreover, the analysis shows that some of the candidates wrongly wrote structural formulae of hexane-1,6-dioic acid and 1,6-diaminohexane. As a result, they failed to explain why the pair of the molecules are suitable for polymerization. Similarly, they could not give the structure of the polymer which might be formed by the pair of molecules and the repeating unit of the polymer formed by the pair of the provided compounds.

The analysis also revealed that some of the candidates mixed up the concepts of "method of polymerization" and "mechanism of polymerization"; hence failed to write the structure of monomer and that of polymer required. Furthermore, they failed to spot out that one of the molecules in the pair is monofunctional, thus the pair cannot undergo polymerization.

In conclusion, the low performance was attributed to insufficient knowledge about polymers and polymerization. Extract 23.2 shows a sample answer from one of the candidates who did not manage to perform well in the question.

Extract 23.2

9. a) To arrange the compounds in the order of decreasing basic strength.

$NH_3 > CH_3-\underset{\underset{H}{|}}{N}-CH_3 > CH_3CH_2NH_2 > C_6H_5NH_2 > CH_3-\underset{\underset{CH_3}{|}}{N}-CH_3$

b) i) Structural formulae of

hexane-1,6-dioic acid

$CH\,CH_2CH_2CH_2CH_2CH$

$COOH \qquad COOH$

or

$COOH-CHCH_2CH_2CH_2CH_2CH-COOH$

1,6-diaminohexane

$NH_3-CHCH_2CH_2CH_2CH_2CH-NH_2$

ii) Pair of molecules in i) is suitable for polymerization because has the longest chain which can be written in isomer.

iii) The structure of the polymer which formed in i)

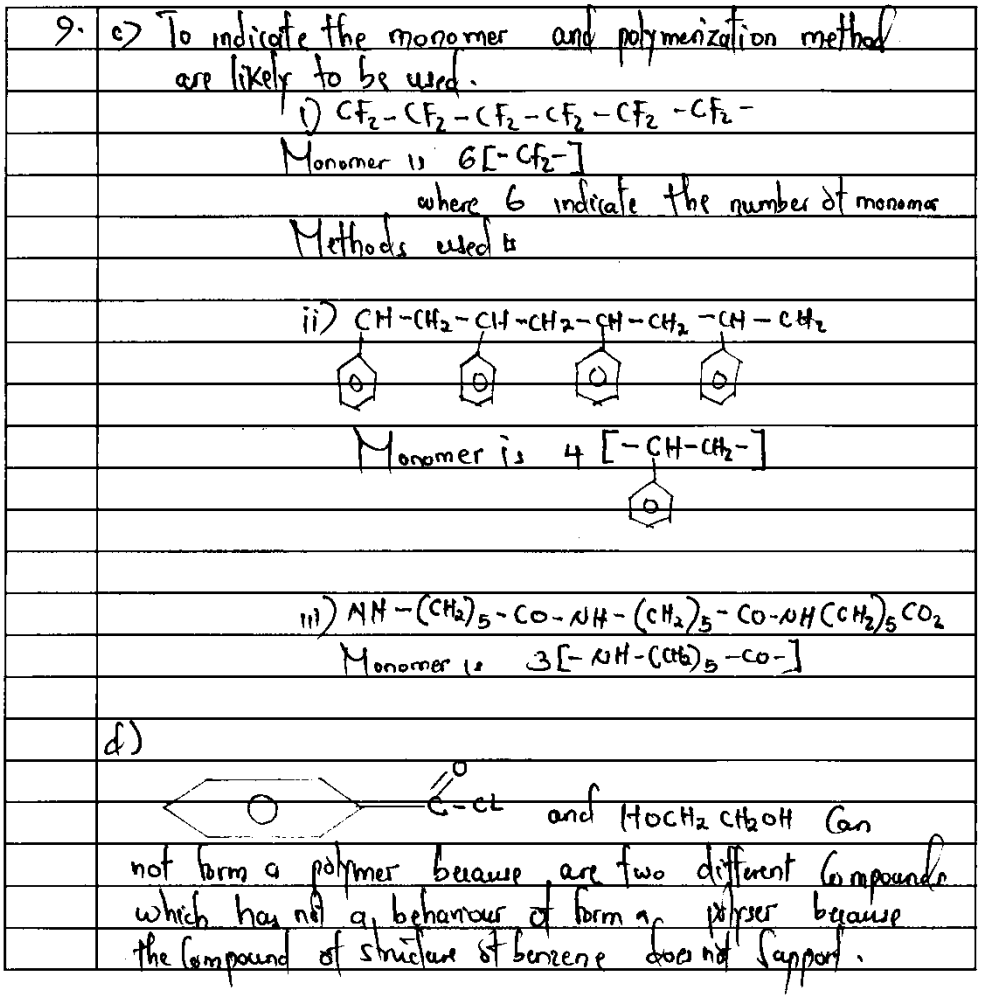
- $COOH-CH-CH_2-CH_2-CH_2-CH_2-$ ~~$COOH$~~ $CH-COOH$

- $NH_3-CH-CH_2-CH_2-CH_2-CH_2-CH-NH_3$

iv) The repeating unit of the polymer formed

- $4\,[-CH_2-]$

- $4\,[-CH_2-]$



Although the work of the candidate shown in Extract 23.2 is well presented, the candidate scored a zero mark since the responses are incorrect.

2.2.10 Question 10: Carbonyl Compounds; Carboxylic Acids and Derivatives

The question was:

(a) Acetic acid, ethyl alcohol and acetaldehyde in the form of solution are given in three different test tubes. By which chemical test could these be identify from one another?

(b) Arrange the following in the order of decreasing acidic strength:
   (i) CH_3COOH, CH_3CH_2COOH and $HCOOH$
   (ii) $ClCH_2COOH$, Cl_3CCOOH and $Cl_2CHCOOH$.

(c) Identify the structures and the names of the compounds represented by letters in the following reaction sequences:

(i) $CH_3-\overset{O}{\overset{\|}{C}}-CH_3 \xrightarrow{LiAlH_4} A \xrightarrow{HBr} B \xrightarrow{alc.KOH} C.$

(ii) $CH \equiv CH \xrightarrow[H^+/Hg^{2+}]{H_2O} D \xrightarrow[H_2O/H^+]{CH_3MgBr} E \xrightarrow[H_2SO_4]{K_2Cr_2O_7} F.$

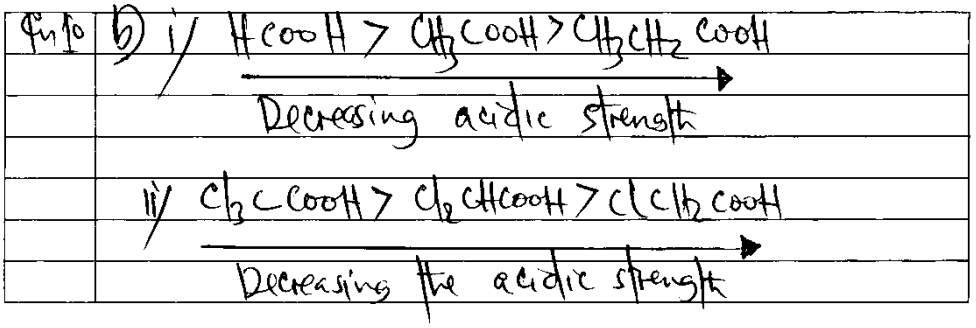
(d) Ozonolysis of alkene (C_6H_{12}), followed by hydrolysis yielded two products P and Q. P gives a positive iodoform test but negative Tollen's test. Q gives a positive Tollen's test but negative iodoform test. Identify structures and names of the alkene and products P and Q.

The question was chosen by 24.8 percent of the candidates, out of which 37.0 percent scored from 0.0 to 6.5 marks. The data further indicate that 30.6 percent of the candidates scored from 7.0 to 11.5 marks and 32.4 percent scored from 12.0 to 20 marks signifying general good performance.

The majority of the candidates who scored high marks managed to identify appropriate chemical tests that could be used to identify the given chemical compounds in part (a) of the question. They also arranged the compounds in part (b) in a correct order of decreasing acidic strength. Furthermore, they correctly identified the structures and named the compounds represented by letters A, B, C D, E and F for the reaction sequences provided. Finally, they precisely identified the structures and names of the alkenes and products P and Q from the provided information.

Extract 24.1 shows a sample answer from one of the candidates who managed to answer all the parts of the question.

Extract 24.1



Q4/c

c)i) A

Structure: $CH_3-\underset{OH}{CH}-CH_3$

Name: Propan-2-ol

B

Structure: $CH_3\underset{Br}{CH}CH_3$

Name: 2-bromopropane

C

Structure: $CH_3CH=CH_2$

Name: Propene / Prop-1-ene

ii) D

Structure: $CH_3\overset{O}{\overset{\|}{C}}-H$

Name: Ethanal

E

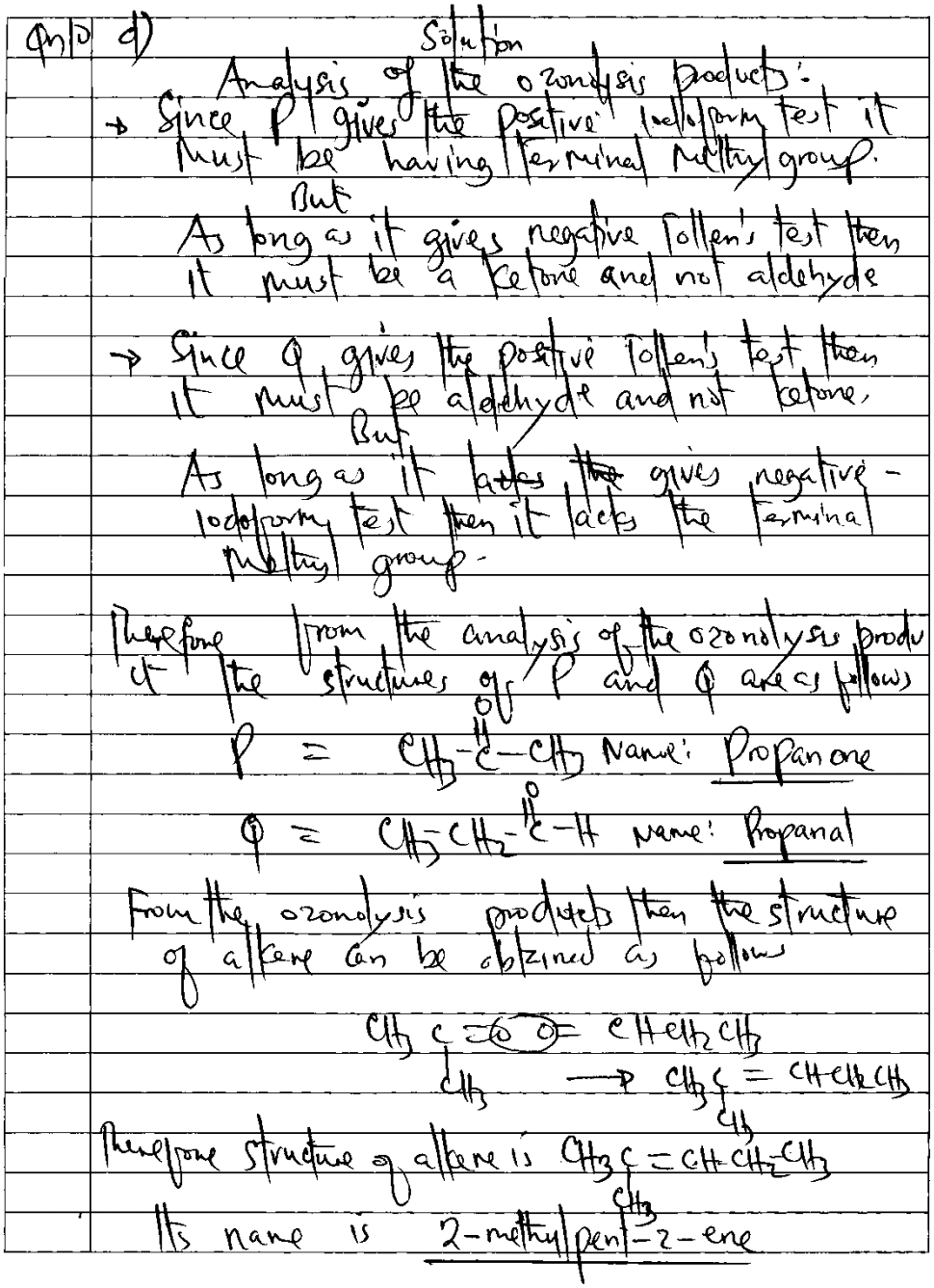
Structure: $CH_3\underset{OH}{CH}CH_3$

Name: Propan-2-ol

F

Structure: $CH_3\overset{O}{\overset{\|}{C}}-CH_3$

Name: Propanone



In Extract 24.1, the candidate correctly arranged the provided compounds in the order of decreasing acidity, identified structures and names of compounds represented by the given letters in the two reaction sequences and finally, correctly identified the structures and names of compound S, P and Q.

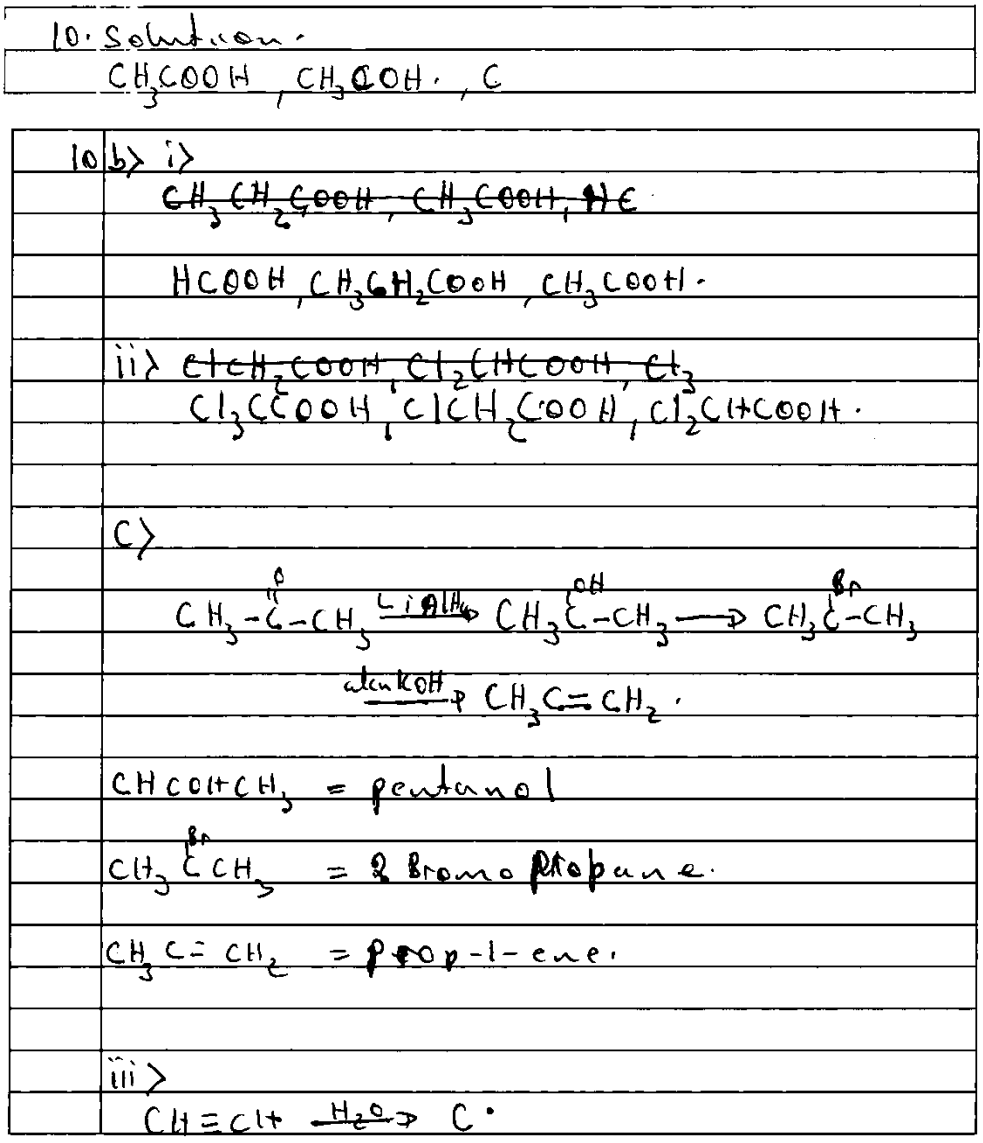
On the other hand, the candidates who scored low marks did not manage to suggest suitable chemical tests that could be used to identify acetic acid, ethyl alcohol and acetaldehyde in the form of solutions. The analysis

reveals that, instead of suggesting chemical tests for distinguishing the compounds in solution, some of the candidates were explaining methods of separating the provided compounds in solution, while others gave irrelevant tests. The analysis also shows that some of the candidates failed to arrange the given compounds in part (b) in the order of decreasing acidic strength, which implies lack of knowledge about inductive effect and its role in acidity of carboxylic acids and their derivatives.

It was also observed that some of the candidates failed to identify correct structures and the names of the compounds represented by letters for the reaction sequences that were provided. However, some of them obtained correct structures but failed to give their correct names. The candidates failed to identify the structures and names of the alkenes and products P and Q from the provided information. This shows that the candidates lacked knowledge of the reactions of organic compounds and the chemistry of the functional groups.

Extract 24.2 shows a sample answer from one of the candidates who performed poorly in this question.

Extract 24.2



In Extract 24.2, the candidate failed to correctly respond to any part of the question hence scored a zero mark.

3.0 ANALYSIS OF THE CANDIDATES' PERFORMANCE IN EACH TOPIC

In the Chemistry examination, a total of twenty-four (24) out of twenty-six (26) topics were examined in paper 1 and paper 2. The analysis of the candidates' performance in these topics reveals that the candidates performed well in 13 topics which is equivalent to 54.2 percent of the examined topics. These topics are: Chemical Kinetics; Acids, Bases and Salts; Solubility, Solubility Product and Ionic Product; The Atom; Chemical

Equilibrium; Relative Molecular Masses in Solution; Amines; Polymers; Transition Elements; Chemical Bonding; Carbonyl Compounds; Carboxylic Acids and Derivatives and Periodic Classification.

On the other hand, the candidates performed averagely in 7 topics which is equivalent to 29.2 percent of the examined topics. These topics are: Environmental Chemistry; Soil Chemistry; Halogen Derivatives of Hydrocarbons; Aliphatic Hydrocarbons, Gases; Two Component Liquid Systems and Energetics. The analysis also shows that the candidates performed poorly in 4 topics, which is equivalent to 16.6 percent of the examined topics. These topics are: Electrochemistry; Extraction of Metals; Aromatic Hydrocarbons and Selected Compounds of Metals.

The good performance in the stated topics was attributed to the fact that most of the candidates had adequate knowledge and clearly understood the requirement of the respective questions. Moreover, most of them were able to use English Language correctly in answering questions which required explanations.

However, poor performance in the four stated topics was attributed to inadequate knowledge on these topics. For example in the topic of Selected Compounds of Metals, the candidates lacked sufficient knowledge of the compounds of metals in the question. Furthermore, others failed to write correct chemical formulae of lead oxides and to explain the importance and hazards of lead in life.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The general performance of the candidates in Chemistry (ACSEE 2016) was good as the majority of them scored high marks (see Appendix). The analysis in each topic revealed that 13 topics had good performance, 7 topics had average performance and 4 topics had poor performance.

Further, the analysis has shown that the candidates who performed poorly faced challenges in attempting some of the examinations questions, hence scored low marks. The following are the factors that contributed to failure of some candidates to respond correctly to some of the questions.

(a) Failure to identify the requirement of the question.

(b) Lack of knowledge in some topics as they provided responses which had no relationship with the questions.

(c) Failure to apply the required formula to some of the questions, hence leading to incorrect responses.

(d) Lack of basic mathematics based on Chemistry principles.

4.2 Recommendations

(i) Teachers should put more emphasis on mathematical-based concepts and practical skills related to specific fields of study. This will improve the ability of the candidates in dealing with problems related to the concepts.

(ii) Students should read the question(s) carefully so as to identify the requirement of the question(s) before attempting it.

(iii) Students should be encouraged to revise all topics across the current syllabus in their normal study time and during preparation for examinations.

(iv) Students should do enough exercises specifically on: preparation, characteristics and uses of metal compounds; redox reactions; benzene and benzene reactions, the occurrence of metal ores, mechanisms of thermal and electrolytic reduction and chemical reactions in extraction of metals.

(v) Students should do practical exercises, specifically in investigating properties of metal compounds, in order to build understanding and long memory.

Appendix

Summary of the Performance of Candidates Topic-wise

S/N	Topic	Total Number of Questions	The % of Candidates Who Scored an Average of 35 % or Above	Remarks
1	Chemical Kinetics; Chemical Equilibrium.	1	89.5	Good
2	Acids, Bases and Salts, Solubility, Solubility Product and Ionic Product.	1	80.9	Good
3	The Atom.	2	75.9	Good
4	Chemical Equilibrium.	1	74.2	Good
	Relative Molecular Masses in Solution.	2	69.6	Good
5	Amines and Polymers.	1	68.7	Good
6	Transition Elements.	1	67.1	Good
7	Chemical Bonding.	1	63.8	Good
8	Carbonyl Compounds; Carboxylic Acids and Derivatives.	1	63.0	Good
9	Periodic Classification.	1	62.4	Good
	Two Component Liquid systems.	1	59.2	Average
12	Environmental Chemistry; Soil Chemistry.	1	57.0	Average
	Gases.	2	52.1	Average
13	Halogen Derivatives of Hydrocarbons.	1	51.4	Average
14	Aliphatic Hydrocarbons.	2	49.4	Average
15	Energetics.	1	49.3	Average
16	Electrochemistry.	1	34.0	Weak
17	Extraction of Metals.	1	32.8	Weak
18	Aromatic Hydrocarbons.	1	12.5	Weak
19	Selected Compounds of Metals.	1	6.5	Weak