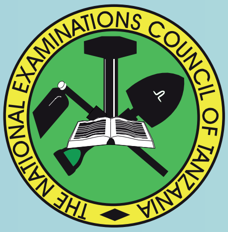
THE NATIONAL EXAMINATIONS COUNCIL OF TANZANIA



CANDIDATES’ ITEMS RESPONSE ANALYSIS FOR ACSEE 2015

132 CHEMISTRY

THE NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

ACSEE 2015 ITEMS RESPONSE ANALYSIS BOOKLET

132 CHEMISTRY

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FOREWORD

The Items Response Analysisof Candidates in Chemistry subject in the Advanced Certificate of Secondary Education Examination (ACSEE) 2015 has been prepared to provide feedback to students, teachers, parents, policy makers and the public in general on the performance of the candidates.

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

The analysis presented in this report is intended to contribute towards understanding of some of the reasons behind the performance of candidates in Chemistry subject. The report highlights some of the factors that made candidates scored high marks and also factors that made a few candidates to score low marks in each question. The factors which made few candidates fail to score high marks include,lack of basic knowledge in relation to a particular conceptand inability to answer questions which demanded mathematical manipulations or explanation and supporting reasons.The feedback provided will enable the educational administrators, school managers, teachers and students to identify proper measures to be taken in order to improve candidates' performance in future examinations administered by the Council.

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

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

Dr. Charles E. Msonde
EXECUTIVE SECRETARY

1.0 INTRODUCTION

This report analyses the performance of candidates who sat for the Advanced Certificate of Secondary Education Examination for Chemistry Paper One and Two. The 2015 Chemistry examination was set according to the ACSEE format which was revised in 2011 to suit the 2010 ACSEE Chemistry syllabus.

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

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

The analysis of examination results showed that, the overall performance of candidates was good as the candidates' scores in most of the questions were above 30 percent of the allocated marks. However, the results show that, candidates' performance in 2015 has increased as 96.40 percent passed the examination compared to 95.78 of the candidates who passed the examination in ACSEE 2014. Hence the performance in 2015 has increased by 0.62 percent.

The following sections provide an analysis of each question by showing the requirements of the question, candidates' performance, and then observed misconceptions. In the analysis, a question or topic is regarded as poorly, averagely or good/well performed provided that, the number of candidates who scored 30 percent or above of the marks allocated to a particular question/topic is 0 – 29, 30 – 49 and 50 – 100 respectively.

2.0 ANALYSIS OF CANDIDATES PERFORMANCE BY QUESTIONS

2.1 132/1-CHEMISTRY 1

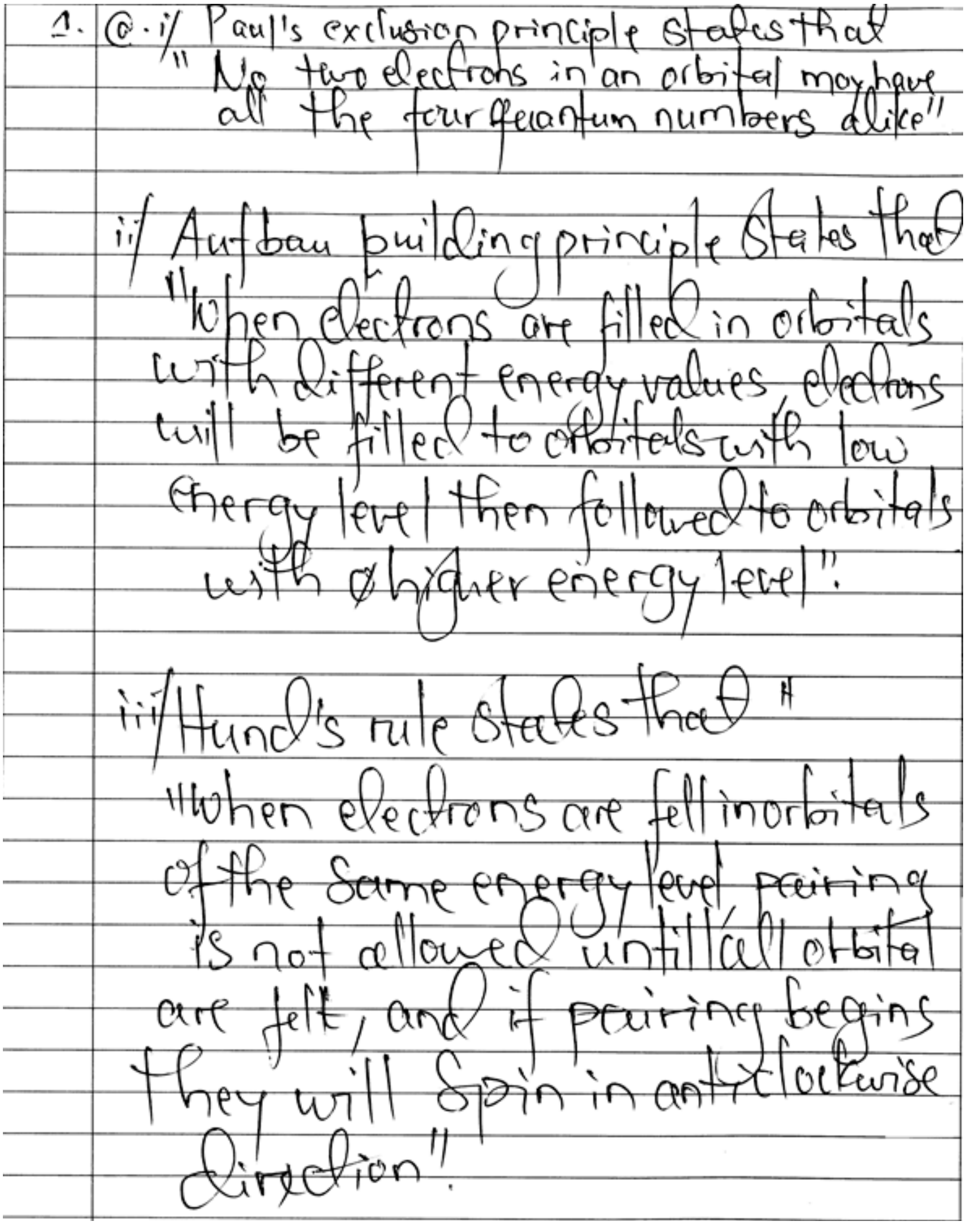
2.1.1 Question 1: The Atom

This question had three parts, namely a, b and c. In part (a),the candidates were required to state Pauli's exclusion principle, Aufbau building principle, Hund's rule of maximum multiplicity and half-filled and full filled orbital rule. Part (b) required the candidates to write the electronic configuration using orbital diagrams of Cl^-, K, $Ca^{2+}$and F. Part (c) stated that;*element Z occurs naturally as a mixture of* ^{69}Z *and* ^{71}Z. Candidates were then required to explain briefly the significance of the numbers 69 and 71 and give a term which describes these two components in the natural element. They were also required to find the percentage of ^{69}Z and ^{71}Z in a sample of Z if ^{69}Z and ^{71}Z have relative atomic mass of 69.8.

Majority (94.2%)of the candidates attempted this question and out ofthem,only 5.4 percent scored below 3 marks out of 10. Out of the 94.6 percent of those who scored 3 or above marks, 11.9 percent scored 3 to 4.5 marks, 31.1 percent scored 5 to 7 marks and the majority (51.6%) scored 7.5 to 10 marks. This is an indication that the question was well performed.

Good performance in this question was attributed to the fact that, candidates had sufficient knowledge on the structure of an atom and the principles and rules guiding the arrangement of electrons in it. They managed to stateall the terms persuasively as well as writing electronic configurations of the given species.Moreover, they wrote appropriateformulae to find the percentage of ^{69}Z and ^{71}Z in a sample of Z,made correct substitution of the data and eventually, obtained correct percentages.Extract 1.1 is asample good response.

Extract 1.1



1. (a) i/ Paul's exclusion principle states that " No two electrons in an orbital may have all the four quantum numbers alike"

ii/ Aufbau building principle States that "When electrons are filled in orbitals with different energy values, electrons will be filled to orbitals with low energy level then followed to orbitals with higher energy level".

iii/ Hund's rule States that "when electrons are fell in orbitals of the Same energy level pairing is not allowed until all orbital are felt, and if pairing begins they will Spin in anticlockwise direction".

1 ⓐ. iv/ Half-filled and full-filled orbital rule states that" the filling of electrons will be filled first to an orbital with higher energy level before that of lower energy level, so as to obtaine a stable electronic configuration of either half filled or full filled" example in Chromium and Copper.

ⓑ. i/ $Cl^- = [Ar]$ or

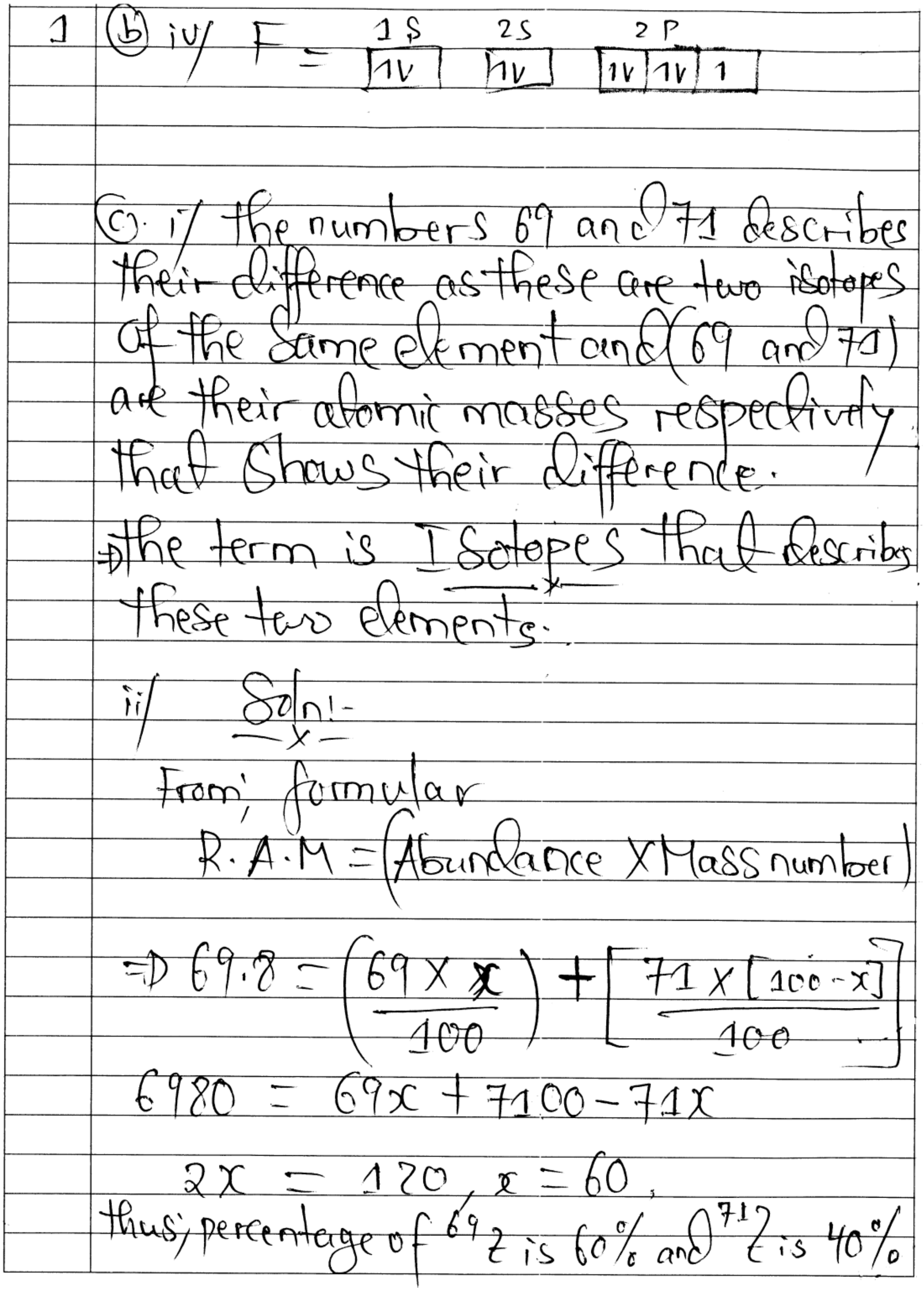
1S	2S	2P	3S	3P
↑↓	↑↓	↑↓ ↑↓ ↑↓	↑↓	↑↓ ↑↓ ↑↓

ii/ K =

1S	2S	2P	3S	3P	4S
↑↓	↑↓	↑↓ ↑↓ ↑↓	↑↓	↑↓ ↑↓ ↑↓	↑

iii/ Ca^{2+} =

1S	2S	2P	3S	3P
↑↓	↑↓	↑↓ ↑↓ ↑↓	↑↓	↑↓ ↑↓ ↑↓



1 (b) iv/ F =

1S	2S	2P
↑↓	↑↓	↑↓ ↑↓ ↑

(c) i/ the numbers 69 and 71 describes their difference as these are two isotopes of the same element and (69 and 71) are their atomic masses respectively that shows their difference.

⇒ the term is Isotopes that describes these two elements.

ii/ Soln:-

From; formular

R.A.M = (Abundance X Mass number)

$$\Rightarrow 69.8 = \left(\frac{69 \times x}{100}\right) + \left[\frac{71 \times [100 - x]}{100}\right]$$

$$6980 = 69x + 7100 - 71x$$

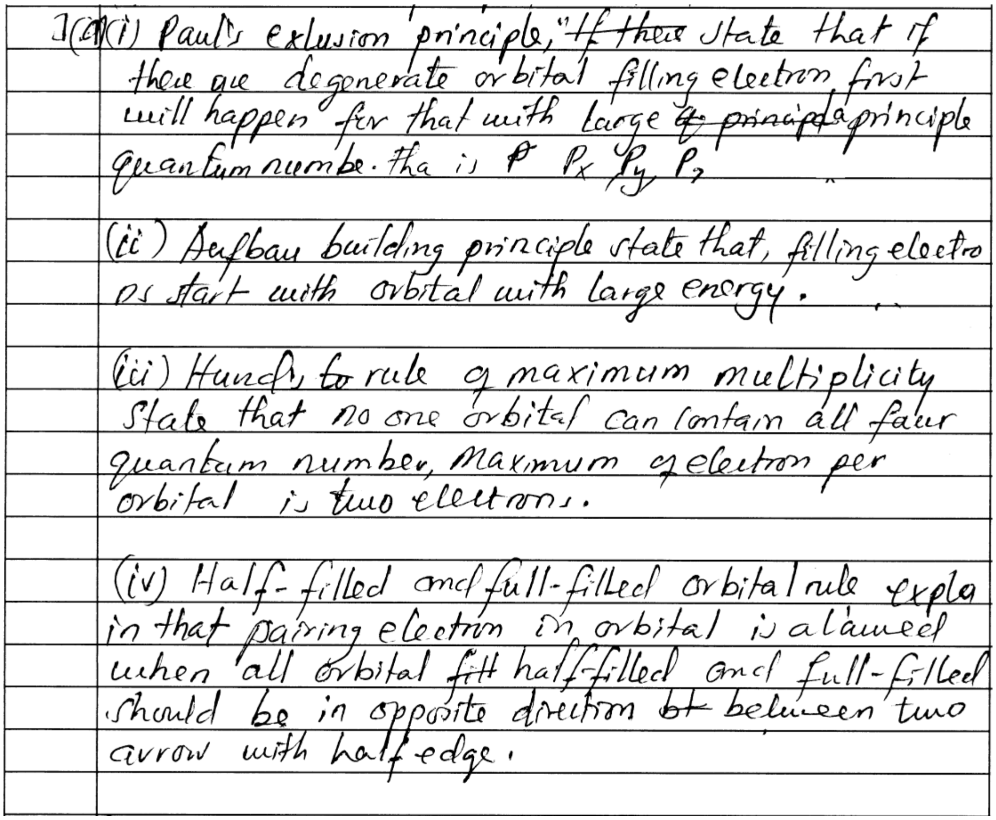
$$2x = 120, \; x = 60,$$

thus; percentage of ^{69}Z is 60% and ^{71}Z is 40%

In Extract 1.1, the candidate gave correct definitions of the enquired terms, wrote the electronic configurations of the species as required and finallyhe/she applied relevant formulas and substituted correct values and eventually, obtained accurate percentages of ^{69}Z and ^{71}Z in a sample of Z.

Some of the few candidates who scored zero marks, failed to give correct meanings of all terms in part (a) while others mixed up the statements of the given terms. For example, in responding to part (b), some candidates wrote electronic configuration of Cl^- as 2:8:8instead of using orbital method as enquired.Furthermore,they failed to describe the significance of the numbers, 69 and 71 in part (c)(i) and some skipped part (c)(ii). Failure might be due tolack of knowledge in presenting atomic symbols with their mass numbers and atomic numbers as well as determining relative atomic masses from the abundance of isotopes. Extract 1.2 illustrates an example of low performances.

Extract 1.2

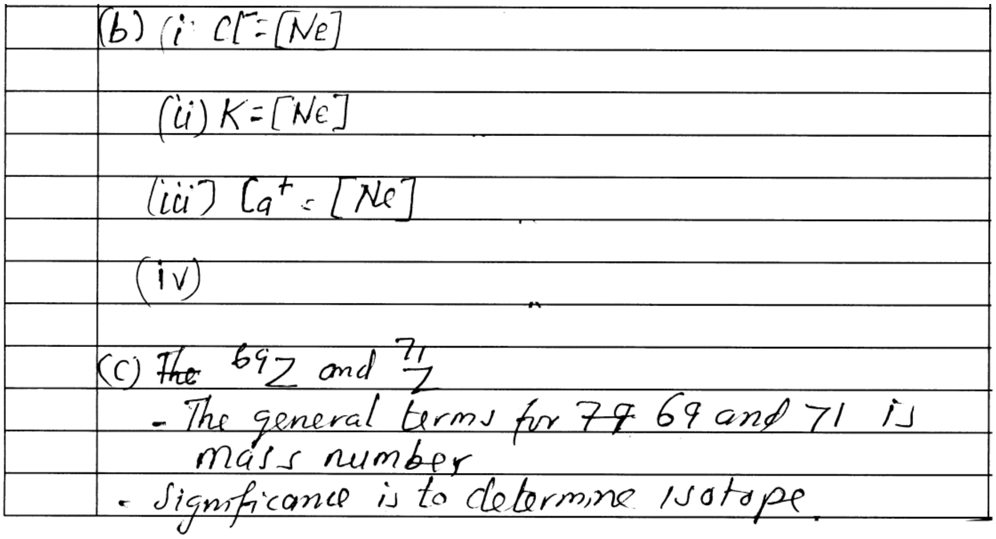


1(a)(i) Paul's exlusion principle, "~~If there~~ state that if
there are degenerate orbital filling electron first
will happen for that with large ~~of principal~~ principle
quantum numbe. tha is ~~P~~ P_x P_y P_z

(ii) Aufbau building principle state that, filling electro
ns start with orbital with large energy.

(iii) Hund's ~~to~~ rule of maximum multiplicity
State that no one orbital can contain all faur
quantum number, maximum of electron per
orbital is two electrons.

(iv) Half-filled and full-filled orbital rule expla
in that pairing electron in orbital is alawed
when all orbital fill half-filled and full-filled
should be in opposite direction ~~bt~~ between two
arrow with half edge.



(b) (i) Cl^- = [Ne]

(ii) K = [Ne]

(iii) Ca^+ = [Ne]

(iv)

(c) ~~The~~ ^{69}Z and ^{71}Z

- The general terms for ~~79~~ 69 and 71 is mass number
- Significance is to determine isotope.

In Extract 1.2,the candidate could not state correctly the inquired terms, neither did he/she write the electronic configurations of the elements in question nor calculate the percentages of the isotopes, indicating lack of knowledge about the question demand.

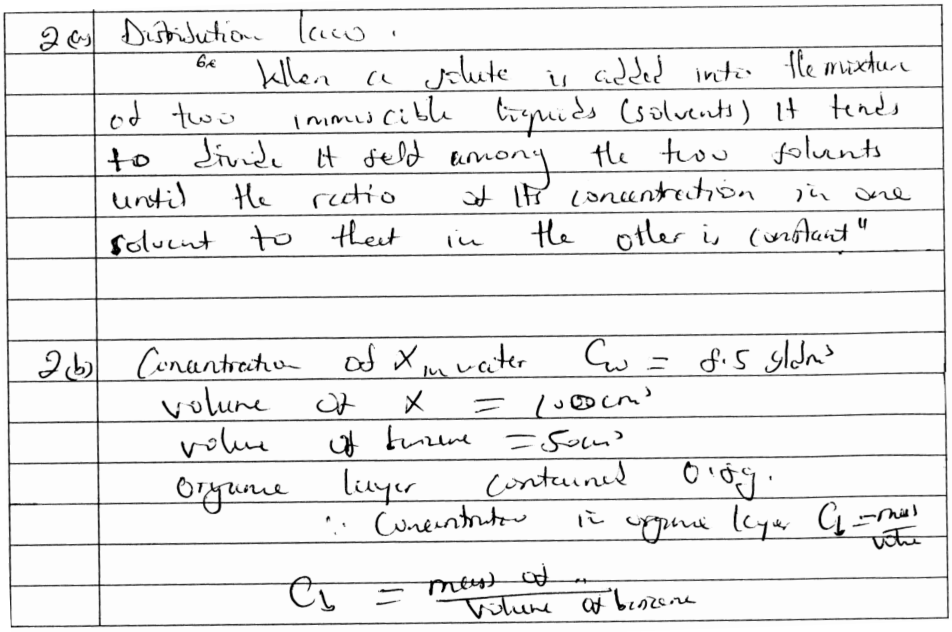
2.1.2 Question 2: Two Component Liquid Systems

In part (a) of the question, the candidates were demanded to state the distribution law. Part (b) stated that: "*The concentration of a solute X in water was found to be 8.5 g/dm^3 at room temperature. 100 cm^3 of this solution was shaken with 50 cm^3 of methyl benzene until equilibrium was obtained. The organic layer was separated and found to contain 0.8 g of X*". Candidates were then required to calculate; (i) the distribution coefficient of solute X between methyl benzene and water,(ii) further mass of X that would be removed from aqueous layer if it was shaken with further 50cm^3 of methyl benzene, (iii) mass of X extracted if 100cm^3 of methyl benzene was used at once instead of using 50cm^3 twice and to state which one of the two alternatives is more efficient extraction process and give reasons for their answer.

This question was attempted by38.8 percent of the candidates and the general performance was poor because majority (71.3%) of the candidates scored below 3 marks of which 25.1 percent scored 0 marks. Furtheranalysis hasshown that,49.8 percent scored 0 to 1 marks and 21.5 percent scored 1.5 to 2.5 marks.On the other hand, 8.7percent scored from 3 to 5 marks, 7.3percent scored 5.0 to 7.0 marks and 13.9 percent scored7.5 to 10 marks of which 2.7 percent scored all the 10 marks.

Majority of candidates with low performances managed to give the statement of the law and wrote correct formula for calculation of partition coefficient. However, they failed to relate masses with their respective volumes in the relationship to calculate partition coefficient, hence inability to identify with reasons the most efficient extraction process. This is because, ‘the correctness of the statements depended on the masses calculated from different extractions. Extract 2.1 is a sample of a response from a candidate with low marks.

Extract 2.1



2(a) Distribution law.

Ex When a solute is added into the mixture of two immiscible liquids (solvents) it tends to divide it self among the two solvents until the ratio of its concentration in one solvent to that in the other is constant"

2(b) Concentration of X in water $C_w = 8.5\ g/dm^3$

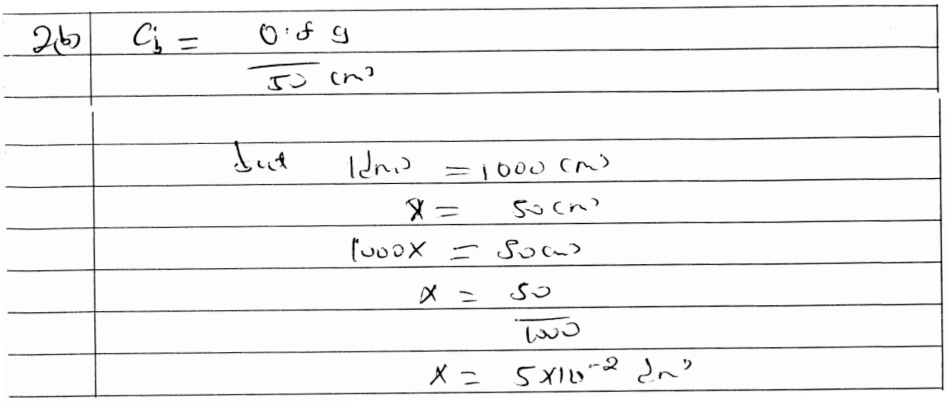
volume of X = 1000 cm³

volume of benzene = 50 cm³

Organic layer contained 0.8g.

∴ Concentration in organic layer $C_b = \frac{mass}{volume}$

$$C_b = \frac{\text{mass of ..}}{\text{volume of benzene}}$$



2(b) $C_b = \frac{0.8\ g}{50\ cm^3}$

but 1 dm³ = 1000 cm³

X = 50 cm³

1000X = 50 cm³

$X = \frac{50}{1000}$

$X = 5 \times 10^{-2}\ dm^3$

$C_b = \frac{0.8g}{5\times10^{-2}\,dm^3} = 16\,g/dm^3$

∴ The concentration of X in benzene is 16g/dm³

ii) distribution coefficient

$K_d = \frac{\text{Concentration in benzene}}{\text{Concentration in water}}$

$K_d = \frac{16g/dm^3}{8.5g/dm^3}$

$K_d = 1.8823$

∴ Distribution coefficient of X is 1.8823

2b) ii) If it was shaken with further 50cm³ of methyl benzene,

$K_d = \frac{\text{Conc in benzene}}{\text{Conc. in water}}$

$1.8823 = \frac{\text{Conc. in benzen}}{\text{Conc. in water.}}$

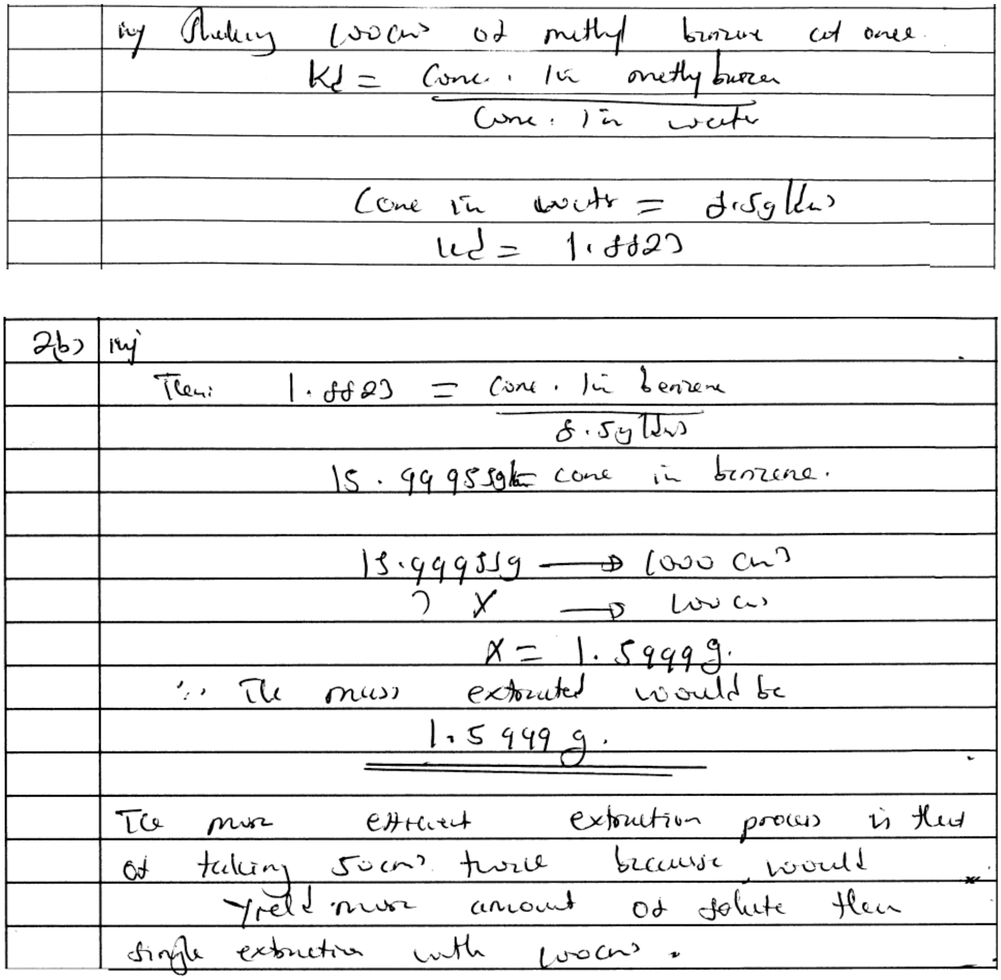
Concentration in water: 8.5g → ~~1000dm³~~
is reduced to (8.5−0.8)g
7.7g in dm³
= 7.7g/dm³.

$1.8823 = \frac{\text{Conc. in benzene}}{7.7\,g/dm^3}$

Concentration = 14.4937 g/dm³
14.4937g → 1000 cm³
X → 50 cm³

X = 0.7246 g.

∴ The mass of X removed is 0.7246g.



by Shaking 100cm³ of methyl benzene at once.

$Kd = \frac{\text{Conc. in methyl benzene}}{\text{Conc. in water}}$

Conc in water = 8.5g/dm³

Kd = 1.8823

2b) by

Then: $1.8823 = \frac{\text{Conc. in benzene}}{8.5\text{g/dm}^3}$

15.99955g conc in benzene.

15.99955g → 1000 cm³

? X → 100 cm³

X = 1.5999g.

∴ The mass extracted would be

1.5999 g.

The more efficient extraction process is that of taking 50cm³ twice because would yield more amount of solute than single extraction with 100cm³.

Extract 2.1 shows an answer in which the candidate answered some parts of the question correctly but missed most of the part. In part 2(b)(i) the candidate made a serious mistake by substituting in the formula the concentration of X in water before mixing with organic layer (8.5/dm^3) which led to incorrect partition coefficient. This had adverse effects since the answer obtained was to be utilized in the subsequentcalculation of other parts of the question.

On the contrary, candidates who scored high marks showed high ability in distribution law and related calculations as they stated properly the distribution law and calculated correctly the distribution coefficient in question. Similarly, they managed to find the masses of X which were extracted during different extraction processes from which they made proper comparisons andidentified with reasons the most efficient extraction process. Extract 2.2 shows a sample of a good response from a candidate.

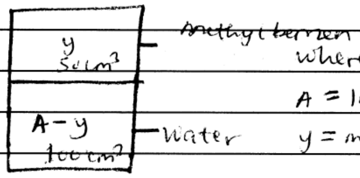
Extract 2.2

2.(a) Distribution law,

"If the solute is disolved into two immiscible liquids, it will tend to distribute itself in such a way that, the ratio of concentration of the solute in one liquid to the ratio of concentration of the solute in another liquid is constant and the constant is called partition constant".

(b) Soln.

Illustration.



where;
A = Initial mass of X
y = mass of X in benzene.

Remember;

$8\cdot5\,g$ of X ≡ $1000\,cm^3 = 1\,dm^3$.

A ≡ $100\,cm^3$.

$A = 0\cdot85\,g$.

on separation of the organic layer;

$0\cdot8g$ of x were found = y.

now;

(i) Distribution coefficient = $\frac{\text{concentration of X in methyl benzene } (C_b)}{\text{concentration of X in water } (C_w)}$

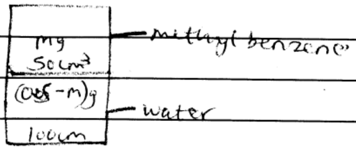
But; $C_b = \frac{y}{50\,cm^3} = \frac{0\cdot8}{0\cdot05} = 16\, g/dm^3$.

$C_w = \frac{A-y}{100\,cm^3} = \frac{0\cdot85 - 0\cdot8}{0\cdot1} = 0\cdot5\, g/dm^3$.

Distribution coefficient $= \frac{C_b}{C_w}\ \frac{16}{0\cdot5}\ \frac{16\cdot5}{0\cdot5} =$ 32

∴ = 32.

2(b) (ii)



Distribution coefficient $= \frac{C_b}{C_w}$

Where; $C_b = \frac{m}{50cm^3} = \frac{m}{0.05dm^3}$

and $C_w = \frac{0.05-m}{0.1dm^3}$.

Then; $32 = \frac{m}{0.05} \Big/ \frac{0.05-m}{0.1}$

$\frac{m}{0.05} \times \frac{0.1}{(0.05-m)} = 32$.

$\frac{0.1m}{0.05(0.05-m)} = 32$.

$32 \times 0.05(0.05-m) = 0.1m$.

$1.6(0.05-m) = 0.1m$.

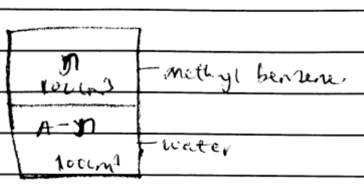
$0.08 - 1.6m = 0.1m$.

$\frac{1.7m}{1.7} = \frac{0.08}{1.7}$.

$m = 0.047g$.

∴ Further mass removed = 0.047g.

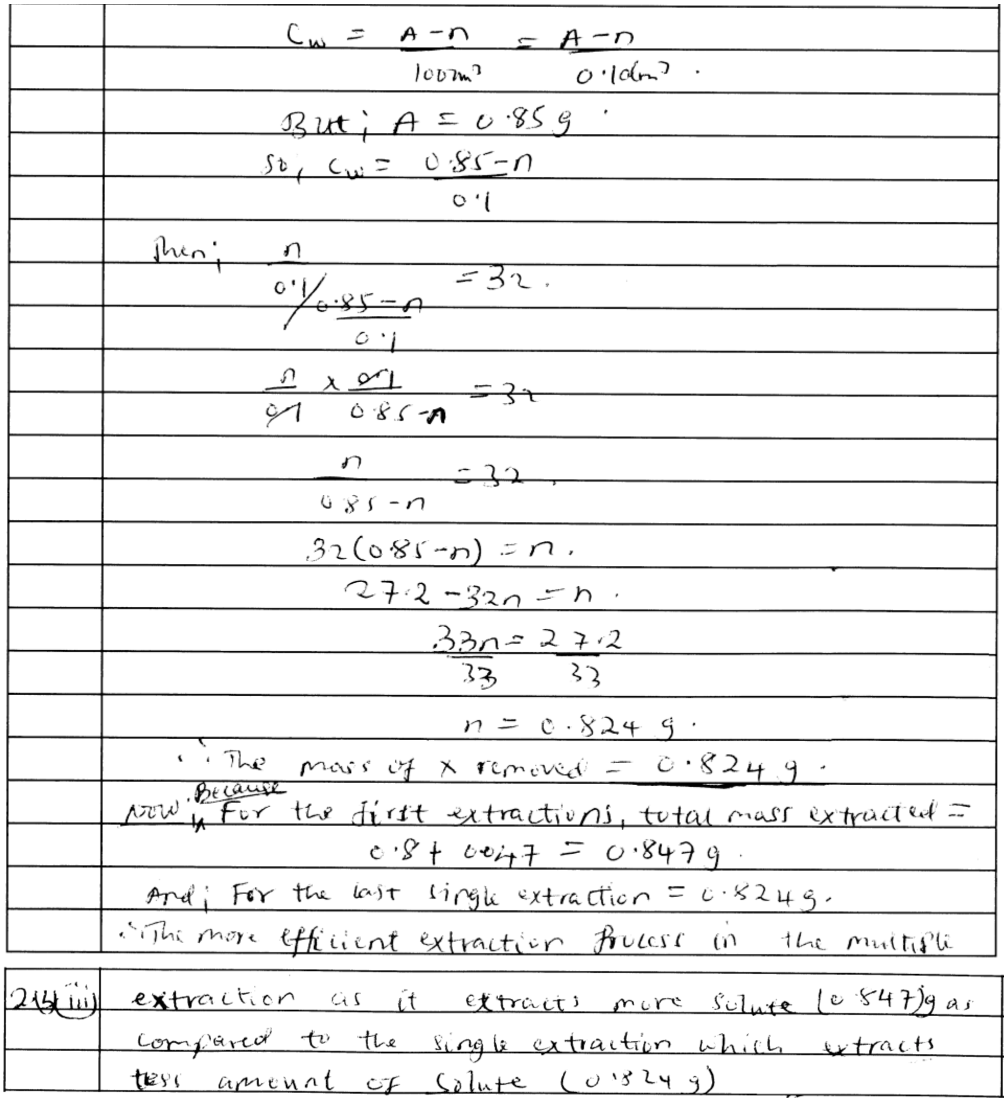
2.(b) (ii)



Soln.

Distribution coefficient $= 32 = \frac{C_b}{C_w}$

C_b ~~32~~ $= \frac{n}{100cm^3} = \frac{n}{0.1dm^3}$.



$C_w = \frac{A-n}{100cm^3} = \frac{A-n}{0.1dm^3}$.

But; $A = 0.85$ g.

So, $C_w = \frac{0.85-n}{0.1}$

Then; $\frac{n}{0.1 / \frac{0.85-n}{0.1}} = 32$.

$\frac{n}{\cancel{0.1}} \times \frac{\cancel{0.1}}{0.85-n} = 32$

$\frac{n}{0.85-n} = 32$.

$32(0.85-n) = n$.

$27.2 - 32n = n$.

$\frac{33n}{33} = \frac{27.2}{33}$

$n = 0.824$ g.

∴ The mass of X removed = 0.824 g.

Now; Because For the first extractions, total mass extracted = 0.8 + 0.047 = 0.847 g.

And; For the last single extraction = 0.824 g.

∴ The more efficient extraction process is the multiple

2(b)(iii) extraction as it extracts more solute (0.847)g as compared to the single extraction which extracts less amount of solute (0.824 g)

Response in Extract 2.2 signifies that the candidate was acquainted with the distribution law and the related calculations.The candidate used diagrams to show how the solute X distributes and carried out correctly all calculations involved leading to anticipated conclusion that extraction using 50 cm^3twice was more efficiency compared to single extraction of using 100 cm^3.

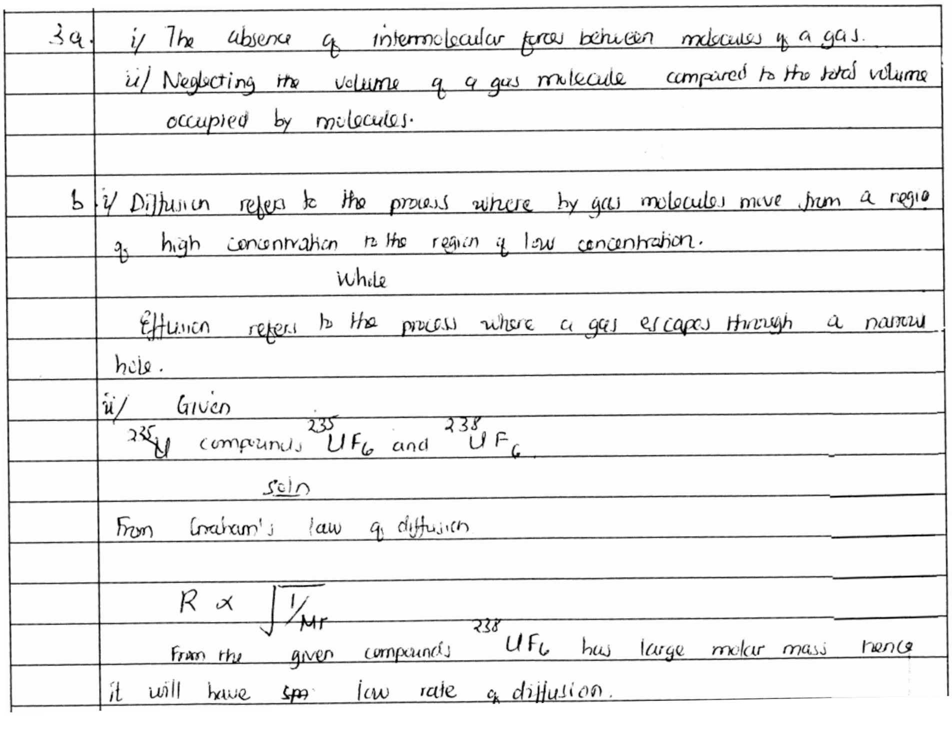
2.1.3 Question 3: Gases

In part (a) of the question,the candidates were demanded to describe two assumptions of kinetic theory of gases that are not obeyed by real gases. Part (b) requiredthe candidates to differentiate between diffusion and effusion for gases and to state which of the gases $^{235}UF_{6\ (g)}$or $^{238}UF_{6\ (g)}$ will diffuse rapidly and by how much. In part (c) candidates were enquired to calculate the mass of CO_2 which will be produced if 8.56g of $C_6H_{12}O_6$ is consumed by a person,given that the general equation for the breakdown of glucose is $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$.

The question was attempted by 46.1 percent of the candidates and out of them, 70.0 percent scored 3 to 10 marks.The candidates whoscored 3 to 4.5 marks were 30.6 percent while those who scored 5 to 10 marks were 39.4, out of which 9.3 percent scored 7.5 to 10 marks indicating good performance of the question.

The candidates who performed well described accurately the assumptions of kinetic theory of gases that are not obeyed by real gases by incorporating all key concepts required. Furthermore, they managed to differentiate correctly diffusion from effusion of gases and also performed appropriately the required calculationsand obtain the mass of $CO_2$to be 1255.47g. Extract 3.1 reveals the case.

Extract 3.1



3a. i/ The absence of intermolecular forces between molecules of a gas.

ii/ Neglecting the volume of a gas molecule compared to the total volume occupied by molecules.

b i/ Diffusion refers to the process where by gas molecules move from a regio of high concentration to the region of low concentration.

While

Effusion refers to the process where a gas escapes through a narrow hole.

ii/ Given

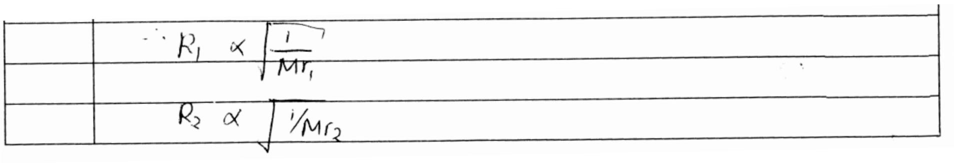
^{235}U compounds $^{235}UF_6$ and $^{238}UF_6$

Soln

From Graham's law of diffusion

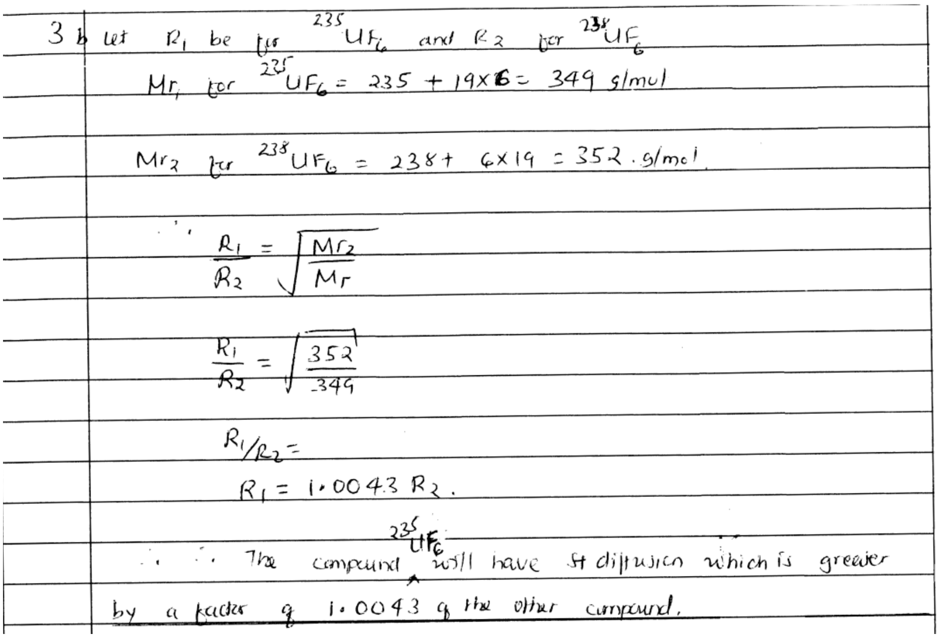
$R \propto \sqrt{1/Mr}$

From the given compounds $^{238}UF_6$ has large molar mass hence it will have ~~sp~~ low rate of diffusion.



∴ $R_1 \propto \sqrt{\frac{1}{Mr_1}}$

$R_2 \propto \sqrt{1/Mr_2}$



3 b Let R_1 be for $^{235}UF_6$ and R_2 for $^{238}UF_6$

Mr_1 for $^{235}UF_6 = 235 + 19\times6 = 349$ g/mol

Mr_2 for $^{238}UF_6 = 238 + 6\times19 = 352$ g/mol

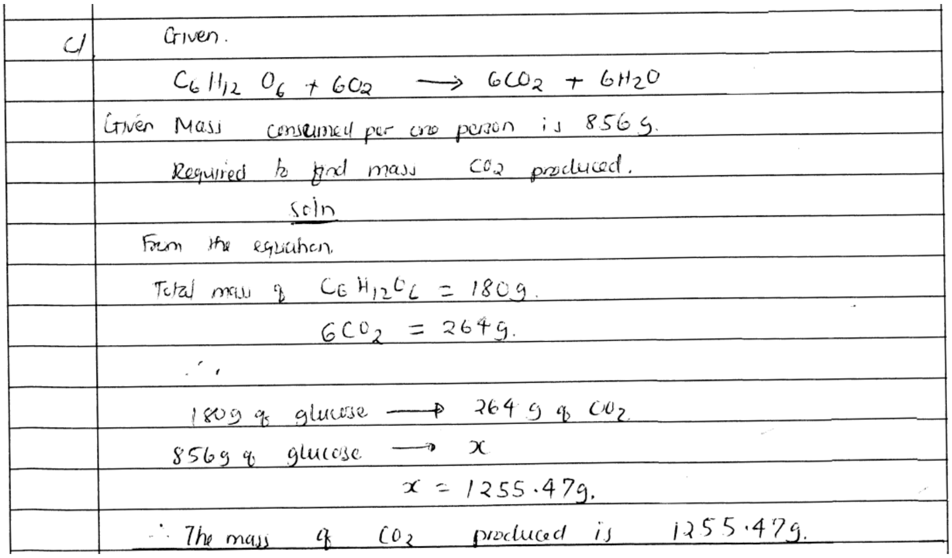
∴ $\frac{R_1}{R_2} = \sqrt{\frac{Mr_2}{Mr}}$

$\frac{R_1}{R_2} = \sqrt{\frac{352}{349}}$

$R_1/R_2 =$

$R_1 = 1.0043 R_2$.

∴ ∴ The compound $^{235}UF_6$ will have it diffusion which is greater by a factor of 1.0043 of the other compound.



c) Given.

$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$

Given Mass consumed per one person is 856 g.

Required to find mass CO_2 produced.

Soln

From the equation.

Total mass of $C_6H_{12}O_6 = 180$ g.

$6CO_2 = 264$ g.

∴

180 g of glucose → 264 g of CO_2

856 g of glucose → x

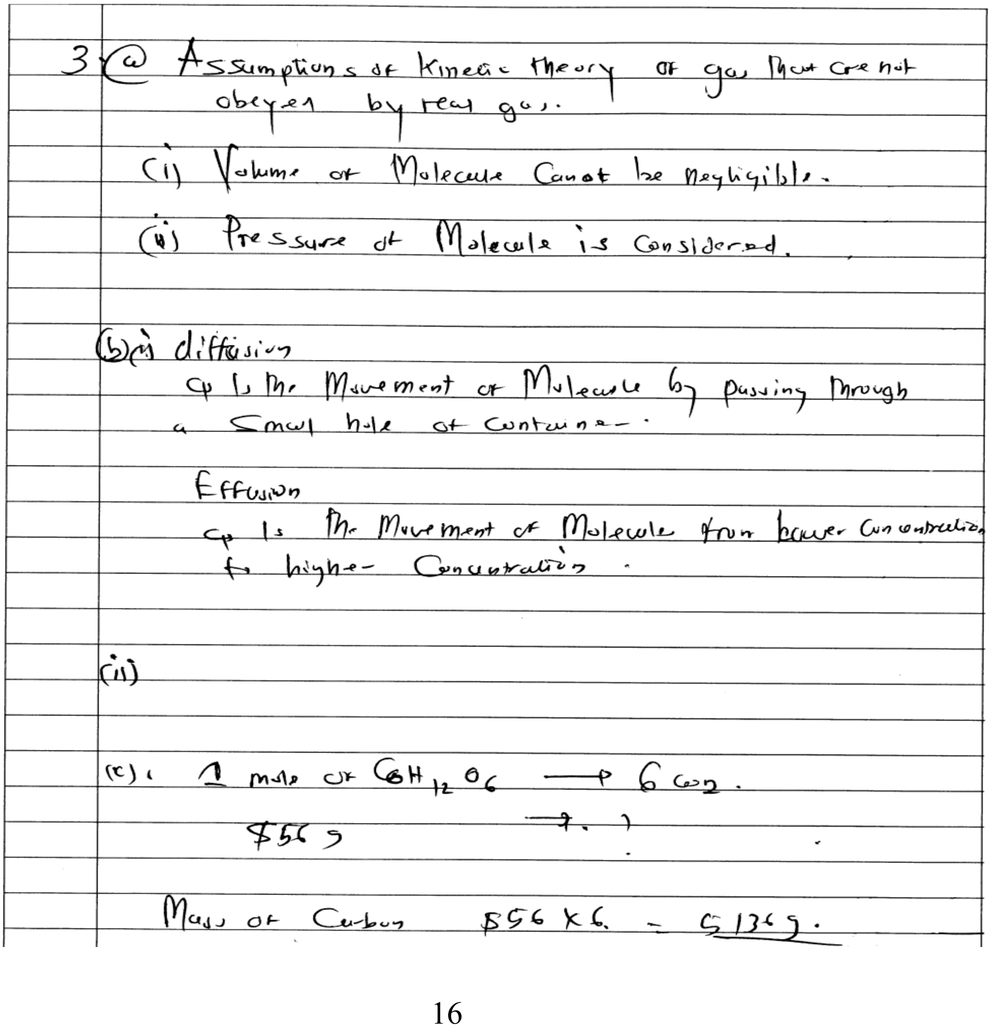
x = 1255.47 g.

∴ The mass of CO_2 produced is 1255.47 g.

In Extract 3.1, the candidate responded concisely to the question and arranged the work properly with appropriate formulas and calculations

On the other hand, the candidates who scored low marks had low descriptive ability in the assumptions of kinetic theory that are not obeyed by real gases;they alsoshowed low ability in differentiating effusion from diffusion. Some of them substituted inappropriate values in the ratio of the rate of diffusion of the two gaseous compounds. For example; some candidates substituted isotopic masses i.e. 235 and 238 as molar masses instead of 235 + (19 x 6) and 238 + (19 x 16) respectively as molar masses of the gaseous compounds, something which denied them of many marks. In part (c), some candidates were unable to relate the mass of glucose consumed with the stoichiometric equation for the breakdown of glucose, indicating insufficient knowledge in mole concept and related calculations which is also taught in ordinary level. Extract 3.2 represents a sample of a response from a candidate with low marks.

Extract 3.2



3 (a) Assumptions of Kinetic theory of gas that are not obeyed by real gas.

(i) Volume of Molecule Canot be negligible.

(ii) Pressure of Molecule is Considered.

(b)(i) diffusion

it is the Movement of Molecule by passing through a Small hole of Containe-.

Effusion

it is the Movement of Molecule from lower Concentration to higher Concentration.

(ii)

(c) i 1 mole of $C_6H_{12}O_6 \longrightarrow 6CO_2$.

856 g $\longrightarrow$?

Mass of Carbon 856 x 6 = 5136 g.

Responses in Extract 3.2 signify that the candidate had insufficient knowledge of all concepts in question. For example he/she interchanged the meaning of diffusion and effusion in part (b)(i) while he/she skipped (b)(ii).In part (c), he/she made inappropriate associationof the mass of glucose consumedwith CO_2produced, hence ended up with incorrect answer.

2.1.4 Question 4: Chemical Equilibrium

In part (a),the candidates were provided with four equilibrium equations and they were asked to write the equilibrium constant expression,K_c for each. In part (b) they were provided with equilibrium constant, K_c for the reaction$N_2O_{4(g)}2NO_{2(g)} \rightleftharpoons$as 4.63 x 10^{-3} at 25ºC and they were asked to determine the value of K_p at the given temperature. In part (c), the candidates were provided with equilibrium constants for hydro-sulphuric acid at 25ºC as follows:

$H_2S \rightleftharpoons H^+_{(aq)} + HS^-_{(aq)}$ $K_c = 9.5 \times 10^{-8}$and

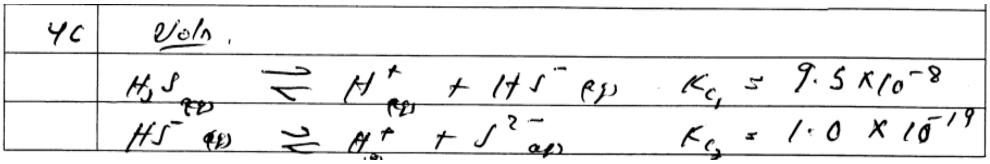
$HS^-_{(aq)} \rightleftharpoons H^+_{(aq)} + S^{2-}_{(aq)}$ $K_c = 1.0 \times 10^{-19}$.

Candidates were then required to calculate the equilibrium constant for the reaction $H_2S \rightleftharpoons 2H^+ + S^{2-}$at 25ºC.

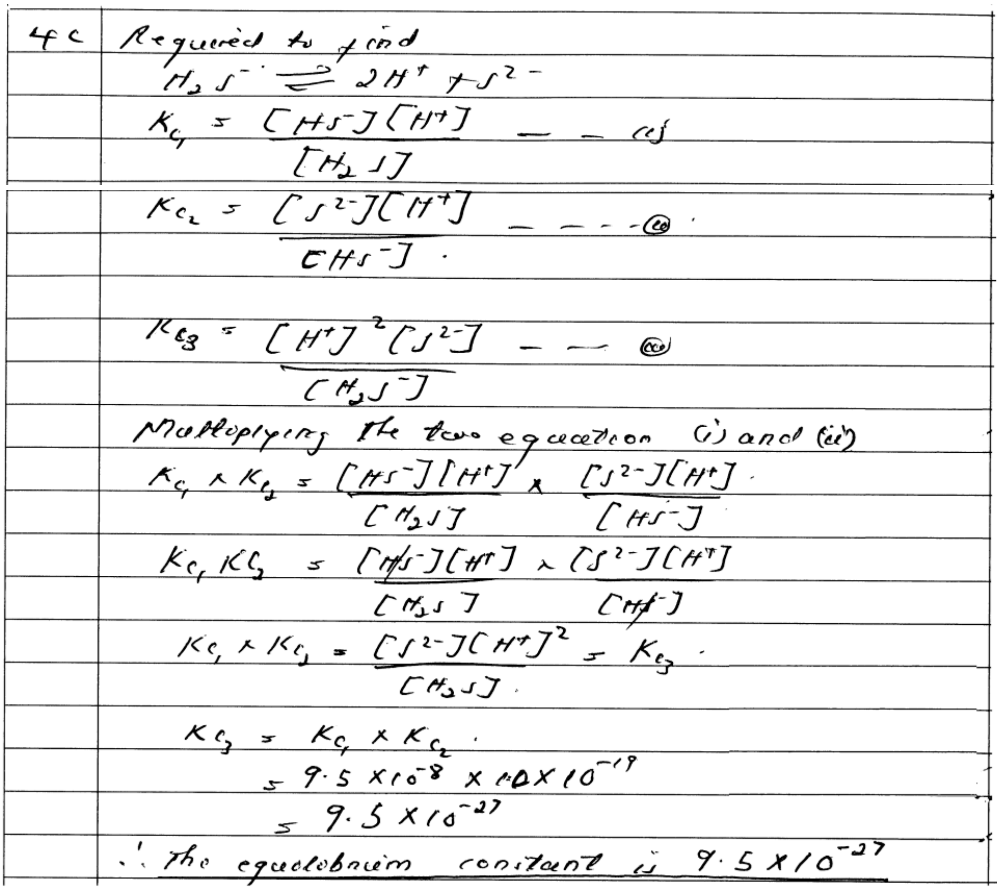
The question was attempted by most(87.6%) candidatesand the general performance was good as majority (85.9%) of the candidates scored 3 to 10 marks while a few(14.1%) scored 0 to 2.5 marks.It was noted that, 24.4 percent of the candidates scored 3 to 4.5 marks,46.2 percentscored 5 to 7 marks and 15.3 percent scored 7.5 to 10 marks of which 2.7 percent scored all the 10 marks.

The candidates who scored high marks attempted well all parts of the question. They wrote correct the equilibrium expressions, converted K_c to Kp with proper units andcalculated appropriately K_c for the given reaction. Extract 4.1 is just a part of the candidate's response with good answer.

Extract 4.1



4c	Soln.
	$H_2S_{(aq)} \rightleftharpoons H^+_{(aq)} + HS^-_{(aq)}$ $K_{c_1} = 9.5 \times 10^{-8}$
	$HS^-_{(aq)} \rightleftharpoons H^+_{(aq)} + S^{2-}_{(aq)}$ $K_{c_2} = 1.0 \times 10^{-19}$



4c Required to find

$H_2S^- \rightleftharpoons 2H^+ + S^{2-}$

$K_{c_1} = \frac{[HS^-][H^+]}{[H_2S]}$ — — (i)

$K_{c_2} = \frac{[S^{2-}][H^+]}{[HS^-]}$ — — — (ii)

$K_{c_3} = \frac{[H^+]^2[S^{2-}]}{[H_2S^-]}$ — — (iii)

Multiplying the two equation (i) and (ii)

$K_{c_1} \times K_{c_2} = \frac{[HS^-][H^+]}{[H_2S]} \times \frac{[S^{2-}][H^+]}{[HS^-]}$

$K_{c_1} K_{c_2} = \frac{\cancel{[HS^-]}[H^+]}{[H_2S]} \times \frac{[S^{2-}][H^+]}{\cancel{[HS^-]}}$

$K_{c_1} \times K_{c_2} = \frac{[S^{2-}][H^+]^2}{[H_2S]} = K_{c_3}$

$K_{c_3} = K_{c_1} \times K_{c_2}$

$= 9.5 \times 10^{-8} \times 1.0 \times 10^{-19}$

$= 9.5 \times 10^{-27}$

∴ The equilibrium constant is 9.5×10^{-27}

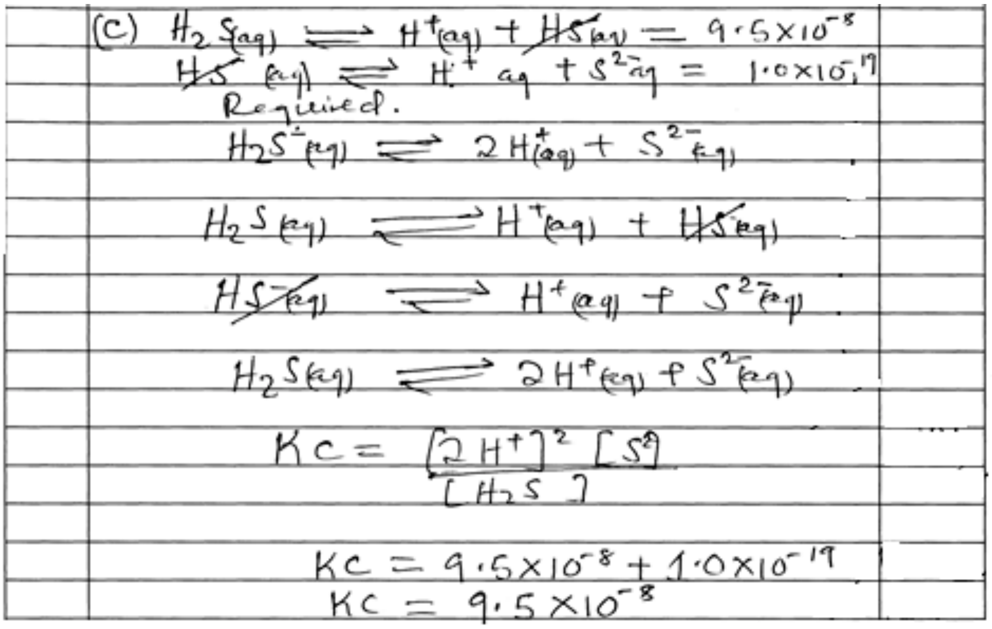
The work of the candidate shown by Extract 4.1 is an indication that the candidate was competent in Chemical Equilibrium. He/she managed to manipulate the given equations and made appropriate substitutions to obtain the correct value of equilibrium constant.

On the hand, candidates who scored low marks seemed to have inadequate knowledge about equilibrium reactions and its appropriate symbols. This is because some of them used ordinary brackets (   ) instead of square brackets [   ] to represent molarconcentration in writing equilibrium constant expression,K_c and therefore lost marks in part (a).In responding to part (c),some candidates were unable to combine the two equilibrium reactions to get the overall equilibrium reaction whose equilibrium constant was to be obtained by multiplying the equilibrium constants of two monobasic acids to get the equilibrium of the final dibasic acid. i.e$K_c = K'_c \times K''_c$where

$$K_c = \frac{[H+]^2[S^{2-}]}{[H_2S]},\quad K'_c = \frac{[H^+][HS^-]}{[H_2S]} \text{ and } \quad K''_c = \frac{[H^+][S^{2-}]}{[HS^-]}.$$

Extract 4.2 illustrates a case with inadequate response.

Extract 4.2



(c) $H_2S_{(aq)} \rightleftharpoons H^+_{(aq)} + \cancel{HS}_{(aq)} = 9\cdot5\times10^{-8}$

$\cancel{HS}\ (aq) \rightleftharpoons H^+\ aq + S^{2-}aq = 1\cdot0\times10^{-19}$

Required.

$H_2S^-_{(aq)} \rightleftharpoons 2H^+_{(aq)} + S^{2-}_{(aq)}$

$H_2S_{(aq)} \rightleftharpoons H^+_{(aq)} + \cancel{HS}_{(aq)}$

$\cancel{HS^-}_{(aq)} \rightleftharpoons H^+_{(aq)} + S^{2-}_{(aq)}$

$H_2S_{(aq)} \rightleftharpoons 2H^+_{(aq)} + S^{2-}_{(aq)}$

$$Kc = \frac{[2H^+]^2[S^2]}{[H_2S]}$$

$Kc = 9\cdot5\times10^{-8} + 1\cdot0\times10^{-19}$

$Kc = 9\cdot5\times10^{-8}$

In Extract 4.2 acandidate used a wrong approach by addingthe given two equations,instead of multiplying them to formulateone equation. However, the expression for K_c is not correct. Likewise, the candidate added the given two K_c constant values instead of multiplying and thus ended up with a wrong answer.

2.1.5 Question 5: Gases

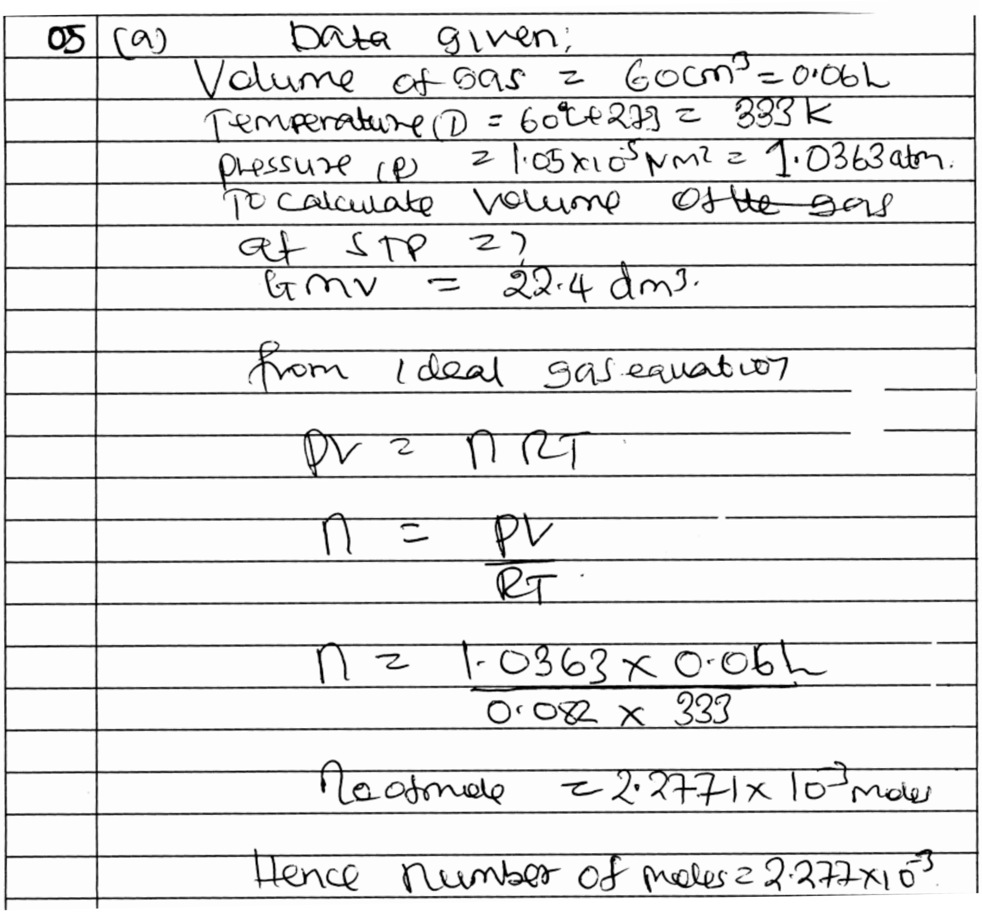
Part (a) of the question required the candidates to calculate the volume at stp of 60cm^3 of a certain gas which was collected at 60ºC and 1.05 x 10^5 NM^{-2}. In part (b),the candidates were required to calculate: partial pressure of each gas and mass of each gas when 0.5dm^3 of $O_2$and 1.0dm^3 of CO_2 were mixed at 27ºC where the total pressure in the vessel was found to be 1.2 atmospheres.

A large group (69.8%) of candidates attempted this question.A good number (65.8%) scored 3 marks and above out of which 31.3 percent scored 3 to 4.5 marks, 25.8 percent scored 5 to 7 marks and 8.7 percent managed to score

7.5 to 10 marks. Out of the small group (34.2%) which scored below 3 marks, 22.2 percent scored 0 to 1 mark and 12.0 scored 1.5 to 2.5 marks.

Candidates who scored high marks performed proper calculations involving gaseous interactions as demanded by the questions.In part (a), some candidatesused the Combined Gas Law ($\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$) while others used the Ideal Gas Equation (PV = nRT) to calculate the volume of the gas by correct manipulation of the given data and managed to attain to the same expected answer.In the same way, some candidates applied Dalton's Law of Partial Pressures and others appliedIdeal Gas Equation to calculate parameters in part (b). Extract 5.1 isa sample good answer.

Extract 5.1



05 (a) Data given;

Volume of gas = $60cm^3 = 0.06L$

Temperature (T) = $60°C+273 = 333K$

pressure (P) = $1.05\times10^5 Nm^2 = 1.0363atm.$

To calculate volume of ~~the gas~~

at STP =?

GMV = $22.4 dm^3$.

from ideal gas equation

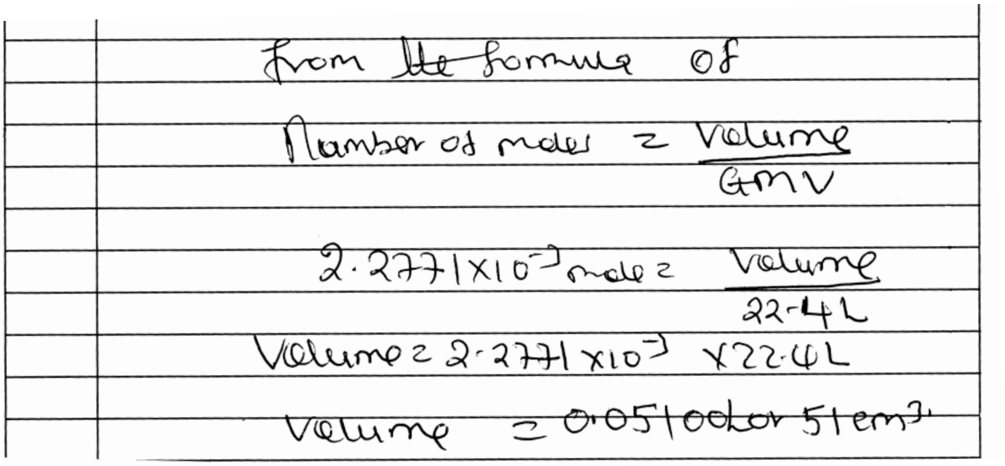
$PV = nRT$

$n = \frac{PV}{RT}$

$n = \frac{1.0363 \times 0.06L}{0.082 \times 333}$

No of mole $= 2.2771 \times 10^{-3}$ moles

Hence number of moles $= 2.277 \times 10^{-3}$



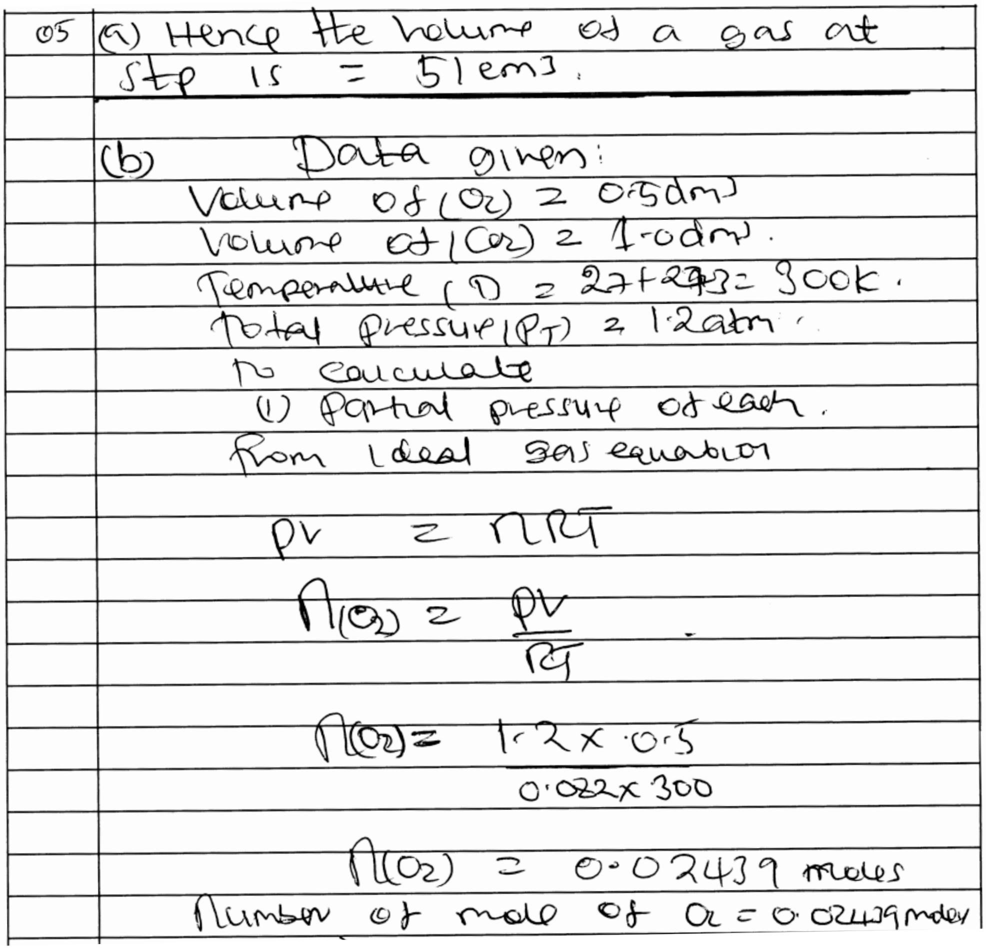
from the formula of

Number of moles = $\frac{\text{Volume}}{\text{GMV}}$

2.2771×10^{-3} mole = $\frac{\text{Volume}}{22.4L}$

Volume = $2.2771 \times 10^{-3} \times 22.4L$

Volume = 0.05100L or 51cm³.



05 (a) Hence the volume of a gas at stp is = 51cm³.

(b) Data given:

Volume of (O_2) = 0.5dm³

Volume of (CO_2) = 1.0dm³.

Temperature (T) = 27+273 = 300K.

Total pressure (P_T) = 1.2atm.

To calculate

(i) Partial pressure of each.

From Ideal gas equation

$$PV = nRT$$

$$n_{(O_2)} = \frac{PV}{RT}$$

$$n_{(O_2)} = \frac{1.2 \times 0.5}{0.082 \times 300}$$

$$n(O_2) = 0.02439 \text{ moles}$$

Number of mole of O_2 = 0.02439 moles

and also

$$n_{(CO_2)} = \frac{PV}{RT}$$

$$n_{(CO_2)} = \frac{1.2\times 1}{0.082\times 300}$$

$n_{(CO_2)} = 0.04878$ moles

number of mole of $CO_2 = 0.04878$

05(b) $n_{(O_2)} = 0.02439$ moles

$n_{(CO_2)} = 0.04878$ moles

Total number of mole $= 0.02439 + 0.04878$

$n_T = 0.0732$ mole.

Hence: $$P'(O_2) = \frac{n_{O_2}}{n_T}\times P_T$$

$$P'(O_2) = \frac{0.02439}{0.0732}\times 1.2$$

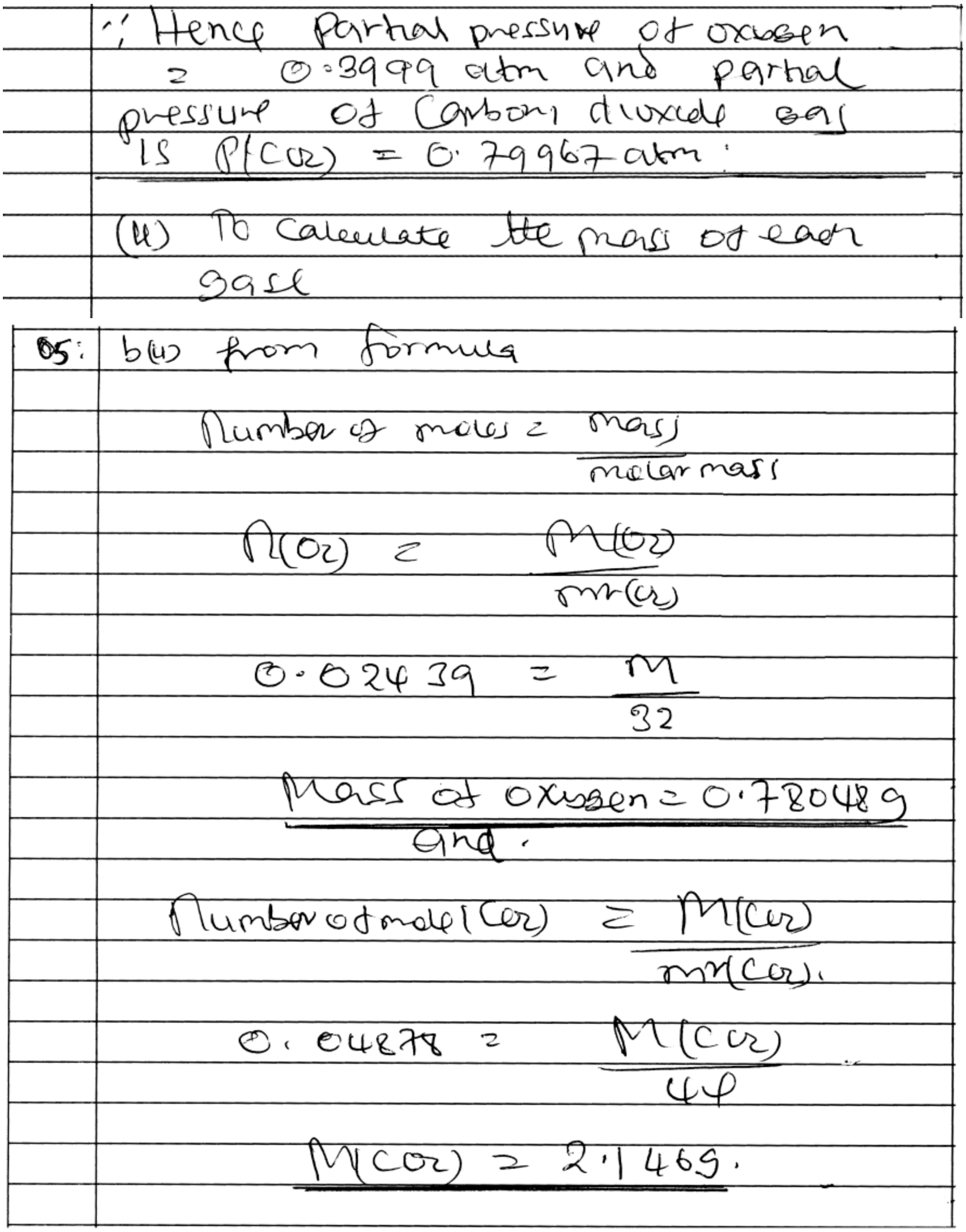
$P'(O_2) = 0.3999$ atm:

and

$$P'(CO_2) = \frac{n_{(CO_2)}}{n_T}\times P_T$$

$$P'(CO_2) = \frac{0.04878}{0.0732}\times 1.2$$

$P'(CO_2) = 0.79967$ atm



∴ Hence partial pressure of oxygen = 0.3999 atm and partial pressure of carbon dioxide gas is $P(CO_2) = 0.79967$ atm.

(ii) To calculate the mass of each gase

05: b(ii) from formula

$$\text{Number of moles} = \frac{\text{mass}}{\text{molar mass}}$$

$$n(O_2) = \frac{M(O_2)}{mr(O_2)}$$

$$0.02439 = \frac{M}{32}$$

$$\underline{\text{Mass of oxygen} = 0.78048\ g}$$

and.

$$\text{Number of mole}(CO_2) = \frac{M(CO_2)}{mr(CO_2)}.$$

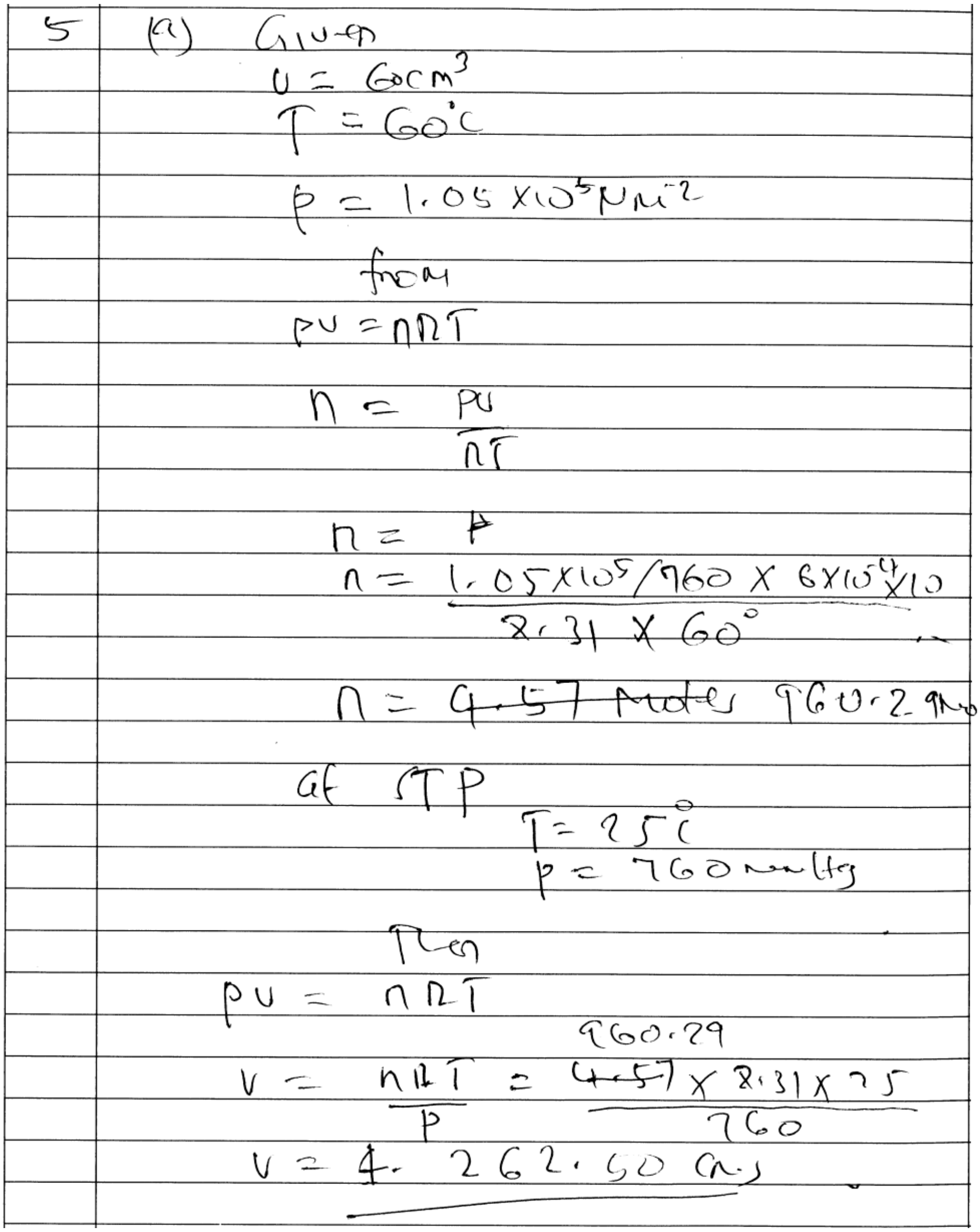
$$0.04878 = \frac{M(CO_2)}{44}$$

$$\underline{M(CO_2) = 2.1465.}$$

In Extract 5.1, the candidate put forward relevant formulae for the approaches he/she applied in all parts in the calculationof the values required by the question.

On the other part, candidates who scored low marks were unable to carry out calculations particularly those involving gas laws and to calculate new volumes at s. t. p. They also failed to carry out calculations pertaining to partial pressures. For example, some candidates had the idea about the formulae to be used i.e. PV = nRTor Dalton's Law of Partial Pressures,but they failed to utilize the formulae and the provided volumes and pressures at the given temperature to calculate the partial pressures of the individual gases indicating insufficient knowledge about gas laws. Extract 5.2 shows a sample response.

Extract 5.2



5 (a) Given

$v = 60cm^3$

$T = 60°C$

$p = 1.05 \times 10^5 Nm^{-2}$

from

$pv = nRT$

$n = \frac{pv}{RT}$

$n = \cancel{P}$

$n = \frac{1.05\times10^5/760 \times 6\times10^{-4}\times10}{8.31 \times 60°}$

$n =$ ~~4.57 moles~~ 760.29mo

at STP

$T = 25°C$

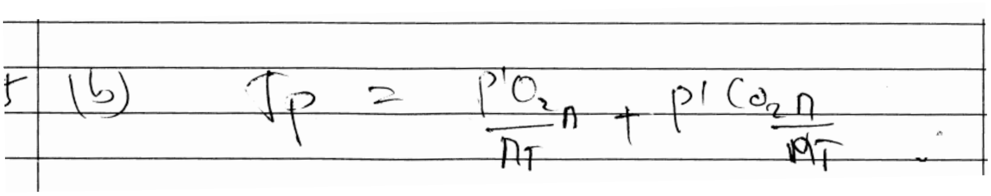
$p = 760mmHg$

Then

$pv = nRT$

$v = \frac{nRT}{P} = \frac{\overset{760.29}{\cancel{4.57}} \times 8.31 \times 25}{760}$

$v =$ ~~4.~~ 262.50 cm3



(b) $Tp = \frac{P'O_2 n}{n_T} + \frac{P' Co_2 n}{n_T}$

In part (a) of Extract 5.2, the candidate calculated incorrectly the volume of the gas at s.t.p. Similarly, he/she merely wrote the formula for total pressure in part (b) without any further proceeding.

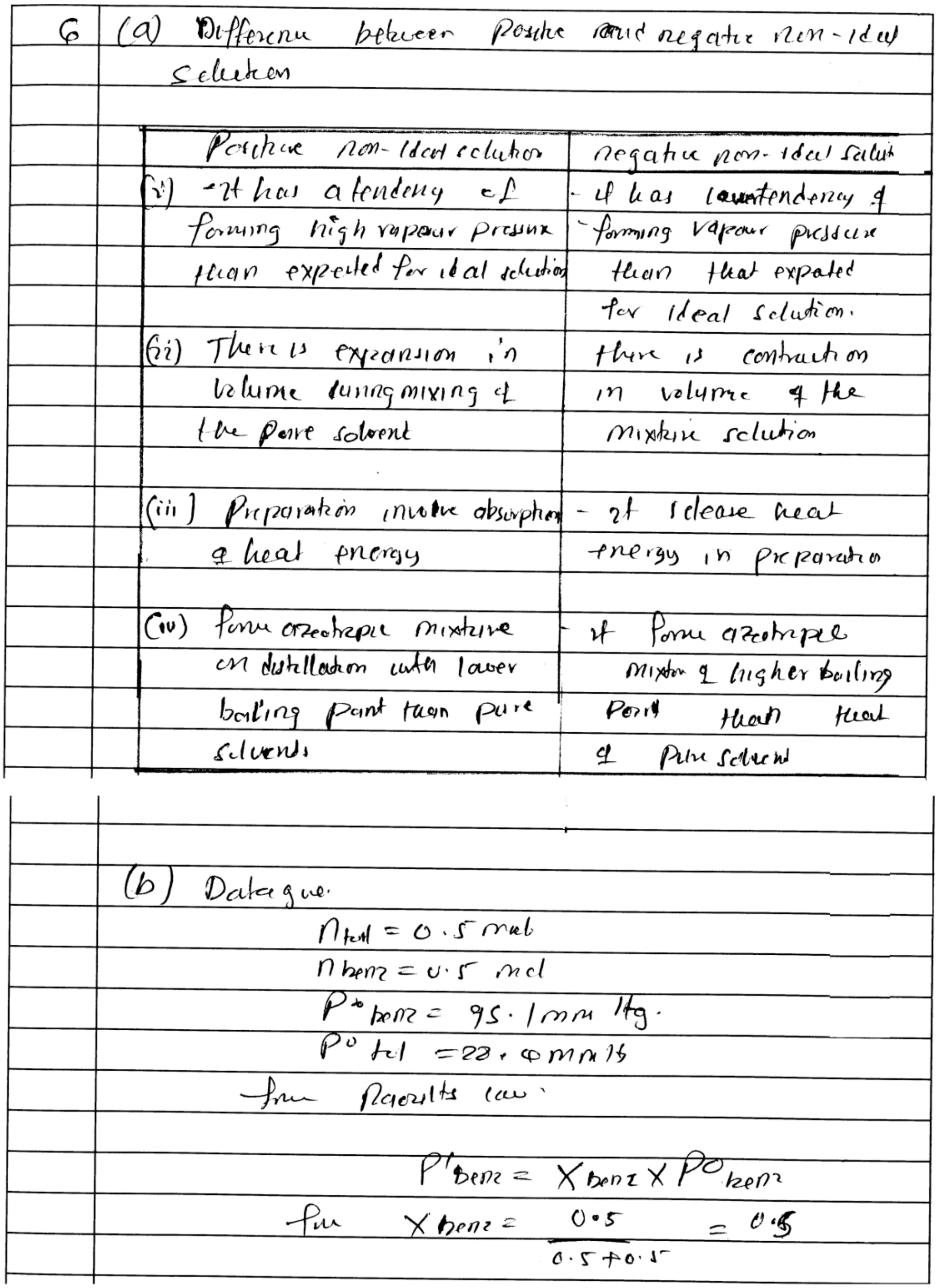
2.1.6 Question 6: Two Component LiquidSystems

Part (a) of the question required candidates to give any four differences between positive and negative non-ideal solutions. In part (b) candidates were asked to calculate the fraction of benzene and that of toluene in the second vapour, when equal moles (0.5 moles) of benzene and toluene were mixed to form an ideal solution given that P^o benzene = 95.1 mmHg and P^o toluene = 28.4 mmHg.

The question was attempted by almost half (49.8%) of the candidates and the performance was good as majority of candidates (71.1%) scored 3 to 10 marks out of which 27.3 percent scored 3 to 4.5 marks and 29.5 scored 5 to 7 marks. Moreover, 14.3percent scored 7.5 marks or above.

The candidate who had good performance managed to give all four differences between positive and negative non – ideal solutions as enquired. Theywere also able to calculatecorrectly the fractions of benzene and toluene in the second vapour from the provided data. Extract 6.1 illustrates a good response.

Extract 6.1



6 (a) Difference between Positive and negative non-ideal solution

Positive non-Ideal solution	negative non-ideal solution
(i) - It has a tendency of forming high vapour pressure than expected for ideal solution	- It has lowertendency of forming vapour pressure than that expected for ideal solution.
(ii) There is expansion in volume during mixing of the pure solvent	there is contraction in volume of the mixture solution
(iii) Preparation involve absorption of heat energy	- It release heat energy in preparation
(iv) Form azeotrope mixture on distillation with lower boiling point than pure solvents	- It form azeotrope mixture of higher boiling point than that of pure solvent

(b) Data given.

$n_{tol} = 0.5$ mol

$n_{benz} = 0.5$ mol

$P^o_{benz} = 95.1$ mm Hg.

$P^o_{tol} = 28.4$ mmHg

from Raoult's law:

$P'_{benz} = X_{benz} \times P^o_{benz}$

for $X_{benz} = \frac{0.5}{0.5+0.5} = 0.5$

6 (b)

$P_{benz} = 0.5 \times 95.1$ mmHg

$P_{benz} = 47.55$ mmHg.

$X_{tol} = 1 - 0.5 = 0.5$

$P_{tol} = X_{tol} \times P^{o}_{tol}$

$= 0.5 \times 28.4$

$= 14.2$ mmHg

$P_T = (14.2 + 47.55)$ mmHg

$P_T = 61.75$ mmHg.

from:

composition in second vapour

$X_{benz} = \frac{P_{benz}}{P_T}$

$X_{benz} = \frac{47.55}{61.75} = 0.77$

$X_{tol} = \frac{P_{tol}}{P_T}$

$X_{tol} = \frac{14.2}{61.75} = 0.23$

The in Secn.

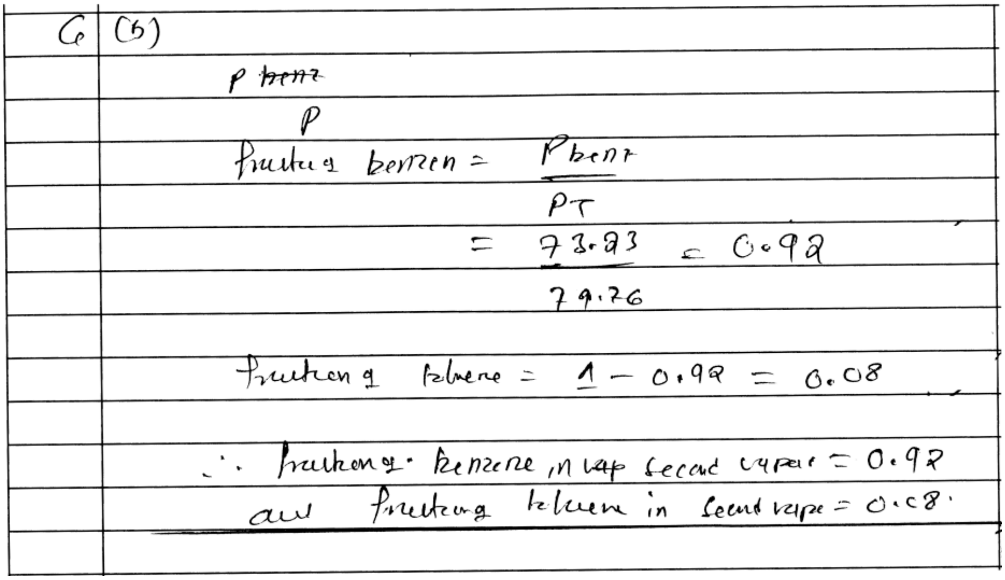
$P'_{benz} = 0.77 \times 95.1$

$= 73.23$ mmHg.

$P_{tol} = 0.23 \times 28.4$

$= 6.53$ mHg

$P_T = 73.23 + 6.53 = 79.76$



6 (b)

~~P benz~~

P

fraction of benzen = $\frac{P_{benz}}{P_T}$

= $\frac{73.23}{79.76}$ = 0.92

fraction of toluene = 1 − 0.92 = 0.08

∴ fraction of benzene in vap second vapour = 0.92

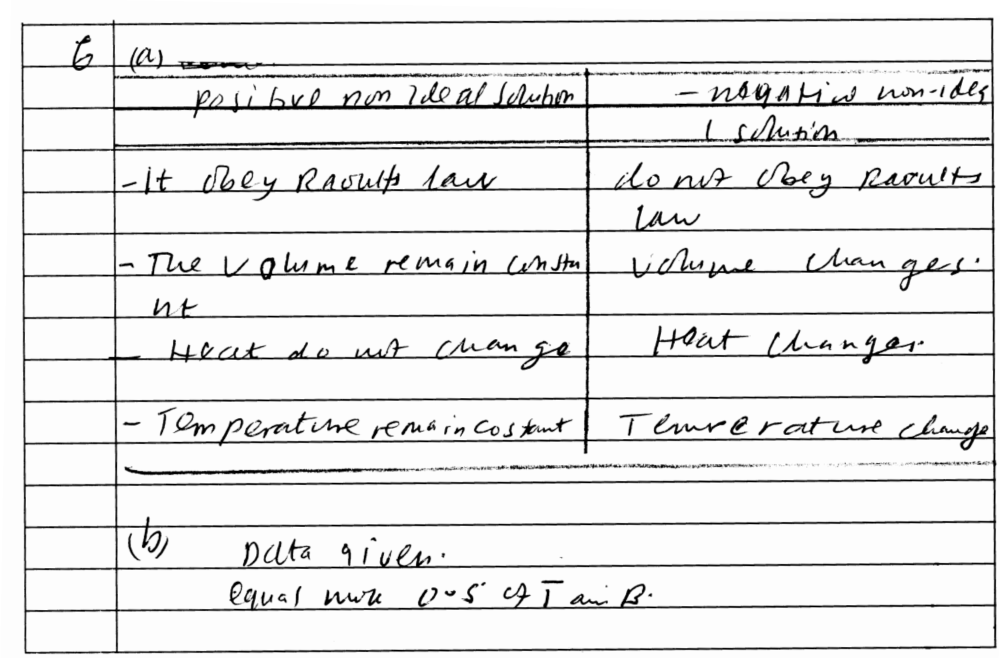
and fraction toluen in second vape = 0.08.

The answers in Extract 6.1 indicate that the candidate had sufficient knowledge onTwo Component Liquid Systems as he/she presented his/her work correctly and systematically.

On the contrary, the candidates who scored low marks in this question failed to give all four differences between a positive and a negative non – ideal solution. Some of them managed to mention one to three differences while some interchanged ideas. For example, “*Positive deviation non-ideal form azeotropic mixture with maximum boiling point while negative deviation forms azeotropic mixture with minimum boiling point*” to mention just one.

On responding to part (b), some candidates stacked in the very initial stages in an attempt to find the total pressure hence they failed to calculate the composition of benzene and toluene in the first vapour.In another case, some candidatesfailed to calculate total pressure in the first condensation which led to incorrect calculation of mole fraction of benzene and toluene in second vapour. This implies that candidates had inadequate knowledge about the topic.However, candidates who scored zero failed all parts of the question as Extract 6.2 shows.

Extract 6.2

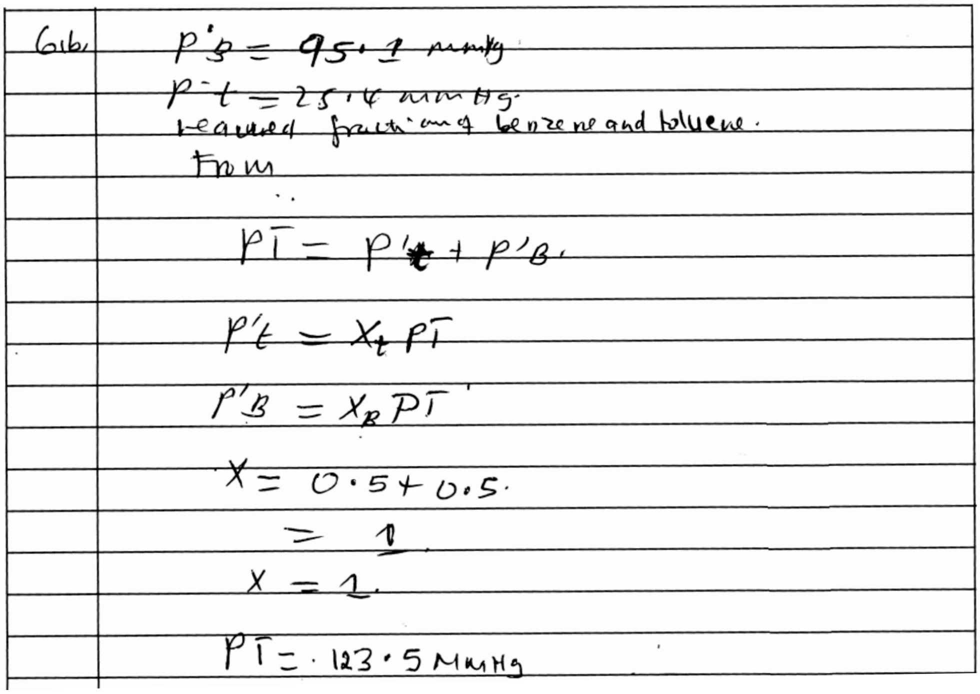


6 (a)

positive non ideal solution	- negative non-ideal solution
-It obey Raoults law	do not obey Raoults law
- The volume remain constant	volume changes.
- Heat do not change	Heat changes.
- Temperature remain costant	Temrerature change

(b) Data given.

equal mole 0.5 of T and B.



6(b) ~~$P^\circ_B = 95.1$ mmHg~~

~~$P^\circ t = 25.4$ mmHg.~~

required fraction of benzene and toluene.

From

$PT = P' + P'_B.$

$P'_t = X_t PT$

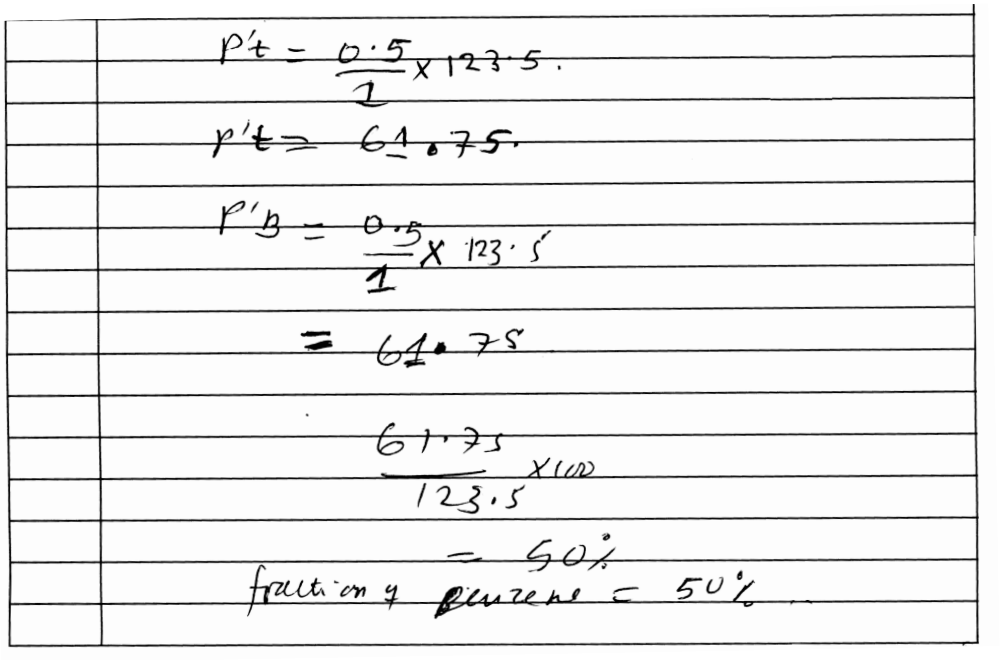
$P'_B = X_B PT$

$X = 0.5 + 0.5.$

$= 1$

$X = 1.$

$PT = 123.5$ MmHg



$P't = \frac{0\cdot5}{1} \times 123\cdot5.$

$P't = 61.75.$

$P'B = \frac{0.5}{1} \times 123\cdot5$

$= 61.75$

$\frac{61\cdot75}{123.5} \times 100$

$= 50\%$

fraction of benzene = 50%

In Extract 6.2 the candidate gave incorrect differences between a positive and a negative non-ideal solution. In the first steps of part (b), the candidate managed to write the appropriate formulae for total pressure but he/she made incorrect substitution of data hence failed to proceed correctly to calculate the fractions of benzene and toluene in the second vapour.

2.1.7 Question 7: Relative Molecular Masses in Solution

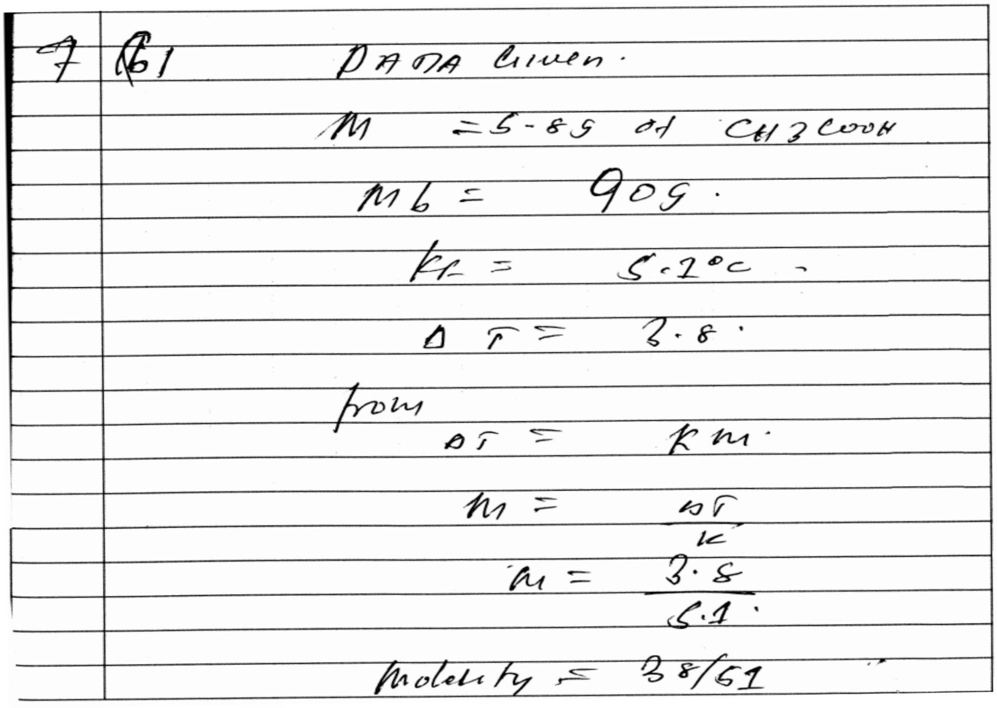
Part (a) of this question required the candidates to calculate the osmotic pressure (π) of 0.01 M aqueous solution of NaCl whose degree of dissociation is 92.5% at 18ºC. Part (b) stated; *When 5.8g of acetic acid* (CH_3CO_2H)*was dissolved in 90g of benzene the freezing point depression was found to be 3.8ºC.*Candidates were then required to calculate the degree of association of acetic acid in benzene, given that acetic acid dimerizes in benzene and $K_f = 5.1^\circ C\ mol^{-1}kg^{-1}$.

The question was attempted by 41.7 percentof the candidates, out of which 55.1 percent scored 0 to 2.5 marks and 44.9 percent scored 3 marks or above out of 10 marks.Out of the candidates who scored above 2.5 marks, 28.0 percent scored 3 to 4.5 marks, 12.2 percent scored 5 to 7 marks while 4.7 percent scored 7.5 to 10 marks indicating an average performance.

The performance was average due to the fact that, majority of the candidates responded partially to all parts of the question. In attempting part (a),they managed to put forward the preliminary formulae like, $\alpha = \frac{i-1}{n-1}$ where $i = \frac{\pi - \text{observed}}{\pi - \text{calculated}}$ and $\pi - \text{calculated} = \frac{nRT}{V}$.However, majority of the candidates failed to realize that $\frac{n}{V}$ is the molarity hence were unable to calculate the observed osmotic pressure, thus, they scored partial marks in this part. Likewise,some candidates failed to calculate the freezing point depression produced by the given mass of acetic acid which could help them to calculate VantHoffs factor (i) which then could be used to calculate degree of association.

The candidates who scored zero(3.6%) marks failed to respond correctly to either part of the question as Extract 7.1 portrays. However, few (0.3%) candidates who scored all 10 marks in the question managed to put forward suitable formulae and substituted the given parameters appropriately. Extract 7.2gives a good response.

Extract 7.1



7 (b) DATA Given.

$M = 5.8g$ of CH_3COOH

$Mb = 90g$.

$Kf = 5.1°c$

$\Delta T = 3.8$.

from

$\Delta T = Km$.

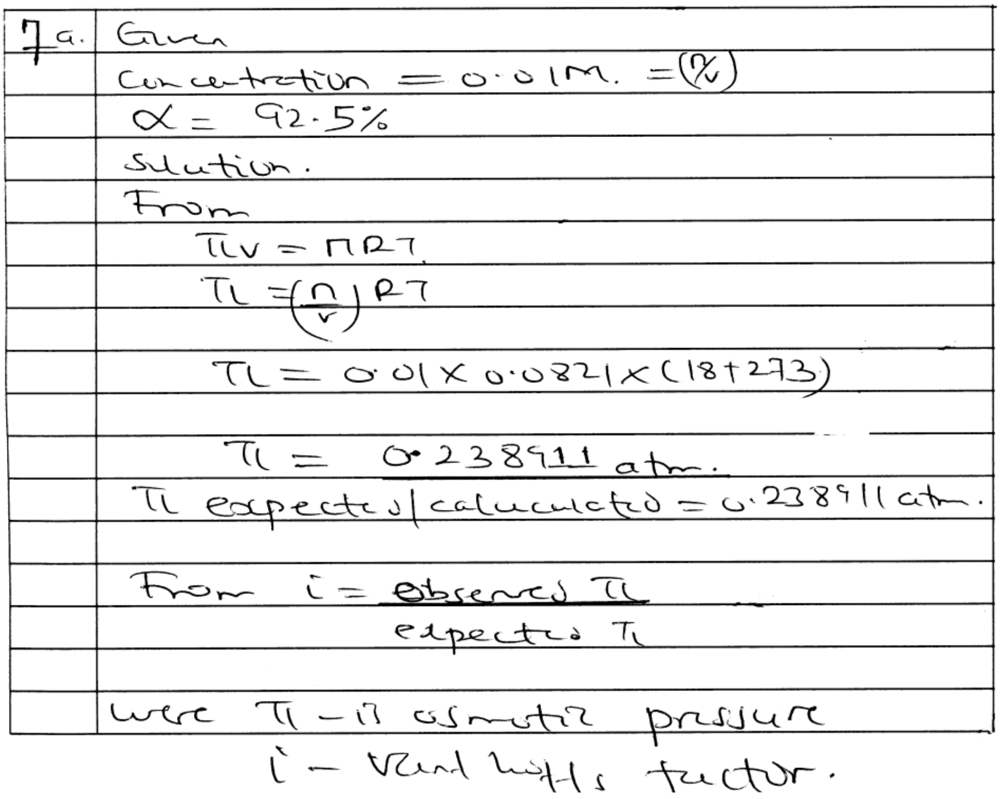
$m = \frac{\Delta T}{K}$

$m = \frac{3.8}{5.1}$

Molality $= 38/51$

Extract 7.1 is a response to part (b) of the question where a candidate presented data and few calculations which were not of any use to give a correct response.

Extract 7.2



7a. Given

Concentration $= 0.01M. = (\frac{n}{v})$

$\alpha = 92.5\%$

Solution.

From

$\pi V = nRT$

$\pi = (\frac{n}{v}) RT$

$\pi = 0.01 \times 0.0821 \times (18+273)$

$\pi = \underline{0.238911}$ atm.

π expected/calucucted $= 0.238911$ atm.

From $i = \frac{\text{observed } \pi}{\text{expected } \pi}$

were π - is osmotic pressure

i - Vant hoffs factor.

observed π = expected $\pi \times i$

~~tra~~ from

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

7c

Consider

$NaCl \longleftrightarrow Na^{+} + Cl^{-}$

$N = 2$

$$0.925 = \frac{i-1}{2-1}$$

$i = 1.925$

observed $\pi = 1.925 \times 0.238911$

$= 0.459903675$ atm

7(b) solution.

Finding expected freezing point depression

From

$$\Delta T = \frac{K_f \, m_{so}}{M_{so} \, M_{sv}(kg)}$$

where

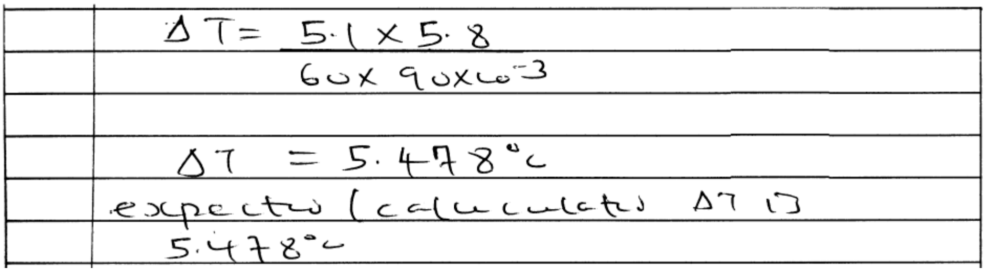
ΔT – depression in freezing point

K_f – cryscopic constant = 5.1°c

m_{so} – mass of solute (5.8g)

M_{sv} – mass of solvent (90×10^{-3})

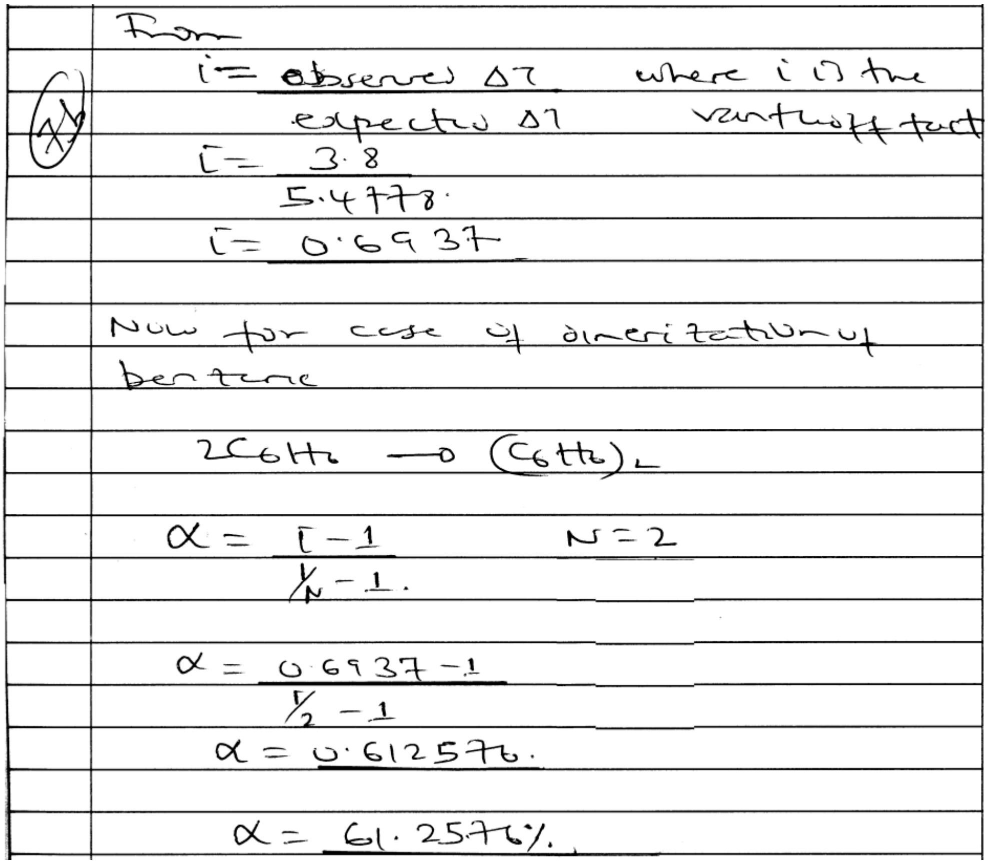
M_{so} – Molar mass of solute (60g/mol



$\Delta T = \frac{5.1 \times 5.8}{60 \times 90 \times 10^{-3}}$

$\Delta T = 5.478°c$

expected (calculated ΔT is $5.478°c$



From

$i = \frac{\text{observed } \Delta T}{\text{expected } \Delta T}$ where i is the vant hoff fact

$i = \frac{3.8}{5.4778}$

$i = 0.6937$

Now for case of dimerization of benzene

$2C_6H_6 \rightarrow (C_6H_6)_2$

$\alpha = \frac{i - 1}{1/N - 1}$ $N = 2$

$\alpha = \frac{0.6937 - 1}{1/2 - 1}$

$\alpha = 0.612576.$

$\alpha = 61.2576\%.$

The answers in Extract 7.2 signify that the candidate was competent in the inquired responses. Relevant formulae are applied and appropriate substitution of the data is made in all parts of the question and eventually, correct answers areattained.

2.1.8 Question 8: Energetics

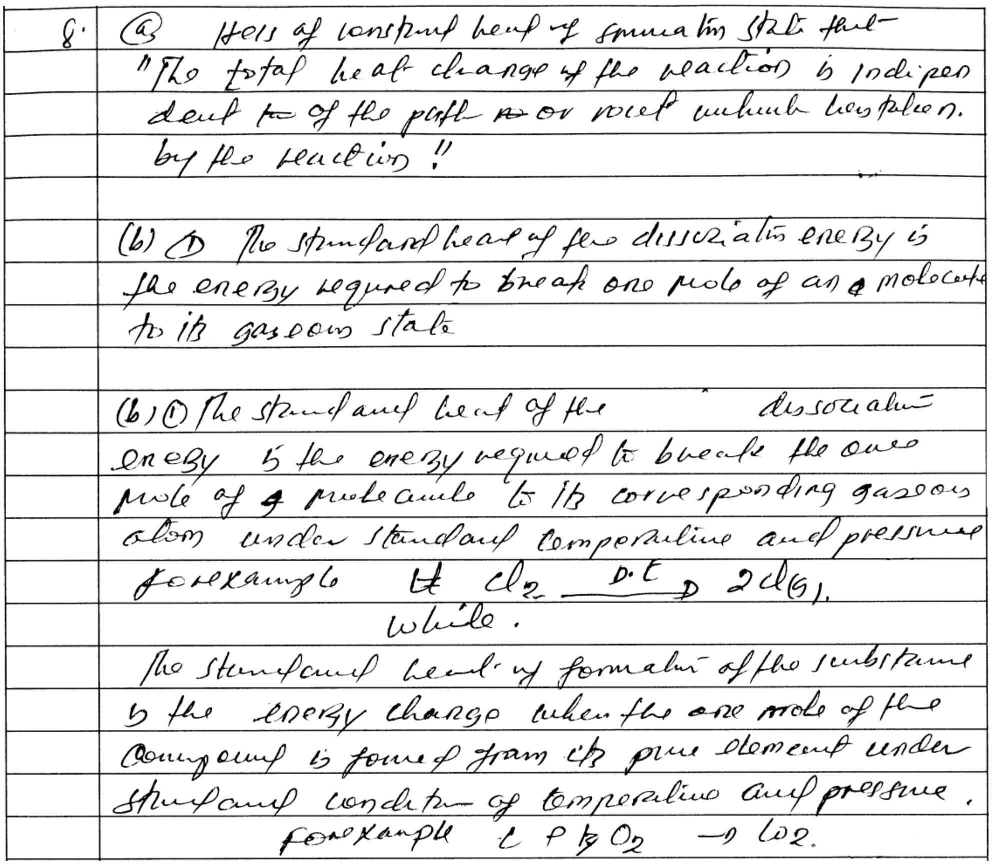
In part (a) of the question, candidates were required to state Hess's law of constant heat summation. Part (b) asked candidates to give the differences between the standard bond dissociation energy and standard heat of formation of a substance and calculate the enthalpy change for the reaction

$2NH_{3(g)} \rightarrow N_{2(g)} + 3H_{2(g)}$ given that E(N – H) = 288kJmol^{-1}, E(N≡N) = 944kJmol^{-1} and E(H-H) = 436kJmol^{-1}.

This question was attempted by a good number (87.3%) of candidates and out of which, majority (77.9%) scored 3 to 10 marks.The percentage of candidates who scored 3 to 4.5 marks was 32.1 whereas the percentage of candidates who scored 5.0 to 7.0 marks was 38.9. Additionally, 6.9 percent scored 7.5 marks to 10, a trend that designates good performance.

Candidates who scored high marks stated properly Hess's law of constant heat summation and gave proper differences between the standard bond dissociation energy and standard heat of formation of a substance. They also managed to calculate correctly the enthalpy change for the reaction $2NH_{3(g)} \rightarrow N_{2(g)} + 3H_{2(g)}$ from the provided bond energies. Extract 8.1 shows a sample good response.

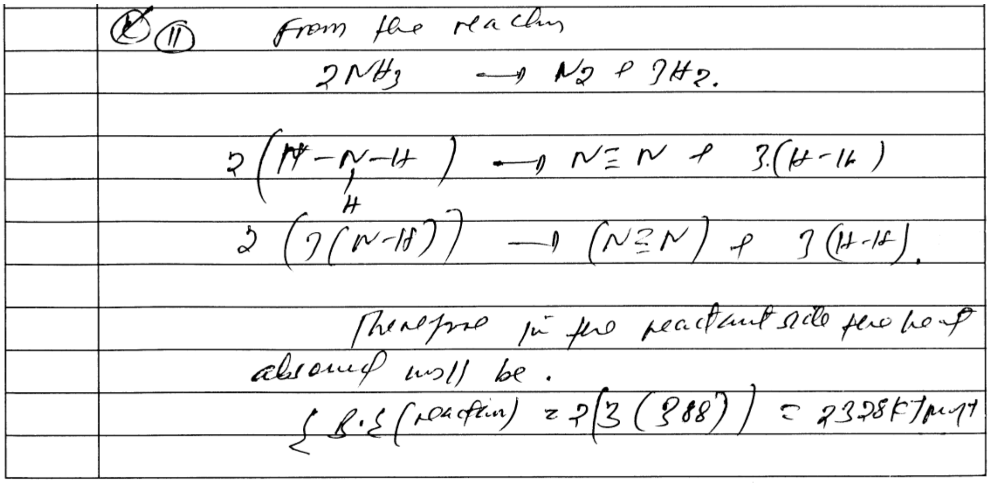
Extract 8.1



8. (a) Hess of constant heat of summation state that
"The total heat change of the reaction is indipen
dent ~~to~~ of the path ~~to~~ or root which has taken.
by the reaction !"

(b) (i) The standard heat of the dissociation energy is
the energy required to break one mole of an ~~a~~ molecule
to its gaseous state

(b) (i) The standard heat of the dissociation
energy is the energy required to break the one
mole of ~~a~~ moleaule to its corresponding gaseous
atom under standard temperature and pressure
forexample Et $Cl_2 \xrightarrow{D.E} 2Cl_{(g)}$.
while.
The standard heat of formation of the substance
is the energy change when the one mole of the
compound is formed from its pure element under
standard condition of temperature and pressure.
forexample $C + O_2 \rightarrow CO_2$.


(c)(ii) From the reaction

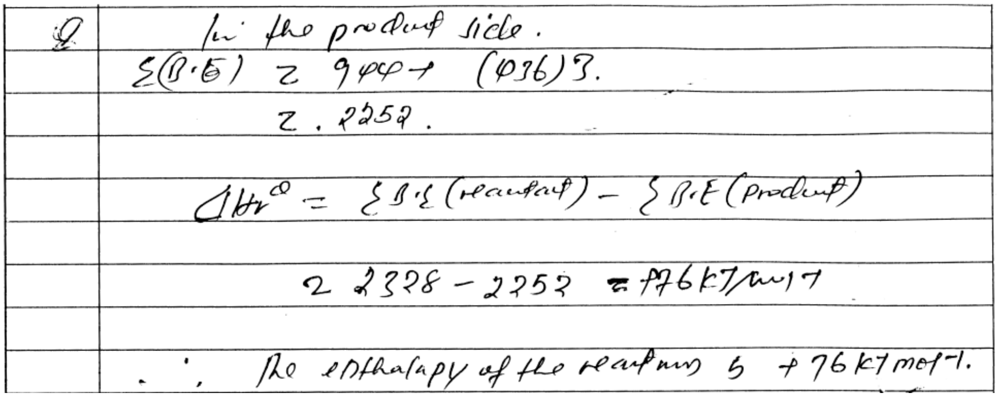
$2NH_3 \rightarrow N_2 + 3H_2$.

$2(H-\underset{H}{N}-H) \rightarrow N\equiv N + 3(H-H)$

$2(3(N-H)) \rightarrow (N\equiv N) + 3(H-H)$.

Therefore in the reactant side the heat absorbed will be.

$\Sigma B.E(reaction) = 2[3(388)] = 2328 kJ/mol$


(c) In the product side.

$\Sigma(B.E) = 944 + (436)3$.

$= 2252$.

$\Delta H_r^\circ = \Sigma B.E(reactant) - \Sigma B.E(product)$

$= 2328 - 2252 = +76 kJ/mol$

∴ The enthalpy of the reaction is $+76 kJ mol^{-1}$.

Extract 8.1 shows a response from the candidate who performed well in this question. All workings are well organized and the responses are precisely presented.

On the other part, candidates who scored low marksfailed to state Hess's law of constant heat summation. They also failed to differentiate between the standard bond dissociation energy and standard heat of formation of a substance.Equally, they did not succeed to calculate the standard heat of formation of a substance from bond energies because they failed to identify the number of bonds broken and those formed in the given reaction and as a result they ended up with unanticipated answers. Extract 8.2 reveals one of these cases.

Extract 8.2

8 a)

b) i) Standard bond dissociation energy is the amount of energy of the mole mole which required to breeke bond or to form bond While Standard heat of formation refer to the heat change when one mole of substance required to form a compound.

In standard bond it has

$\Sigma_f^\circ H_{(R)} - \Sigma_f^\circ H_{(P)}$

In heat formation of substance

$= \Sigma f^\circ H_{(P)} - \Sigma f^\circ H_{(P)}$

ii) $2NH_3 \longrightarrow N_2 + 3H_2$

Product

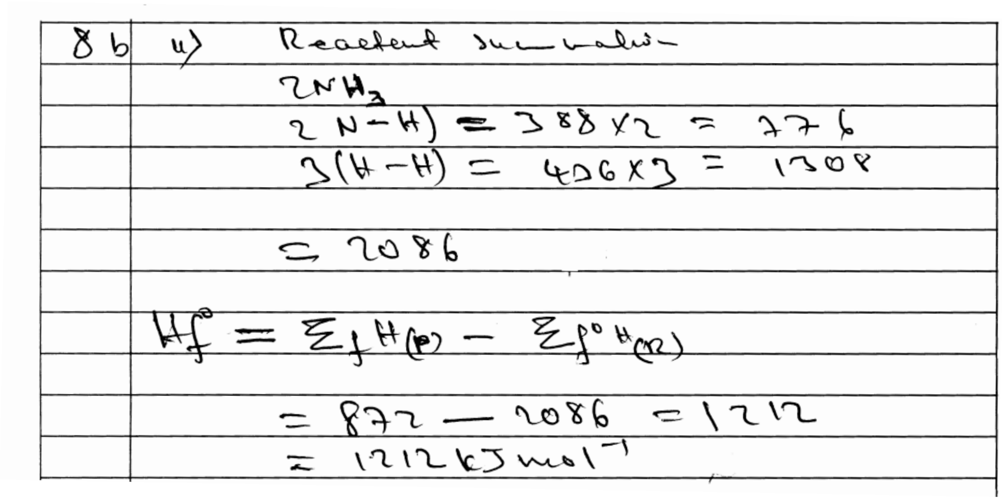
$N_2 + 3H_2$

$(N \equiv N) = 944$

$2(H-H) = 436 \times 2 = 872$

Total = 872

Reactant



8 b	ii) Reactant sum value –
	2NH$_3$
	2 N–H) = 388 x2 = 776
	3(H–H) = 436 x3 = 1308
	= 2086
	$H_f^{\circ} = \Sigma_f H_{(P)} - \Sigma_f^{\circ} H_{(R)}$
	= 872 — 2086 = 1212
	= 1212 kJ mol^{-1}

In Extract 8.2, the candidate left Hess's law unstated in part (a) and failed to differentiate the given terms in part (b). Likewise, he/she failed to identify the correct number of bonds in the reactants and products sides as a result he/she obtained unexpected answer.

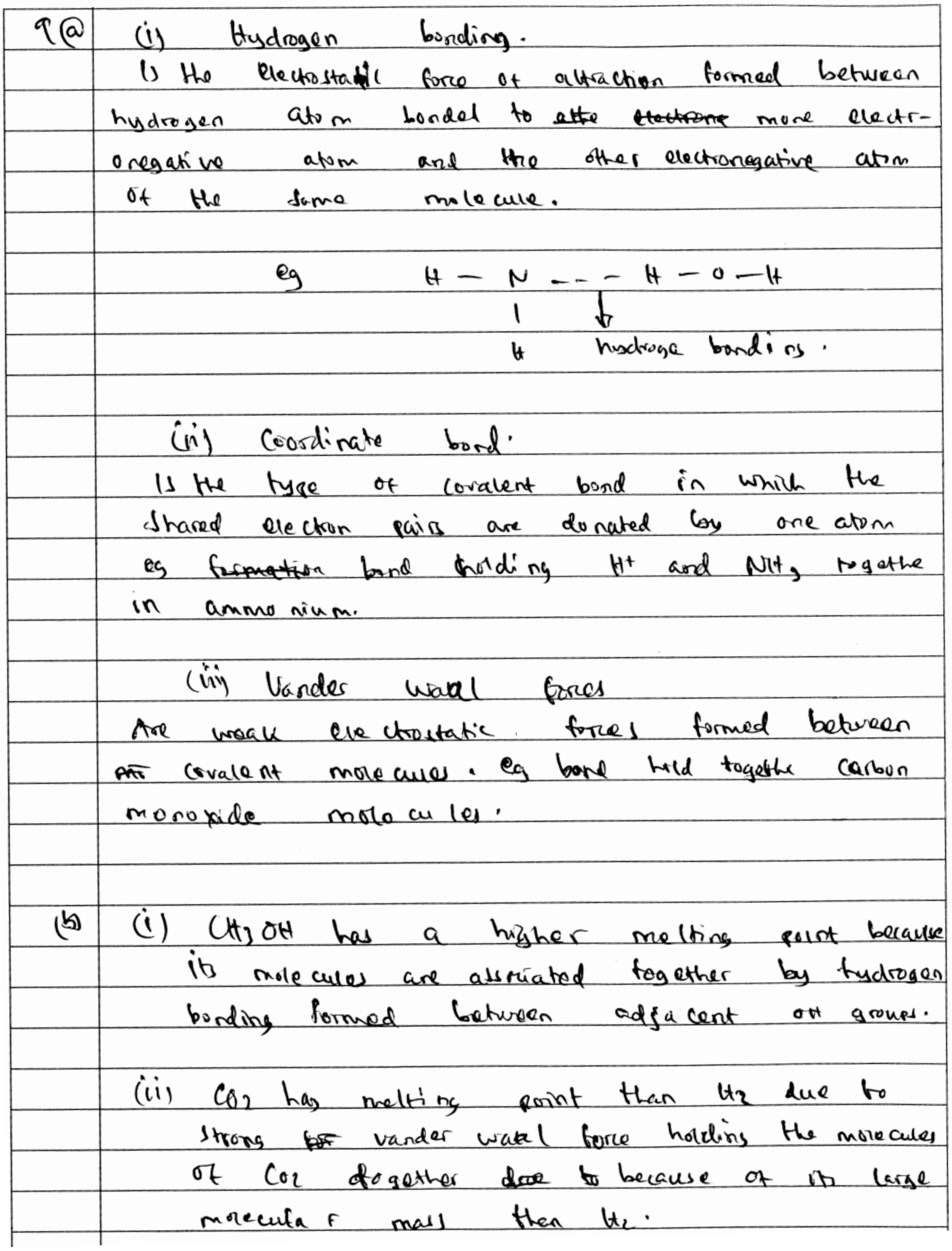
2.1.9 Question 9: Chemical Bonding

In part (a) of the question candidates were asked to explain briefly with examples: hydrogen bonding, coordinate bond and Van der Waal forces. Part (b) enquired the candidates to predict which substance in each pair has higher melting point and give reason for each choice. The pairs were: $CH_3CH_3$and CH_3OH; CO_2 and H_2;HCl and H_2O; Al and Mg and Si and Na. In part (c), candidates were required to describe the hybridization of beryllium in beryllium chloride ($BeCl_2$).

A total of 14,795 (79.4%) candidates attempted this question, out of which 77.7 percent scored 3 to 10 marks. Good numbers(34.3% and 35.8%) scored 3 to 4.5 marksand 5 to 7marks respectively. Moreover, 7.6 percent managed to score 7.5 to 10 marks indicating good performance in this question.

Candidates with high scores managed to explain with examples the chemical phenomena asked in part (a). Furthermore, they predicted correctly with reasons the substance which had higher melting point from the given pairs of substances and finally, they described correctly the hybridization of beryllium in beryllium chloride ($BeCl_2$) as per demand of the question. Extract 9.1 illustrates a response with good score.

Extract 9.1



9ⓐ (i) Hydrogen bonding.

Is the electrostatic force of attraction formed between hydrogen atom bonded to ~~atte~~ ~~electrone~~ more electronegative atom and the other electronegative atom of the same molecule.

eg H — N - - - H — O — H
|
H hydroge bondings.

(ii) Coordinate bond.

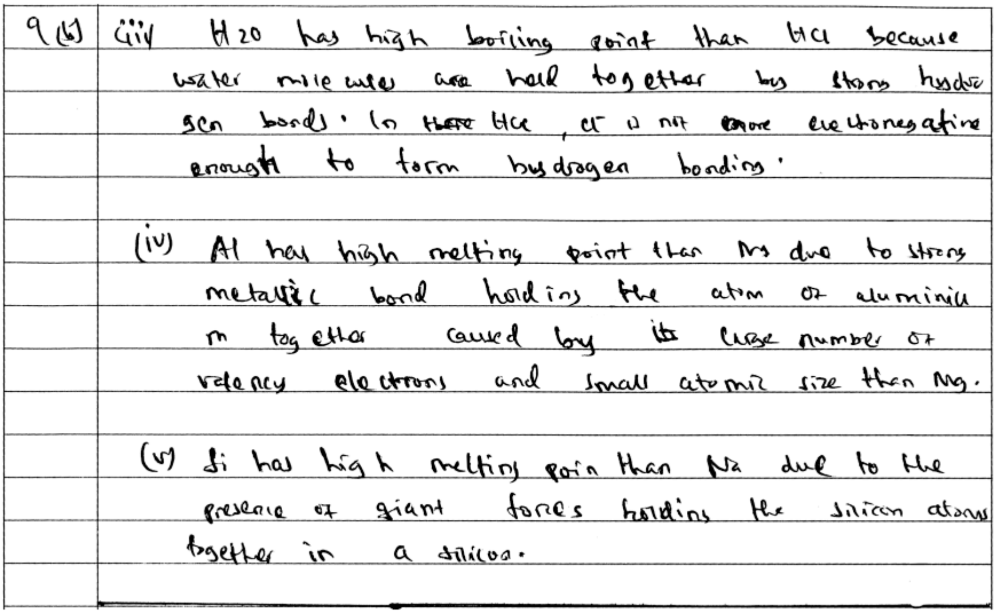
Is the type of covalent bond in which the shared electron pairs are donated by one atom eg ~~formation~~ bond holding H^+ and NH_3 togethe in ammonium.

(iii) Vander waal forces

Are weak electrostatic forces formed between ~~An~~ covalent molecules. eg bond held togethe carbon monoxide molecules.

(b) (i) CH_3OH has a higher melting point because its molecules are associated together by hydrogen bonding formed between adjacent OH groups.

(ii) CO_2 has melting point than H_2 due to strong ~~for~~ vander waal force holding the molecules of CO_2 together ~~due~~ to because of its large molecular mass then H_2.



9(b) (iii) H20 has high boiling point than HCl because water molecules are held together by strong hydrogen bonds. In ~~there~~ HCl, Cl is not more electronegative enough to form hydrogen bonding.

(iv) Al has high melting point than Mg due to strong metallic bond holding the atom of aluminium together caused by its large number of valency electrons and small atomic size than Mg.

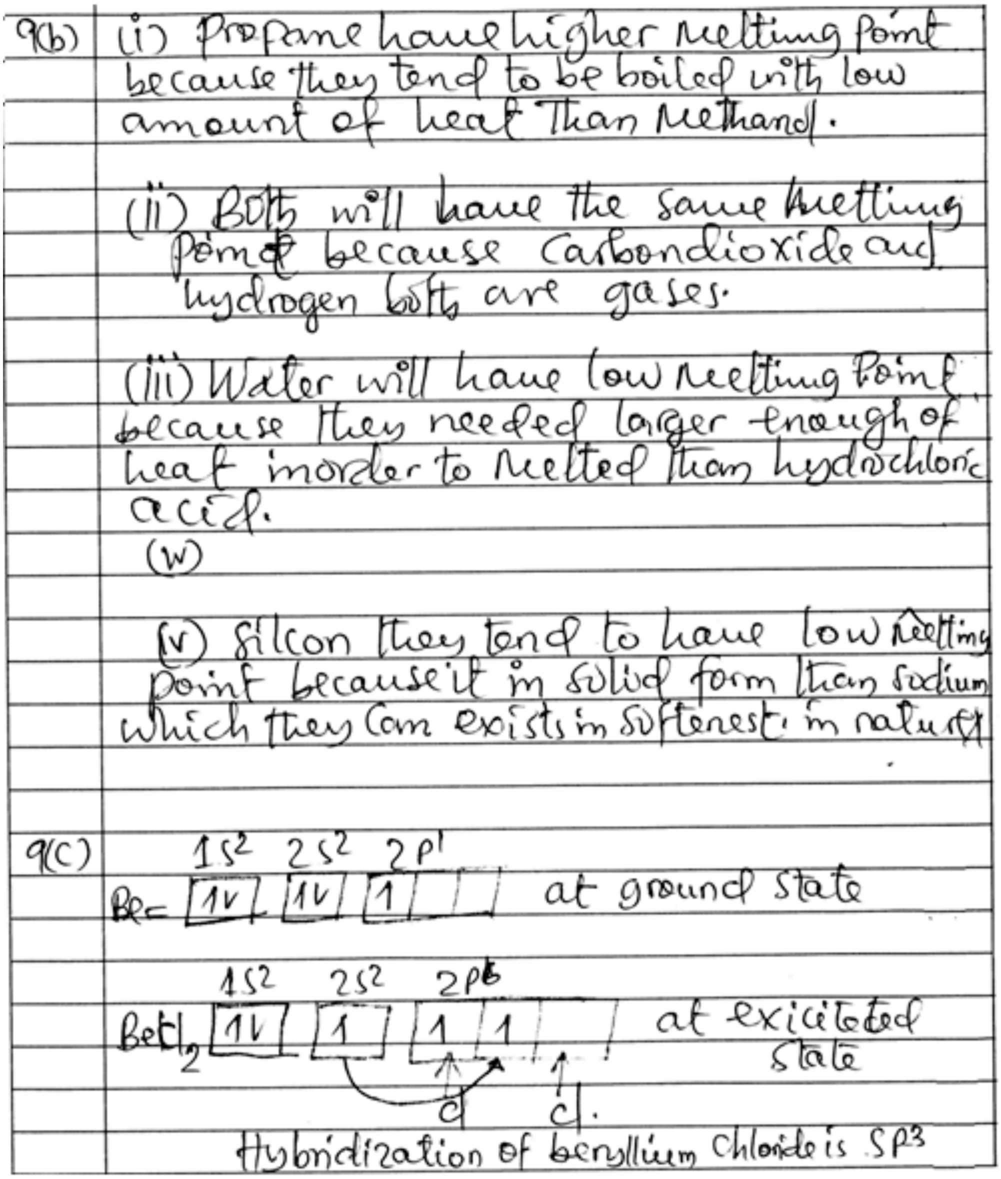
(v) Si has high melting poin than Na due to the presence of giant forces holding the silicon atoms together in a silicon.

Extract 9.1 is one of the good answers. The responses indicate that the candidate is acquainted with sufficient knowledge of properties of substances due to the chemical bonding which exist in them.

Candidates who performed partially managed to answer well only some part(s) of the question. Some candidates succeeded to explain the chemical phenomenon in part (a) without giving reasons while others managed to identify a substance with higher melting point from the given pairs in part (b) but could not give suitable reason, hence scored partial marks.

On the other hand, the candidates who performed extremely low in this question failed to explain with reasons the chemical phenomena asked in part 9(a). They also failed to predict with reasons the substances in a pair which had higher melting point than the other.For example they failed to realize that CH_3OH and H_2O have higher melting points because they have strong hydrogen bond which does not exist in their counterparts. Failure in this part signifies that, the candidates lacked knowledge of factors which contribute towards melting point of substances. In part 9 (c), candidates skipped the item indicating inadequate knowledge about hybridization of atomic orbitals. Extract 9.2 illustrates unsatisfactory responses for part (b) and (c).

Extract 9.2



9(b) (i) Propane have higher melting point because they tend to be boiled with low amount of heat Than Methanol.

(ii) Both will have the same melting point because Carbondioxide and hydrogen both are gases.

(iii) Water will have low melting point because they needed larger enough of heat inorder to melted than hydrochloric acid.

(iv)

(v) Silcon they tend to have low melting point because it in solid form than sodium which they can exists in softenest in nature.

9(C) $1s^2$ $2s^2$ $2p^1$

Be= [↑↓] [↑↓] [↑ | |] at ground state

$1s^2$ $2s^2$ $2p^6$

$BeCl_2$ [↑↓] [↑] [↑ ↑ |] at exicited state

Cl Cl

Hybridization of beryllium Chloride is SP^3

Extract 9.2 shows that, although the candidate attempted all items in part (b) and (c) of the question, none of the item was correctly answered. For instance, the candidate indicates that beryllium has 5 electrons instead of 4 electrons and thus he/she failed to achieve to the expected response.

2.1.10 Question 10: The Atom

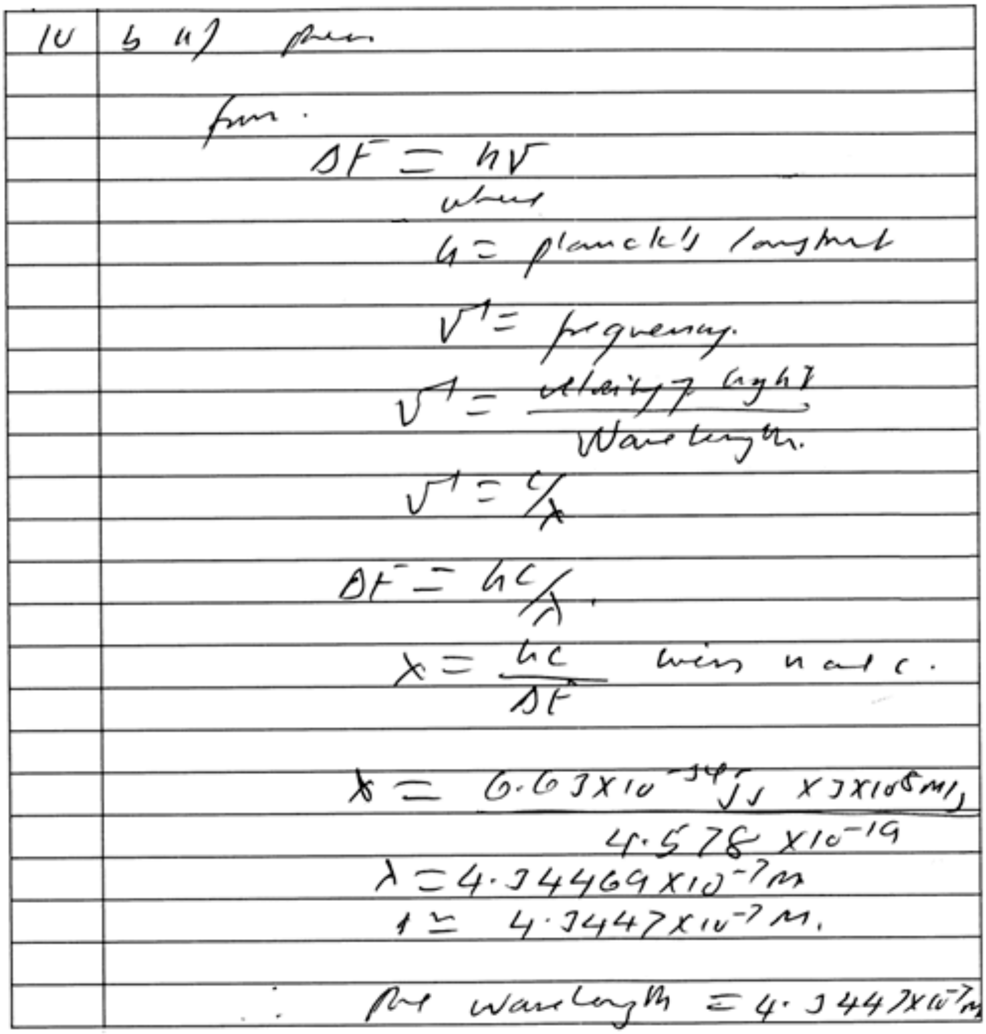
Part (a) of the question required the candidates to distinguish between atomic number from mass number and a photon from quanta. In part (b) candidates were provided with the information that; a photon was absorbed by a hydrogen atom in its ground state and the electron was promoted to the 5th orbit. When the excited electron returned to its ground state, visible radiation and other quanta were emitted. They were then required to explain briefly the transition made by the electron for the excited electron to return to its ground state, and calculate the wavelength of a photon emitted during a transition from n = 5 to n = 2 in the hydrogen atom given that $\Delta E = 2.18 \times 10^{-18}\,J\,[\frac{1}{n_1^2} - \frac{1}{n_2^2}]$.

About three quarters (75.1%) of the candidates attempted this question and almost half (48.8%) of them scored 3 to 10 marks which indicate an average performance.Among the candidates who scored 3 marks or above, 27.3 percent scored 3 to 4.5 marks, 18.8 percent scored 5 to 7 marks while only 2.7 percent managed to score 7.5 to 10 marks. On the other part, 29.8 percent scored 0 to 1 marks while 21.4 percent scored 1.5 to 2.5 marks.

The analysis indicated that, the question was averagely performed due to the fact that, many candidates performed well in parts (a) and b(i) but failed to respond correctly to part b (ii).It was observed that, candidates failed to comprehend and abide to the requirement of the question and the provided information. For example, a good number of candidates used Rydberg's equation $\frac{1}{\lambda} = R_h(\frac{1}{n_1^2} - \frac{1}{n_2^2})$ to calculate wavelength instead of using the given equation $\Delta E = 2.18 \times 10^{-18} J(\frac{1}{n_1^2} - \frac{1}{n_2^2})$, an attempt which denied them marks. However, candidates who scored the lowest mark missed all parts of the question.

On the other hand, candidates who scored high marks managed to differentiate correctly atomic number from mass number and photon from quanta. They also realized that, since visible light was observed, then the transition should be to the second orbit (Balmer series) then to the ground state (Lyman series). Furthermore, they employed the given relation and substituted appropriate data to calculate the wavelength of a photon emitted during a transition from n = 5 to n = 2 in the hydrogen atom. Extract 10.1 is a sample of good responses whileExtract 10.2 is a sample of inadequate response.

Extract 10.1



10 b ii) Soln.

From .

$\Delta E = hV$

where

h = planck's constant

V = frequency.

$V = \frac{\text{velocity of light}}{\text{Wavelength}}$

$V = c/\lambda$

$\Delta E = hc/\lambda$.

$\lambda = \frac{hc}{\Delta E}$ using h and c.

$\lambda = \frac{6.63\times10^{-34}\,Js \times 3\times10^{8}\,m/s}{4.578\times10^{-19}}$

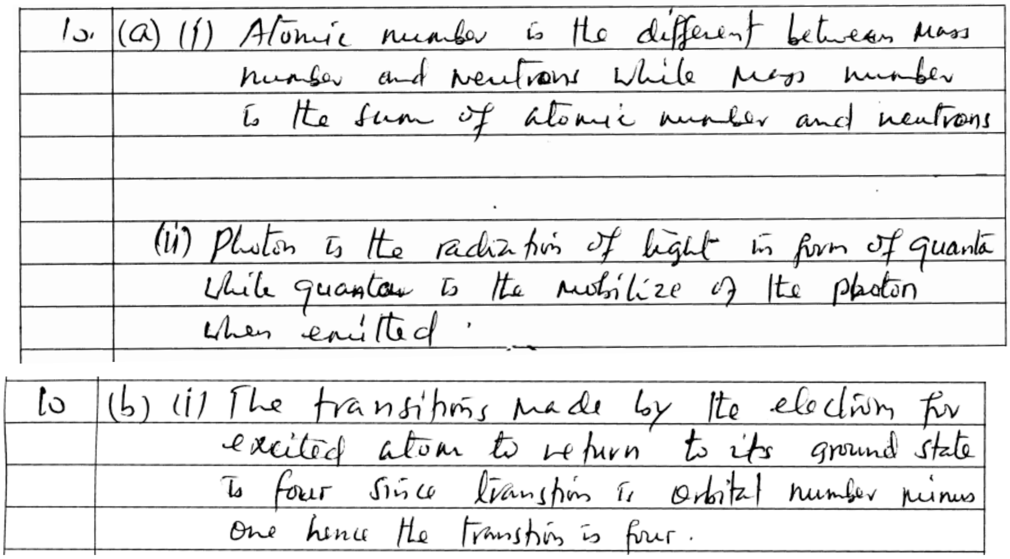
$\lambda = 4.34469\times10^{-7}m$

$\lambda \simeq 4.3447\times10^{-7}m.$

$\therefore$ the wavelength $= 4.3447\times10^{-7}m$

Extract 10.1 shows an example of the answers which indicate how the candidate managed to score all marks allocated to part b(ii). The candidate put forward relevant formulawith definition of all symbols. Eventually, the candidate managed to do the associated calculations clearly and accurately.

Extract 10.2



10. (a) (i) Atomic number is the different between mass number and neutrons while mass number is the sum of atomic number and neutrons

(ii) Photon is the radiation of light in form of quanta while quantam is the mobilize of the photon when emitted.

10 (b) (i) The transitions made by the electron for excited atom to return to its ground state is four since transition is orbital number minus one hence the transition is four.

In Extract 10.2, thecandidate failed to make a distinctionof the pairs asked in 10(a)(i) and (ii). In the same way, the candidateincorrectly explained the transitions made by the electron for the excited atom to return to its ground. He/she explainedthat "transition is orbital number minus one and hence the transition is four" which is completely out of the expected explanation.

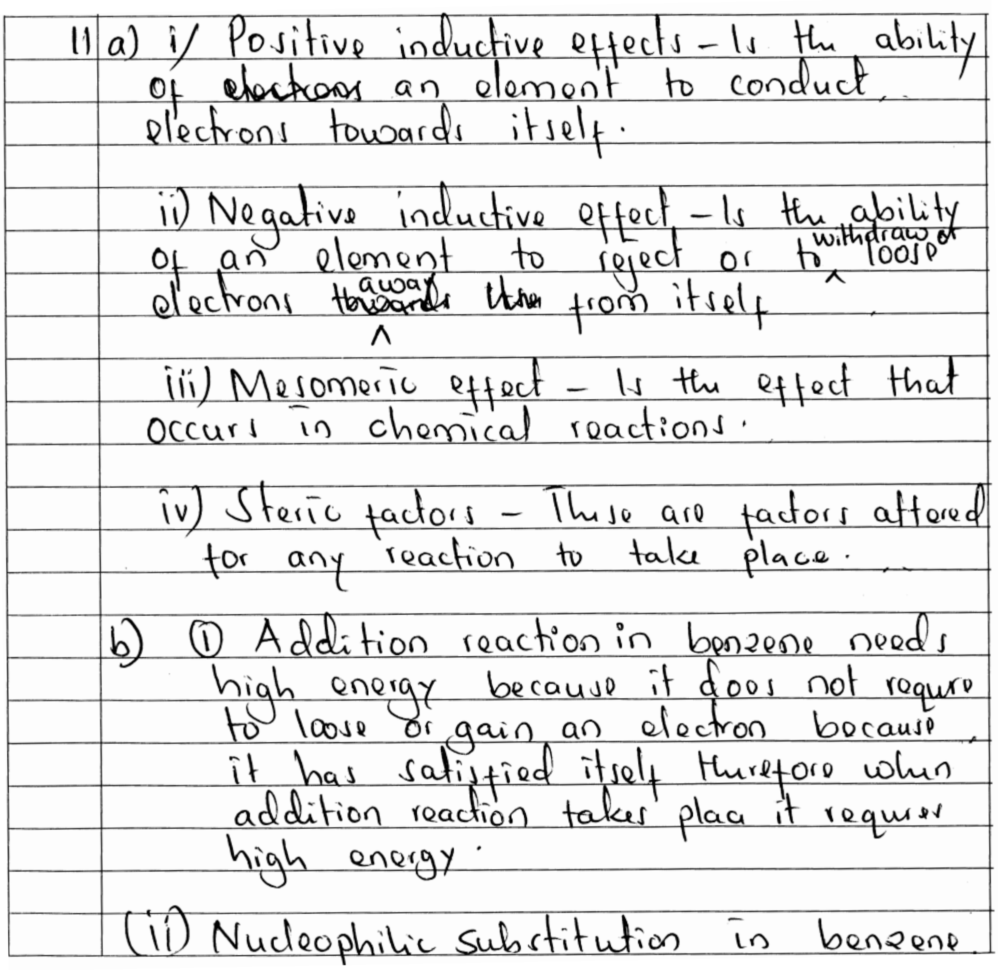
2.1.11 Question 11: Aromatic Hydrocarbons

In part (a) of the question, candidates were required to explain briefly: positive inductive effect, negative inductive effect, mesomeric effect, and stearic factors as applied in organic reactions. In part (b) candidates were required to explain observations that: Addition reaction in benzene needs high energy, nucleophilic substitution reactions in benzene are not possible, methyl group when attached to benzene ring direct another incoming group to ortho or para positions and nitro group when attached to benzene ring direct another incoming group to meta position.

This question was answered by majority (83.6%) of the candidates. Many (85.2%) of the candidates scored 3 to 10 marks and out of them, majority (44.3%) scored 5 to 7 marks, 23.4 percent scored 3 to 4.5 marks and 17.5 percent scored 7.5 to 10 marks an indication that the question was well performed.Candidates who performed well gave correct explanations of the terms as applied in organic reactions. They also wrote the correct explanations for the observations asked in the question.

On the contrary, a few(14.8%) candidates who had low marks in this question failed to give the correct explanation on the terms as applied in organic reactions. For instance in part a(iii), they thought that any electron can cause mesomeric effect instead of either π-electrons or lone pair of electrons. In part b(i) and b(ii), they failed to apply the knowledge of stability of the π-bonds in benzene to explain the difficulties for benzene to undergo addition reaction as well as the possibilities of it to undergo nucleophilic substitution, which are the indications that they lacked knowledge on the importance of mesomerism and delocalization of π-bond electrons in benzene. Extract 11illustrates the case.

Extract 11



11 a) i/ Positive inductive effects – Is the ability of ~~electrons~~ an element to conduct electrons towards itself.

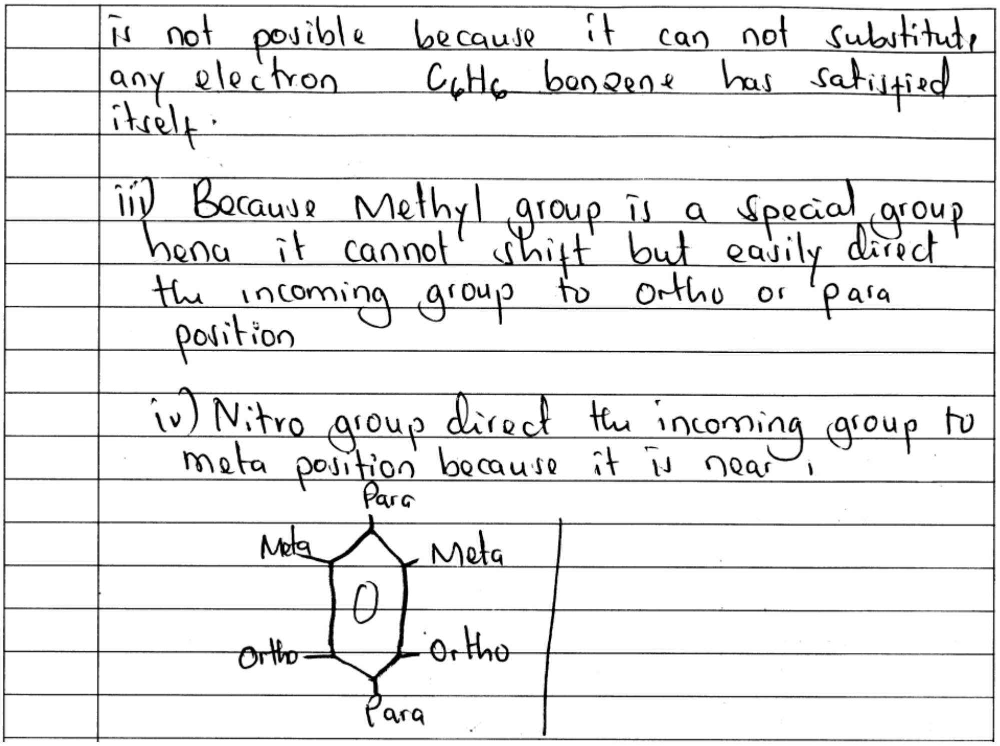
ii) Negative inductive effect – Is the ability of an element to reject or to withdraw or loose electrons ~~towards~~ away ~~the~~ from itself.

iii) Mesomeric effect – Is the effect that occurs in chemical reactions.

iv) Steric factors – These are factors afforded for any reaction to take place.

b) ① Addition reaction in benzene needs high energy because it does not requre to loose or gain an electron because it has satisfied itself therefore when addition reaction takes place it requres high energy.

(ii) Nucleophilic substitution in benzene



is not posible because it can not substitute any electron C_6H_6 benzene has satisfied itself.

iii) Because Methyl group is a special group hena it cannot shift but easily direct the incoming group to ortho or para position

iv) Nitro group direct the incoming group to meta position because it is near.

Extract 11shows that, although the candidate attempted all parts of the question, none of the parts was correctly answered. For instance, the answers given in part (b) (iii) and (iv) do not indicate whether the candidate knew the factors which activate or deactivate the benzene ring and factors which determine the orientation of substitution in the benzene ring.

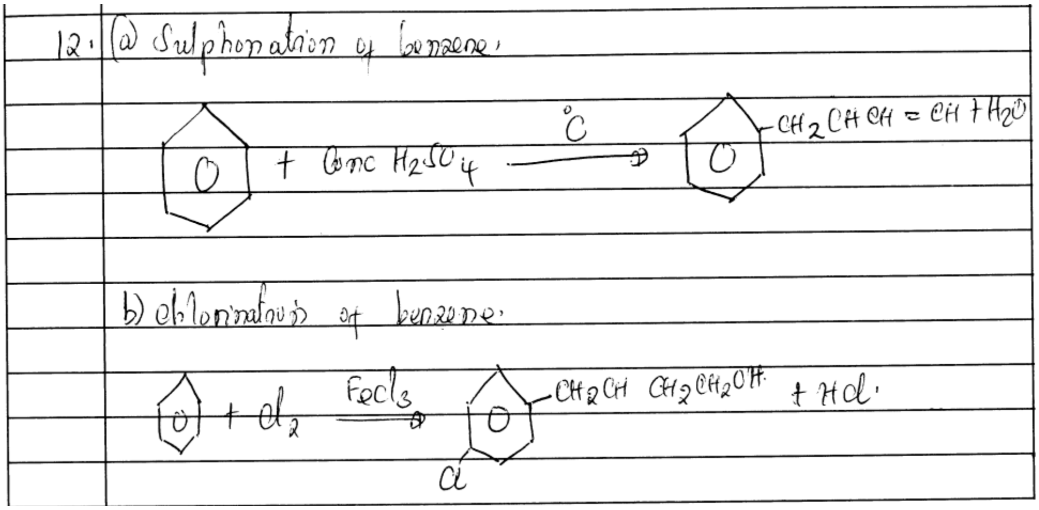
2.1.12 Question 12: AromaticHydrocarbons

Candidates were required to give the mechanism for sulphonation of benzene and chlorination of benzene.

The question was attempted by few (40.0%) candidates and the performance was not good. Majority (92.6%) of the candidates scored 0 to 2.5 marks out of 10. Very few (1.5%) candidates scored 5 marks to 10 with only 0.3 scoring all the 10 marks.

Candidates who performed low in this question failed to show how the electrophiles are generated in both cases. In part (a) for example, they created incorrect electrophile. They used concentrated sulphuric acid instead of fuming sulphuric acid which had sulphur trioxide molecule. In the subsequent part, they also failed to write correct products from the reaction of chlorine molecule with Lewis acid to generate an electrophile $Cl^{\oplus}$ and an ion $AlCl_4^-$. Some generated an electrophile $Cl^{\oplus}$ by splitting chlorine gas with sunlight which was anincorrectapproach. In other cases candidates wrote conversion of reactants to products (reaction equation) instead of showing the mechanisms to achieve to the product. Failure in this question indicates that, candidates had insufficient knowledge on the mechanisms of sulphonation and chlorination of benzene. Extract 12.1 illustrates the answer with extremely low score.

Extract 12.1



12. (a) Sulphonation of benzene,

+ Conc H_2SO_4 $\xrightarrow{°C}$ $-CH_2CH\,CH = CH + H_2O$

b) chlorination of benzene.

+ Cl_2 $\xrightarrow{FeCl_3}$ $-CH_2CH\ CH_2CH_2OH$ + HCl.

Cl

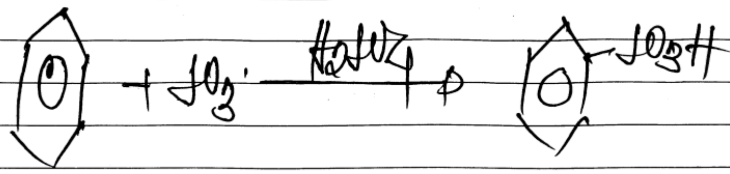
In Extract 12.1 the candidate presented equations for sulphonation and chlorination of benzene with incorrect products and did not show mechanisms in any of the equation.

However, few candidates who performed well gave the correct mechanisms on sulphonation and chlorination of benzene as Extract 12.2presents.

Extract 12.2

12 (a) Sulphonation of benzene.

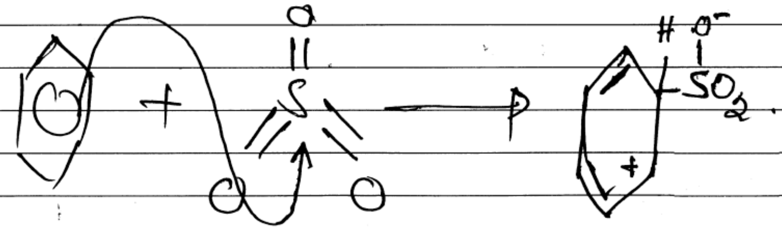
Reaction



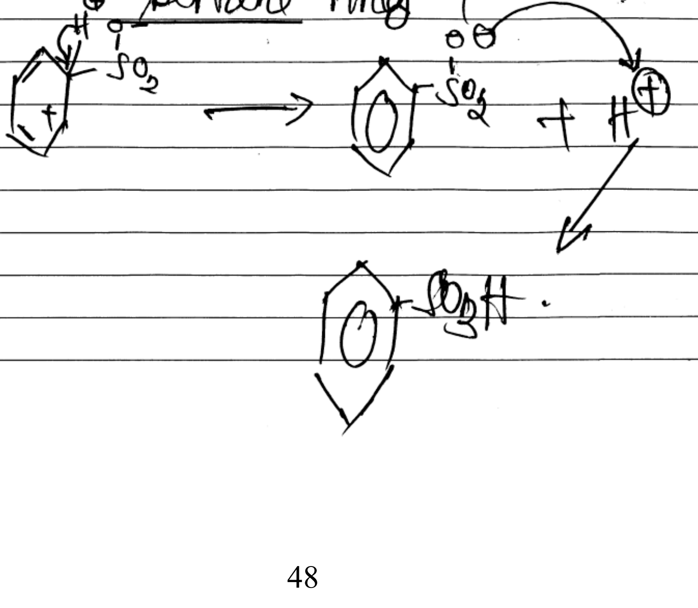
where by H_2SO_4 act as a medium

Mechanism.

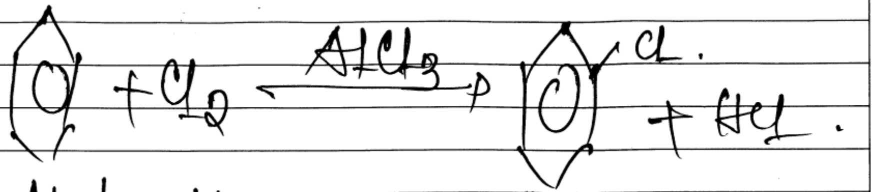
(i) ~~React~~ formation of Intermediate carbenium ion



(ii) Production of Hydrogen ion. and benzene ring



12 ⓑ Chlorination of benzene.



Mechanism

① formation of electrophile.

~~$Cl_2 + AlCl_3$~~

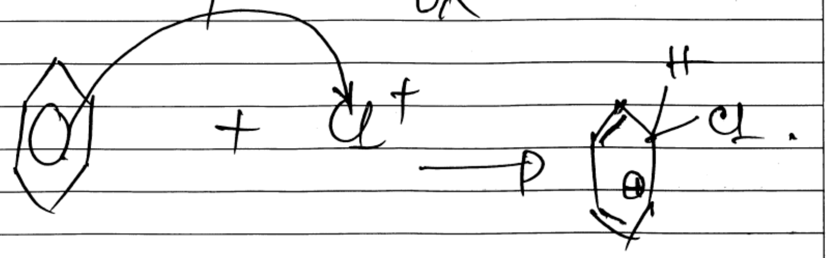
~~$Cl_2 +$ A~~

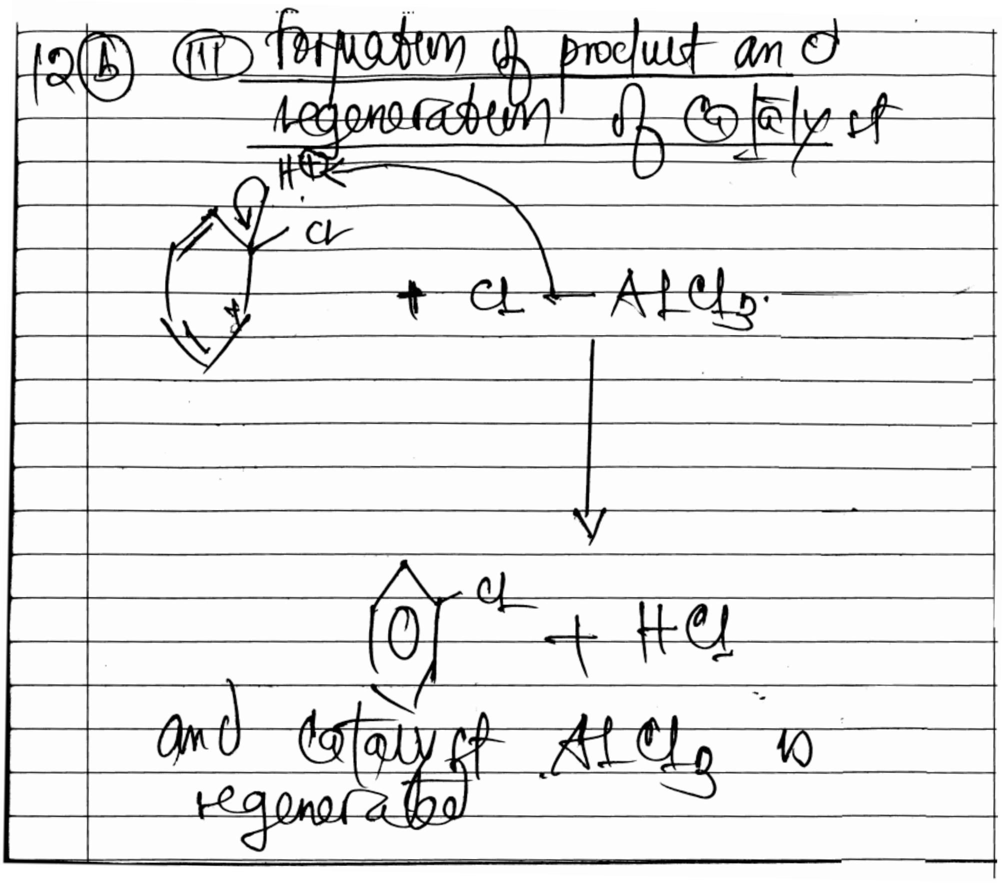
$\Rightarrow Cl - Cl + AlCl_3.$

$\downarrow$

$Cl^+ + [AlCl_4]^-$

Ⓘⓘ formation of intermediate Carbenium ion.





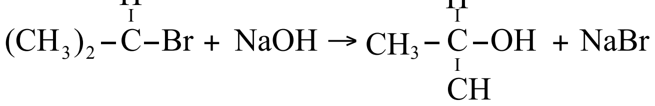
12 (b) (iii) formation of product and regeneration of catalyst

and catalyst AlCl3 is regenerated

Extract 12.2 is a sample of a well presented answer. The candidate showed correctly mechanisms for both sulphonation and chlorination of benzene.

2.1.13 Question 13: Halogen Derivatives of Hydrocarbons

In part (a), candidates were required to write the mechanism of substitution reaction



$$(CH_3)_2-\overset{H}{C}-Br + NaOH \rightarrow CH_3-\underset{CH_3}{\overset{H}{C}}-OH + NaBr$$

indicating clearly the nucleophile, substrate and leaving group. In part (b), candidates were asked to carry out the conversions;propane to 1-chloropropane and propane to propene. Part (c) required candidates to complete the reactions between:ethyne and chlorine in the presence of aluminium chloride as a catalyst;propyne and dilute sulphuric acid in the presence of mercury (II)sulphate as a catalyst at 60ºC; sodium acetylide and Iodo methane;ethene and KmnO$_4$ in alkaline condition.

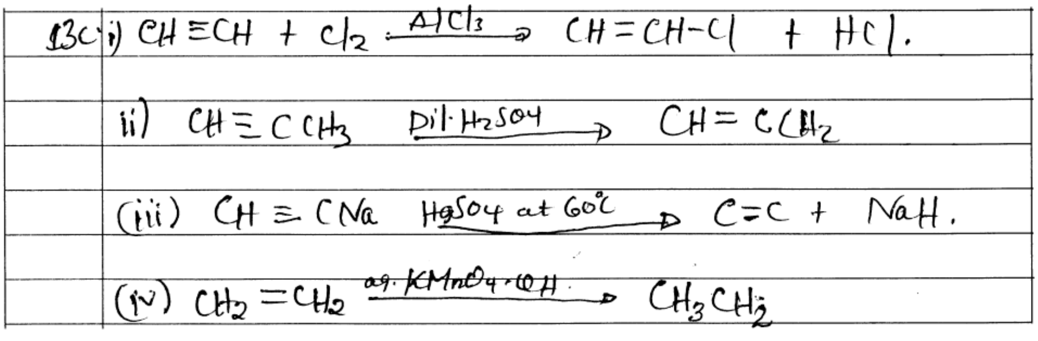
Many (68.7%) candidates attempted this question. The performance of the question was good as majority scored high marks. A good number of candidates (28.2%) managed to score 3 to 4.5 marks, many (35.9%) scored 5 to 7 marks and a few (8.9%) candidates scored 7.5 to 10 marks making a total percent of candidates who scored 3 marks or above to be 73.0 percent.

The candidates who performed well were able to write the mechanism of the given substitution reaction and indicated correctly the nucleophile, substrate and the leaving group. They reported properly the given conversions and finally, they completed well and name appropriately the products for the given organic reactions.

Nevertheless, candidates who scored partial marks managed to identifynucleophile, substrate and the leaving groupbut were unable to write the mechanism of the given substitution reaction. In part (c), some candidates managed to complete the reactions but failed to name the product formed, which denied them some marks.

On the other hand, candidates who scored low marks particularly, those who scored zero marks failed to give correct answers as already described. This might have been caused by lack of adequate knowledge of reactions of aliphatic hydrocarbons and halogens derivatives of hydrocarbons. Extract 13 is given as a sample of those answers.

Extract 13



13c i) $CH \equiv CH + Cl_2 \xrightarrow{AlCl_3} CH=CH-Cl + HCl.$

ii) $CH \equiv CCH_3 \xrightarrow{Dil \cdot H_2SO_4} CH = CCH_2$

(iii) $CH \equiv CNa \xrightarrow{HgSO_4 \text{ at } 60^\circ C} C=C + NaH.$

(iv) $CH_2 = CH_2 \xrightarrow{aq \cdot KMnO_4 \cdot OH} CH_3CH_2$

In Extract 13, the candidate was unable to do parts 13(a) and 13(b);he/she attempted only part 13(c) of which he/she produced incorrect responses in all the equations provided.Moreover, he/she did not give the names of the products formed as enquired.

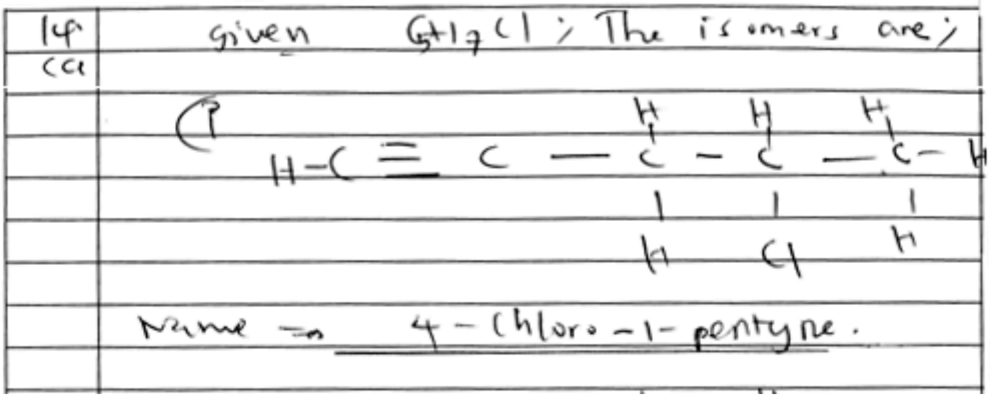
2.1.14 Question 14: Aliphatic Hydrocarbons

Parts (a) of the question demanded the candidates to write open structures of five isomers of the compounds, C_5H_7Cl and their corresponding IUPAC names. In part (b) the candidates were asked to arrange the following list of compounds in the order of increasing acidity and give reasons for their arrangement $O_2N-C\equiv CH$, $CH_3C\equiv CH$, $Cl-C\equiv CH$, $(CH_3)_3C\equiv CH$. Part (c) required the candidates to distinguish: Propyne and propene; 2-methyl pent – 2 – ene and 3 – methyl pent – 2 – ene; But- 2- yne and butane.

About three quarters (72.3%) of the candidates responded to this question. Many (64%) candidates scored 3 marks or above out of 10 marks, of which 18.0 percent scored 3 to 4.5 marks, 46.7 percent scored 5 to 7 marks and 9.3 percent scored 7.5 to 10 marks. On the other part, 23.5 percent scored 0 to 1 marks and 12.5 percent scored 1.5 to 2.5 marks. Thus, this trend proves good performance in this question.

The candidates, who performed well in this question managed to write the open structures of five isomers of the compound provided and were able to assign their correct IUPAC names. They also arranged well in the order of increasing acidity of the given compounds with reasons and finally, were able to suggest the suitable tests to distinguish the given pairs of compounds. Extract 14.1 illustrates a sample of good response.

Extract 14.1

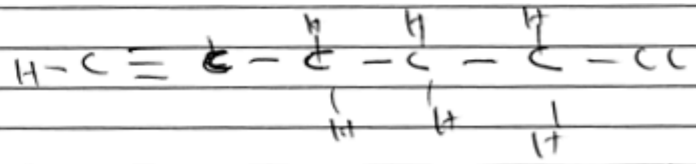


14 (a)

given C_5H_7Cl ; The isomers are ;

Name => 4 - Chloro - 1 - pentyne.

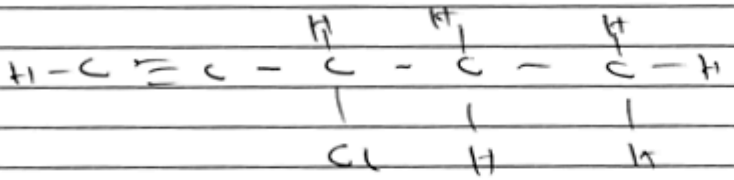
(ii



$H-C\equiv C-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-Cl$

Name ⇒ 5-Chloro-1-pentyne.

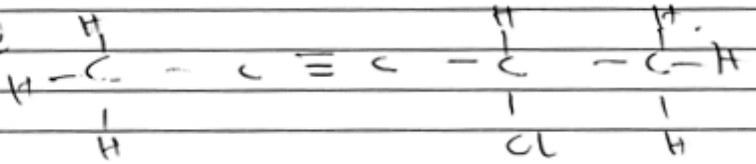
(iii



$H-C\equiv C-\overset{H}{\underset{Cl}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-H$

Name → 3-Chloro-1-pentyne

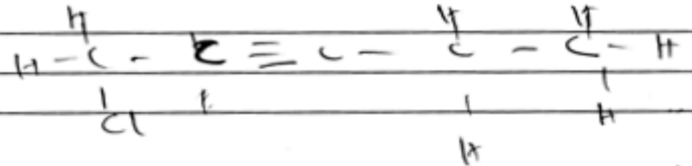
(iv



$H-\overset{H}{\underset{H}{C}}-C\equiv C-\overset{H}{\underset{Cl}{C}}-\overset{H}{\underset{H}{C}}-H$

Name → 4-Chloro-2-pentyne

(v



$H-\overset{H}{\underset{Cl}{C}}-C\equiv C-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-H$

Name: 1-Chloro-2-pentyne

14(b Arrangement:

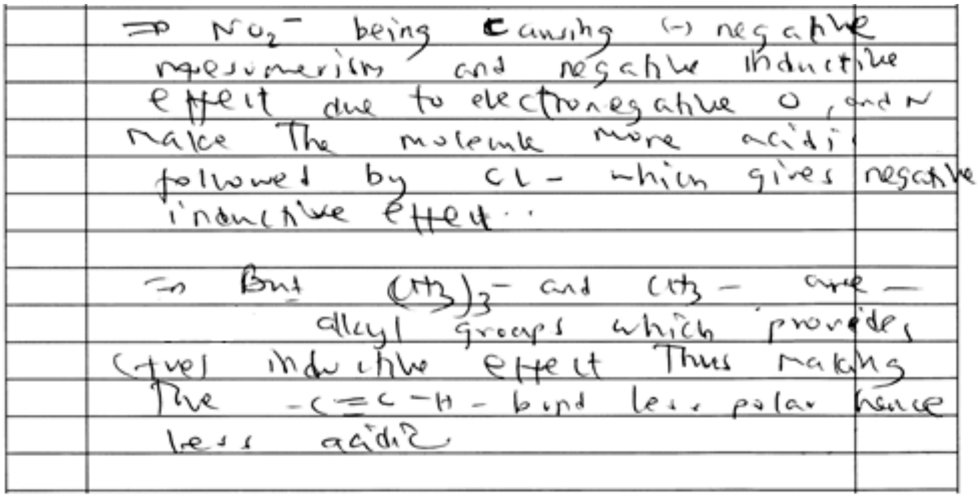
$((CH_3)_3-C\equiv CH < CH_3-C\equiv CH < Cl-C\equiv CH < O_2NC\equiv CH$

$\longrightarrow$

Increasing acidity.

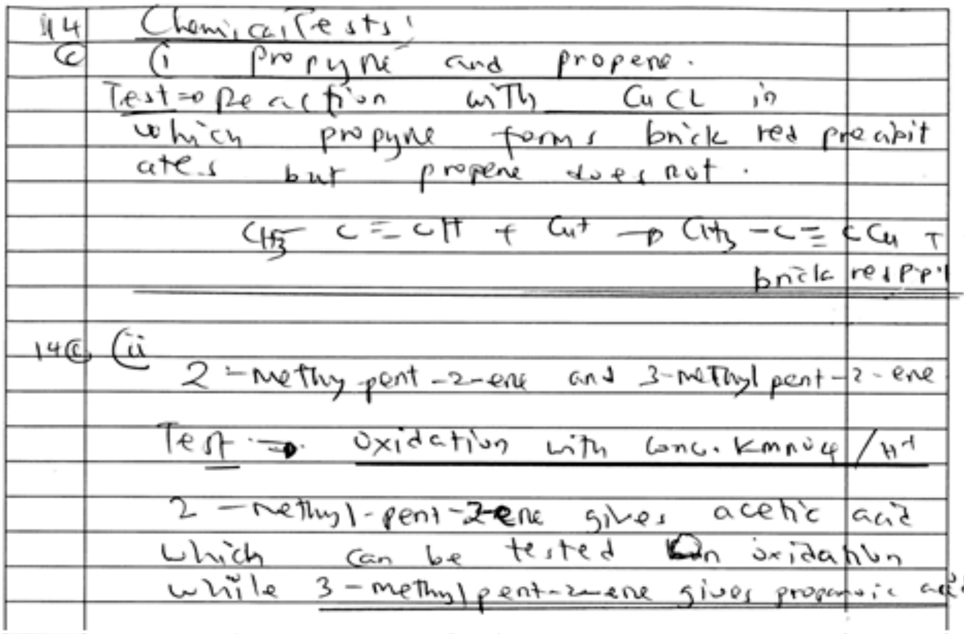
Reason(s)

- The acidic strength increases with the negative inductive effect and the (-) mesomerism which deactivates (removes or attracts) electrons from the functional group $(-C\equiv C-)$ thus making it polar and H^+ more positive.



⇒ NO_2^- being causing (-) negative mesomerism and negative inductive effect due to electronegative O, and N make The molecule more acidic followed by Cl - which gives negative inductive effect..

⇒ But $(CH_3)_3-$ and CH_3- are alkyl groups which provides (+ve) inductive effect Thus making The $-C \equiv C-H-$ bond less polar hence less acidic



14 (c) Chemical Tests!

(i propyne and propene.

Test ⇒ Reaction with CuCl in which propyne forms brick red precipitates but propene does not.

$CH_3 C \equiv CH + Cu^+ \rightarrow CH_3-C \equiv CCu + H^+$

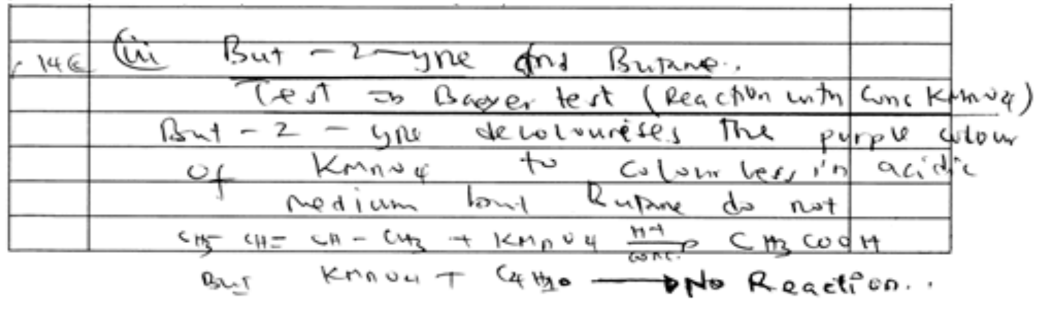
brick red ppt

14(c) (ii

2-methyl pent-2-ene and 3-methyl pent-2-ene

Test ⇒ oxidation with conc. $KMnO_4/H^+$

2-methyl-pent-2ene gives acetic acid which can be tested on oxidation while 3-methyl pent-2-ene gives propanoic acid.



14c (iii But-2-yne and Butane.

Test ⇒ Baeyer test (Reaction with Conc $KMnO_4$)

But-2-yne decolourises The purple colour of $KMnO_4$ to colourless in acidic medium but Butane do not

$CH_3\ CH= CH-CH_3 + KMnO_4 \xrightarrow[conc.]{H^+} CH_3COOH$

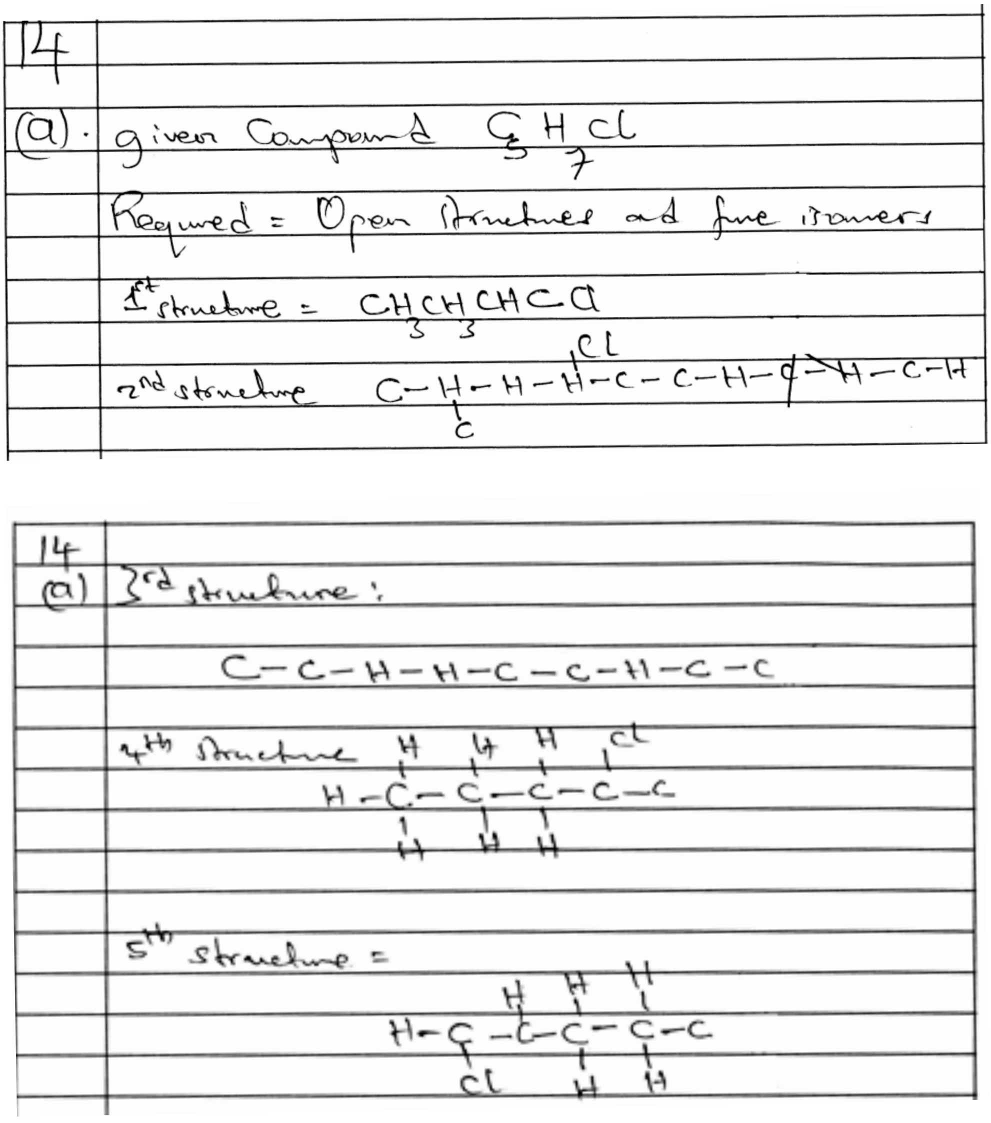
But $KMnO_4 + C_4H_{10} \longrightarrow$ No Reaction..

In Extract 14.1 the candidate gave open structures with their names in part (a). In the same way, he/she managed to arrange the given compounds in the order of increasing acidity with reasons. Furthermore, he/she managed to distinguish the given compounds in part (c).

However, some candidates scoredjust some marks because they could not answer all parts of the question properly. For instance, in part (a), some candidates were able to write open structures of the five or less isomers of the given compound but failed to assign them their correct IUPAC names. Similarly, in part (c) some candidates could suggestthe test to distinguish only some pairs of aliphatic hydrocarbons, hence scored partially.

Candidates who scored zero marks failed to respond well to either part of the question. Extract 14.2 represents a response from a candidate with low marks.

Extract 14.2



14

(a). given Compound C_5H_7Cl

Required = Open structures and five isomers

1st structure = CH_3CH_3CHCCl

2nd structure $C-\underset{C}{H}-H-\overset{Cl}{H}-C-C-H-C-H-C-H$

14

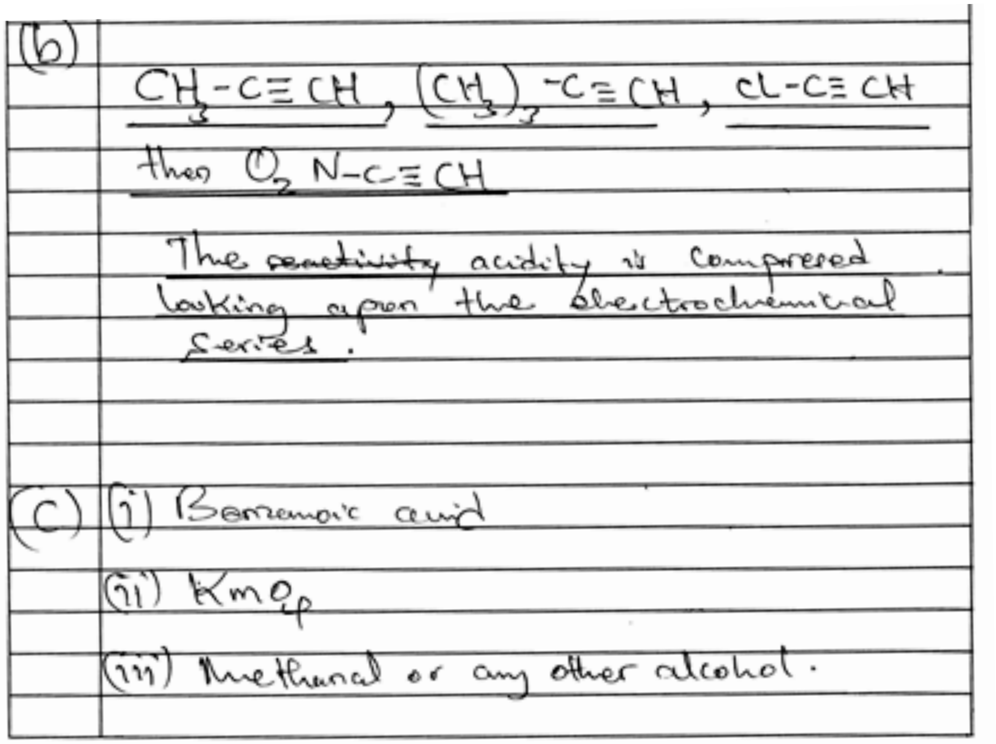
(a) 3rd structure:

$C-C-H-H-C-C-H-C-C$

4th structure $H-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\overset{Cl}{C}-C$

5th structure =

$H-\underset{Cl}{\overset{H}{C}}-\overset{H}{C}-\underset{H}{\overset{H}{C}}-\underset{H}{C}-C$


(b)

$CH_3-C\equiv CH$, $(CH_3)_3-C\equiv CH$, $CL-C\equiv CH$

then $O_2N-C\equiv CH$

The ~~reactivity~~ acidity is compared looking upon the electrochemical series.

(c) (i) Benzenoic acid

(ii) KmO_4

(iii) Methanol or any other alcohol.

In Extract 14.2, all five structures written by the candidate in part (a)are not correct. Moreover, no any structure is assigned IUPAC name. The candidate failed to arrange the given compounds in 14(b) in the order of increasing acidity,remarkably, he/she commented that the acidity is compared looking upon the electrochemical series, a concept which is not applicable in this case. Likewise, he/she could not suggest suitable tests to distinguish between the compounds of pairs in 14(c).

2.2 132/2-CHEMISTRY 2

2.2.1 Question 1: Acids, Bases and Salts

This question consisted of parts (a), (b) and (c). In part (a), the candidates were provided with the statement that, According to Bronsted - Lowry theory, $HSO^-_{3(aq)}$ ion behaves as an acid in the reaction: $HSO^-_{3(aq)} \rightleftharpoons H^+_{(aq)} + SO^{2-}_{3(aq)}$. They were then asked to explain; in terms of Bronsted Lowry theory how HSO_3^- act as an acid, writing the formula for the conjugate base and illustrate with an equation how HSO_3^- ion can also act as a base. In part (b) they were required to calculate the pH at neutralization point for the reaction between 0.01M NH_4OH and 0.01M HCl solutions given that $K_a(NH_4^+) = 5.7 \times 10^{-10}$ moldm^{-3}. In part (c),they were given the pH of ethanoic acid/sodium ethanoate buffer containing 1.0M CH_3COOH as 4.742 and $K_a[CH_3COOH] = 1.8 \times 10^{-5}$mol/dm^3. They were then required to calculate the; concentration of sodium ethanoatein the given buffer solution, pH of the resulting solution after 0.01 mole $HCl_{(aq)}$has tobeen added in 1dm^3 of the buffer solution, pH of the resulting solution after 0.01mole NaOH solution added in 1dm^3 of the buffer solution and pH when 0.01M of NaOH added to 1.0 dm^3 of pure water.

The question was opted by 43.4 percent of the candidates and the general performance was good as 66.5 percentscored from 6 to 20 marks. The candidates who scored from 6.5 to 10 marks were 36.6 percent, 23 percent scored from 10.5 to 15 marks and 3.4 percent scored from 15.5 to 20 marks. On the other hand, 33.5 percent scored below 6 marks with 1.5 percent scoring a zero mark.

The candidates who scored high marks in this question managed to explain how HSO_3^-act as an acid in terms of Bronsted Lowry theory, wrote the formula of the conjugate base and illustrated well with an equation how HSO_3^- can also act as a base. They also calculated correctly; the pH at neutralization point of the reaction between 0.01M NH_4OH and 0.01M HCl solutions and theconcentration of sodium ethanoate and the pH of the given solutions. Extract 1.1 shows an example of a good response from one of the candidates.

Extract 1.1

1\. ⓐ ① According to Bronsted - Lowry theory.
Acid is a substance that donate proton to another substance.
Therefore in equation

$$HSO_3^- \rightleftharpoons H^+ + SO_3^{2-}$$

HSO_3^- donate its H^+ to the surrounding while itself becoming SO_3^{2-}

$$HSO_3^- + H_2O \rightleftharpoons SO_3^{2-} + H_3O^+$$

(ii) Conjugate base is SO_3^{2-}

(iii)

$$HSO_3^- + H_2O \rightleftharpoons H_2SO_3 + OH^-$$

ⓑ Given;
Concentration of NH_4OH, = 0.01M
Concentration of HCl, = 0.01M.
$K_a\ (NH_4^+)$ = 5.7×10^{-10} mol/dm3.
Required; PH at neutralisation point, PH = ?

From;

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

NH_4OH	HCl	NH_4Cl	H_2O	
0.01M	0.01M	—	—	t=0
− α	− α	α	α	t=t
0.01 − α	0.01 − α	α	α	

1 (b) but $0{\cdot}01 - \alpha = 0$

$\alpha = 0{\cdot}01M$

$\therefore [NH_4CL] = 0{\cdot}01M$

~~E+~~

$NH_4CL \longrightarrow NH_4^+ + CL^-$

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

$1C$	$-$	$-$	$t=0$
$(1-\alpha)C$	αC	αC	$t=t$

$$K_a = \frac{[NH_3][H_3O^+]}{[NH_4^+]}$$

$$K_a = \frac{\alpha^2 C}{1-\alpha}$$

$$\alpha^2 C = K_a - \alpha K_a$$

$$C\alpha^2 + K_a\alpha - K_a = 0$$

$$0{\cdot}01\alpha^2 + 5{\cdot}7\times10^{-10}\alpha - 5{\cdot}7\times10^{-10} = 0$$

$$\alpha = 2{\cdot}39\times10^{-4}$$

but

~~EH~~ $pH = -\log[H_3O^+]$ ——— ①

$[H_3O^+] = \alpha C$

$[H_3O^+] = 2{\cdot}39\times10^{-4}\times0{\cdot}01$

$[H_3O^+] = 2{\cdot}39\times10^{-6}$

1/b From equation ① above

$pH = -\log[H_3O^+]$.

$pH = -\log(2.39\times10^{-6})$

$pH = 5.62$

∴ The pH at neutralization point is
$pH = 5.62$.

ⓒ Given;

Concentration of ethanoic acid, $[CH_3COOH] = 1\,M$.

pH of a buffer, $pH = 4.742$.

acid dissociation constant, $ka = 1.8\times10^{-5}\,mol/dm^3$.

Required;

① Concentration of Sodium ethanoate in the given buffer, $[CH_3COONa] = ?$

From;

$$pH = Pka + \log\frac{[CH_3COONa]}{[CH_3COOH]}.$$

$$\log\frac{[CH_3COONa]}{1} = pH - Pka$$

~~lo~~ $[CH_3COONa] = \log^{-}(pH - Pka)$

but $\neq$

$Pka = -\log ka = -\log 1.8\times10^{-5} = 4.745$

$[CH_3COONa] = \log^{-}(4.742 - 4.745)$

$[CH_3COONa] = 0.993\ mol/dm^3.$

∴ Concentration of Sodium ethanoate is 0.993 moles/dm³.

(ii) From;

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

$$CH_3COONa \longrightarrow CH_3COO^- + Na^+.$$

Addition of HCL.

number of moles of ethanoic acid.

$= 1\ mol/dm^3 \times 1dm^3$

$= 1$ moles.

number of moles of sodium acetate.

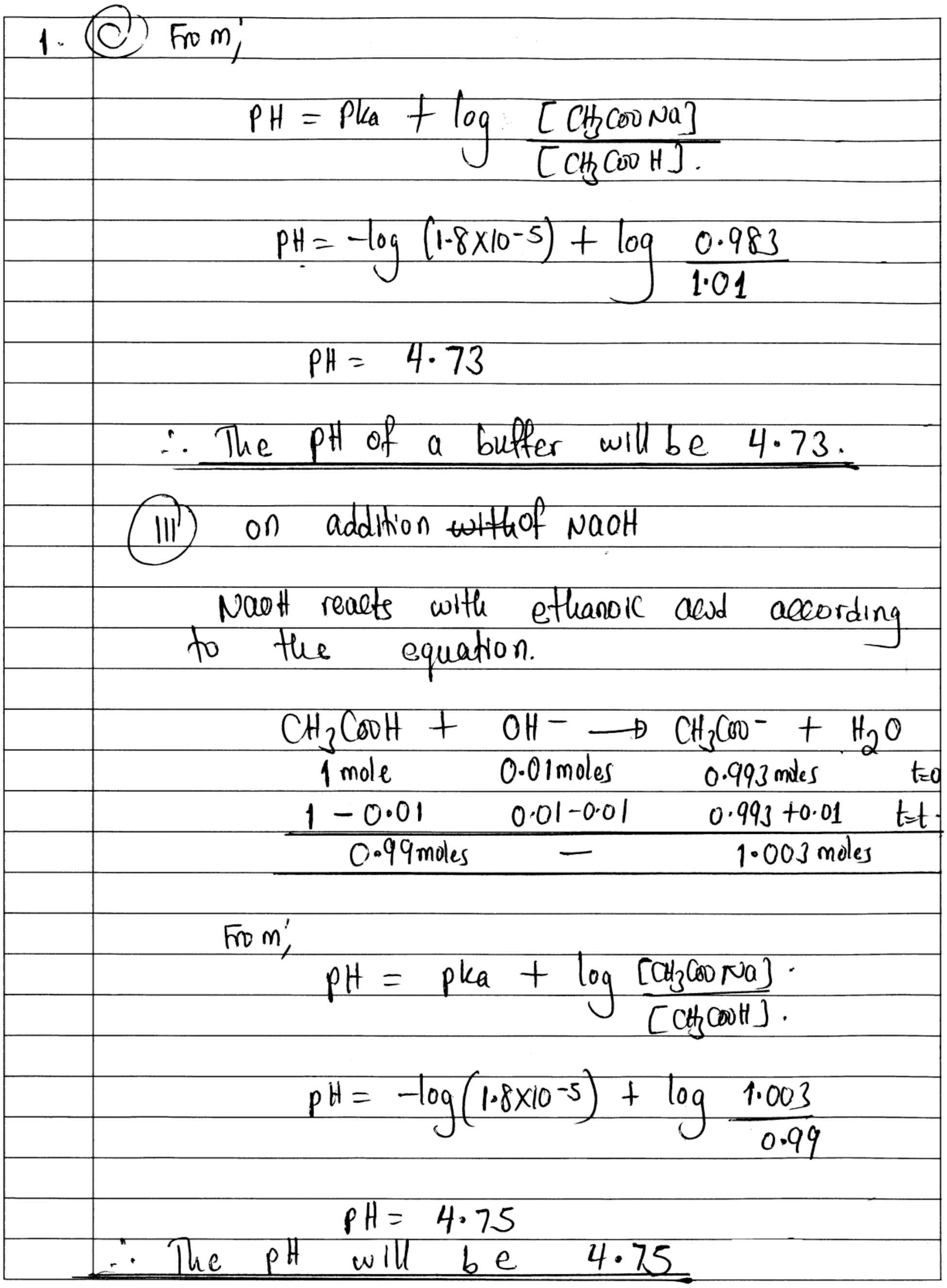
$= 0.993\ mol/dm^3 \times 1\ dm^3$

$= 0.993$ mole

HCL reacts with Sodium ethanoate according to the equation.

$$CH_3COO^- + H_3O^+ \longrightarrow CH_3COOH + H_2O.$$

0.993 moles	0.01 moles	1 moles	t=0
0.993 − 0.01	0.01 − 0.01	1 + 0.01	t=t
0.983 moles	—	1.01 moles	



1. (c) From;

$$pH = pKa + \log \frac{[CH_3COONa]}{[CH_3COOH]}.$$

$$pH = -\log(1.8\times10^{-5}) + \log \frac{0.983}{1.01}$$

$$pH = 4.73$$

∴ The pH of a buffer will be 4.73.

(III) on addition ~~with~~ of NaOH

NaOH reacts with ethanoic acid according to the equation.

$$CH_3COOH + OH^- \longrightarrow CH_3COO^- + H_2O$$

1 mole	0.01 moles	0.993 moles	t=0
1 − 0.01	0.01 − 0.01	0.993 + 0.01	t=t
0.99 moles	—	1.003 moles	

From;

$$pH = pka + \log \frac{[CH_3COONa]}{[CH_3COOH]}.$$

$$pH = -\log(1.8\times10^{-5}) + \log \frac{1.003}{0.99}$$

$$pH = 4.75$$

∴ The pH will be 4.75

Extract 1.1 shows a well presented answer with correct calculation procedures given by the candidate.

The candidates who scored low marks had insufficient knowledge about acids, bases and buffer solutions. For example, one candidate wrote "*HSO_3^- is acting as an acid because an acid is the substance which accepts* *a proton during the chemical reaction*” which in terms of Bronsted – Lowry theory is incorrect. Other candidates wrote incorrect formula for the conjugate base and therefore failed to show how HSO_3^- ion acts as a base.For example, one candidate illustrated by writing $HSO^-_{3(aq)} \rightleftharpoons H^+_{(aq)} + SO^{2-}_{3(aq)}$ instead of $HSO^-_{3(aq)} + H^+_{(aq)} \longrightarrow H_2SO^-_{3(aq)}$.Other candidates had a problem in calculating the pH at neutralization point, the concentration of the salt and the pH of the buffer solutions provided. For example, one candidate used incorrect approach by writing;

“*From the dissociation,*

$$CH_3COOH \rightleftharpoons CH_3COO^- + OH^-$$

$$K_a = \frac{[CH_3COOH][OH]}{[CH_3COOH]}$$

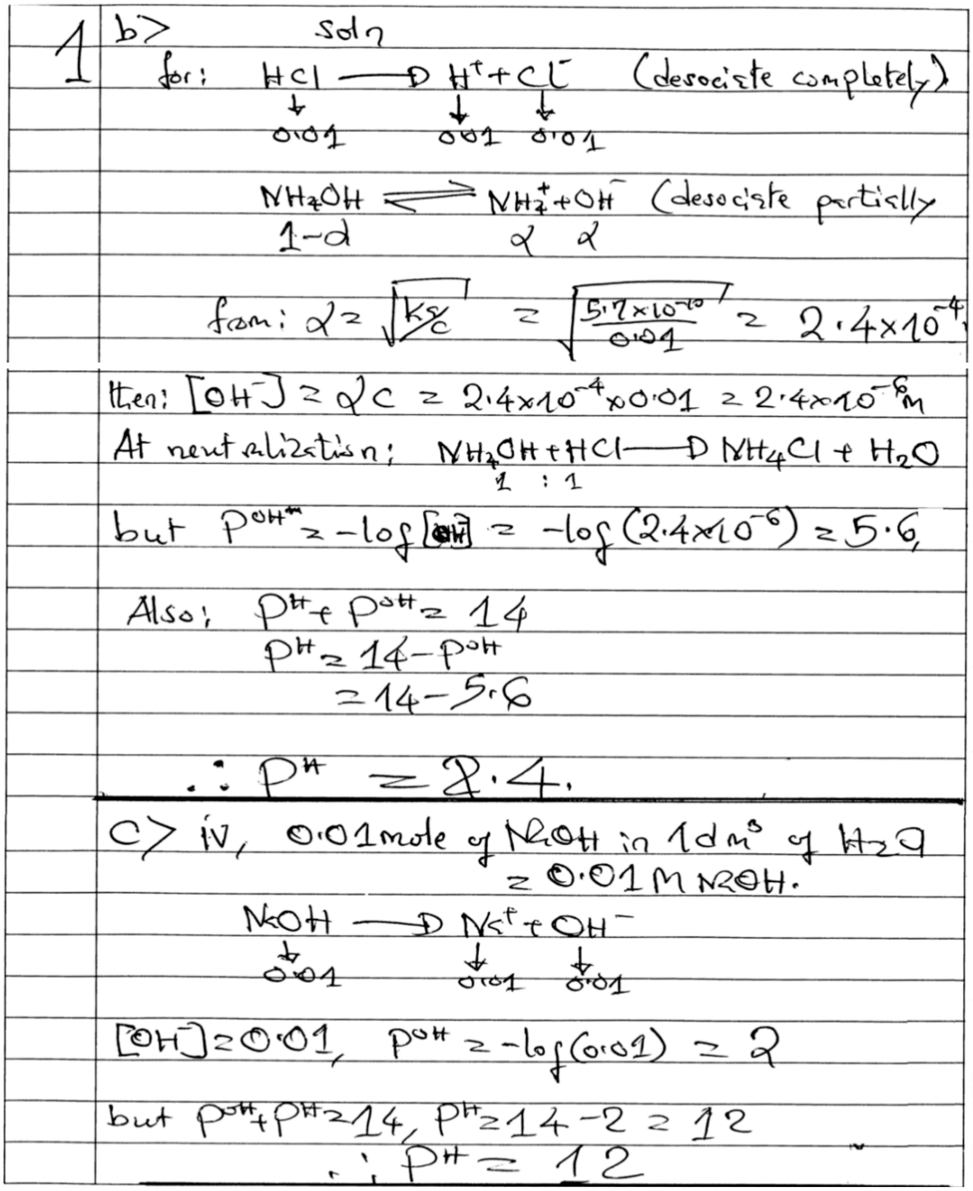
$$\begin{array}{lll} CH_3COOH \rightleftharpoons & CH_3COO^+ & + H^+ \\ 0.01 & 0 & 0 \\ 0.01 & x & x \end{array}$$

$$Ka = \frac{[x][x]}{0.01 - x}$$

$$1.8 \; x10^{-5} = \frac{[x]^2}{0.01 - x}$$

$x^2 = 1.8 \times 10^{-5}(0.01 - x)$, *whereby the value of x becomes 4.153 hence pH = - log [4.153] which gives the pH of -0.618*”. Such incorrect approach and inaccurate answer are among the examples which show that the candidates lacked the knowledge of the concept of salts, acids and bases. A similar answer is presented in Extract 1.2.

Extract 1.2



1 b> Soln

for: $HCl \rightarrow H^+ + Cl^-$ (desociate completely)

$0.01 \quad 0.01 \quad 0.01$

$NH_4OH \rightleftharpoons NH_4^+ + OH^-$ (desociate partially

$1-\alpha \quad \alpha \quad \alpha$

from: $\alpha = \sqrt{K_a/c} = \sqrt{\frac{5.7\times10^{-10}}{0.01}} = 2.4\times10^{-4}$

then: $[OH^-] = \alpha C = 2.4\times10^{-4}\times0.01 = 2.4\times10^{-6}\,M$

At neutralization: $NH_4OH + HCl \rightarrow NH_4Cl + H_2O$

$1 : 1$

but $pOH = -\log[OH^-] = -\log(2.4\times10^{-6}) = 5.6$,

Also: $pH + pOH = 14$

$pH = 14 - pOH$

$= 14 - 5.6$

$\therefore pH = 8.4$.

c> iv, 0.01 mole of NaOH in 1 dm³ of H_2O

$= 0.01\,M\ NaOH$.

$NaOH \rightarrow Na^+ + OH^-$

$0.01 \quad 0.01 \quad 0.01$

$[OH^-] = 0.01$, $pOH = -\log(0.01) = 2$

but $pOH + pH = 14$, $pH = 14 - 2 = 12$

$\therefore pH = 12$

In Extract 1.2 the candidate failed to calculate the pH at neutralization point and incorrectly calculated the pH of 1.0 dm^3 of pure water when 0.01 mole of NaOH is added.

2.2.2 Question 2: Solubility, Solubility Product and Ionic Product

In part (a), the candidates were required to explain with the aid of chemical equation(s) the phenomena that; addition of aqueous solution of silver nitrate into dilute HCl produces a white precipitate which dissolves in aqueous ammonia, zinc sulphide is not precipitated when hydrogen sulphide is passed through a solution to which dilute HCl is added, the passage of carbon dioxide through calcium hydroxide solution changes the latter into a precipitate which dissolves into a clear solution in excess carbon dioxide. In part (b), they were required to state whether a precipitate will form when 0.5 dm^3 of 2 x 10^{-3}M $BaCl_2$ is mixed with $1dm^3$ of 2 x 10^{-4}M Na_2SO_4 given that $Ksp[BaSO_4]$ = 1 x $10^{-10}mol^2dm^{-6}$ and calculate the mass of $Ca(OH)_2$ which is precipitated at 25°C when 500 cm^3 of the saturated solution of $Ca(OH)_2$ is mixed with equal volume of 0.4M NaOH given $Ksp[Ca(OH)_2]$ at 25°C = 4.42 x $10^{-5}mol^3dm^{-9}$. In part (c), they were provided with the statement that, the solubility product of lead (II) chloride $(PbCl_2)$ has a value of 1.6 x $10^{-5}mol^3dm^{-9}$ at 298K. Candidates were required to explain what the statement means, calculate the solubility of lead (II) chloride in water at 298K, and calculate the solubility of $BaCl_2$ in a 0.1M solution of lead (II) nitrate at the same conditions.

The question was opted by 46.7 percent of the candidates and it was noted that, a high percentage (69.2%) of the candidates scored from 6 to 19 marks. The candidate who scored from 6.5 to 10 markswas43.1 percent, 19.6 percent scored from 10.5 to 15 marks and 1.2 percent scored from 15.5 to 19 marks. Despite the fact that such performance was good,no candidate scored all the 20 allocated marks for the question. However, 30.8 percent scored below 6 marks with 1.2 percent scoring a zero mark.

The candidates who performed well supplied the correct explanations along with the chemical reactions for the prescribed chemical phenomena. They calculated correctly the ionic product of $BaSO_4$ which was used to conclude the formation of precipitate. Majority of the candidates calculated correctly the mass of $Ca(OH)_2$ which was precipitated and gave a clear explanation of the meaning of solubility product from the given value. They also calculated correctly the solubility of Lead (II) chloride in water at the given temperature and finally the solubility of lead (II) chloride when saturated with lead (II) nitrate. Extract 2.1 provides a candidate's good response.

Extract 2.1

2 a) (i) When Silver nitrate solution is added in to dilute HCl, white precipitate forms due to formation of white insoluble silver chloride

$$AgNO_{3(aq)} + HCl_{(aq)} \longrightarrow \underset{\text{(white ppt)}}{AgCl_{(s)}} + HNO_{3(aq)}$$

And when aqueous ammonia (NH4OH) is added in the mixture above, nitrogen atom of ammonia forms coordinate bond with Silver (Ag) atom of AgCl to form a complex ion and then compound. The complex compound so formed is soluble.

$$AgCl_{(s)} + NH_4OH_{(aq)} \longrightarrow \underset{\text{(Soluble)}}{[\boxed{Ag(NH_3)_2}]^{+}Cl^{-}_{(aq)}}$$

(ii) In absence of dilute HCl, hydrogen sulphide reacts with Zn^{2+} ions to form Zinc sulphide as follows in reversible reaction;

$$Zn^{2+}_{(aq)} + H_2S_{(g)} \rightleftharpoons ZnS + 2H^{+}_{(aq)}$$

But on adding dilute HCl, the acid dissociates completely to yield $H^{+}_{(aq)}$ ions and $Cl^{-}_{(aq)}$ ion.

$$HCl_{(aq)} \longrightarrow H^{+}_{(aq)} + Cl^{-}_{(aq)}$$

This increases the concentration of hydrogen ions (H^{+}) and thus shifts the ~~bad~~ equilibrium to the left, favouring deformation of ZnS.

2. a) (iii) When Carbon dioxide (CO_2) is passed through solution of $Ca(OH)_2$, White insoluble Calcium Carbonate is formed as per equation.

$$Ca(OH)_{2(aq)} + CO_{2(g)} \longrightarrow \underset{\text{(White ppt)}}{CaCO_{3(s)}} + H_2O_{(l)}$$

But when CO_2 is present in excess, the products above reacts to form soluble, colourless solution of Calcium bicarbonate

$$CaCO_{3(s)} + H_2O_{(l)} + CO_{2(g)} \longrightarrow \underset{\text{(Clear solution)}}{Ca(HCO_3)_{2(aq)}}$$

2 5(ii) Data given.

Volume of $BaCl_2$ $(V_1) = 0.5 dm^3$

Molarity of $BaCl_2$ $(M_1) = 2\times10^{-3} M$

Volume of Na_2SO_4 $(V_2) = 1 dm^3$

Molarity of Na_2SO_4 $(M_2) = 2\times10^{-4} M.$

$Ksp(BaSO_4) = 1\times10^{-10} mol^2 dm^{-6}$

From,

$$BaSO_{4(s)} \rightleftharpoons Ba^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)}$$

$a \quad 0 \quad 0$

$a - x \quad x \quad x$

where x is the solubility (Concentration) of ions

Let Qsp ~~be~~ the solubility product for reaction

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

$$Qsp = (x)(x)$$

$$Qsp = x^2$$

Now,

Concentration of Ba^{2+} $([Ba^{2+}]) = ?$

$$[Ba^{2+}] = \frac{n_{Ba^{2+}}}{V_{soln}}$$

from,

$$n_{Ba^{2+}} = M_{Ba^{2+}} \times V_{Ba^{2+}}$$

and

$$BaCl_2 \rightleftharpoons Ba^{2+}_{(aq)} + 2Cl^-_{(aq)}$$

$2\times10^{-3} \quad 0 \quad 0$

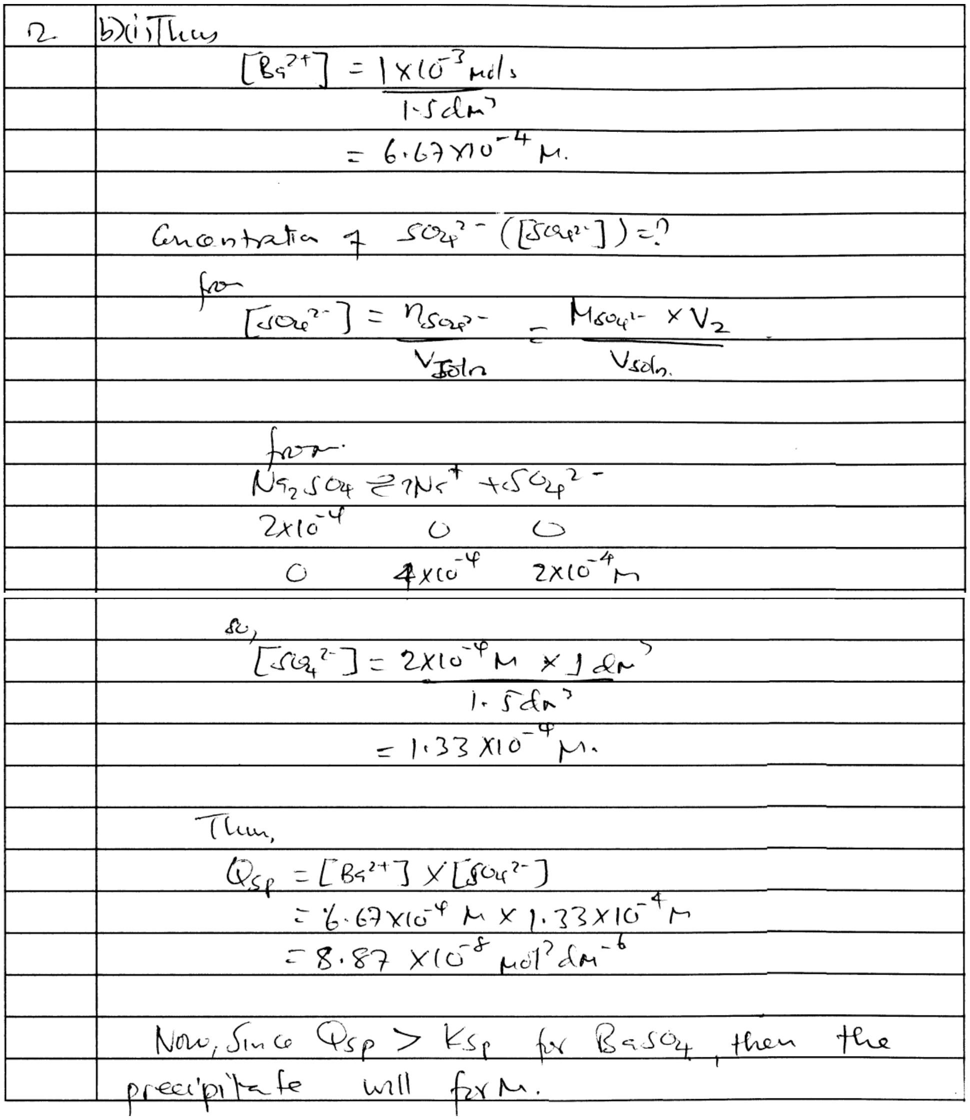
$\overset{0}{2\cancel{\times10^{-3}}} - \quad 2\times10^{-3} M. \quad 4\times10^{-6} M.$

So,

$$n_{Ba^{2+}} = 2\times10^{-3} M \times 0.5 dm^3$$

$$= 1\times10^{-3} moles$$

and $V_{soln} = V_1 + V_2 = 0.5 + 1 = 1.5 dm^3$



2 b)(i) Thus

$[Ba^{2+}] = \frac{1\times10^{-3}\,mols}{1.5\,dm^3}$

$= 6.67\times10^{-4}\,M.$

Concentration of SO_4^{2-} ($[SO_4^{2-}]$) =?

from

$[SO_4^{2-}] = \frac{n_{SO_4^{2-}}}{V_{soln}} = \frac{M_{SO_4^{2-}} \times V_2}{V_{soln}}.$

from:

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

2×10^{-4} 0 0

0 4×10^{-4} $2\times10^{-4}\,M$

so,

$[SO_4^{2-}] = \frac{2\times10^{-4}\,M \times 1\,dm^3}{1.5\,dm^3}$

$= 1.33\times10^{-4}\,M.$

Thus,

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

$= 6.67\times10^{-4}\,M \times 1.33\times10^{-4}\,M$

$= 8.87\times10^{-8}\,mol^2dm^{-6}$

Now, Since $Q_{sp} > K_{sp}$ for $BaSO_4$, then the precipitate will form.

Extract 2.1 shows one of the candidates' responses who provided good responses in part (a) and (b). This illustrates a mastery of solubility product.

However, the candidates who performed poorly, failed to explain the given phenomena with the aid of chemical equations. For example, one candidate wrote: $2HCl_{(aq)} + Ag_2NO_3$ ® $AgCl_2 + NO_2 + H_2O$ instead of $AgCl_{(s)} + 2NH_{3(aq)} \rightarrow [Ag(NH_3)_2]^+_{(aq)} + Cl^-_{(aq}$ for phenomena 2 (a) (i), HCl neutralizes zinc sulphate instead of H_2S dissociation is suppressed in acidic solution hence S^{2-} ions are not sufficient to precipitate ZnS phenomena 2 (a) (ii). Other candidates had a problem of finding whether a precipitate will form when the solutions provided were mixed. Some candidates just guessed that the precipitate will form without doing any calculations. Part 2 (b) (ii) of the question also seemed difficult to them as they could not find the mass of $Ca(OH)_2$ which is precipitated when the solution of $Ca(OH)_2$ is mixed with equal volume of 0.4M NaOH. Besides, they could not even explain the meaning of the term solubility product. One candidate stated it as "*the equilibrium constant of a sparingly soluble substance which is* $1.6 \times 10^{-5} mol^{3} dm^{9}$" showing that the candidate is not familiar with the term. This indicates that the candidates lackedthe knowledge in the tested concept. Extract 2.2 represents responses from candidates with low marks.

Extract 2.2

2(b)(ii) $BaCl_2 \rightarrow Ba^{2+} + 2Cl_2^-$

9.09×10^{-4} 9.04×10^{-4} 9.09×10^{-4}

Consider Na_2SO_4

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

1.82×10^{-4} 1.82×10^{-2} 1.82×10^{-2}

before mixing

$2\times10^{-4} \rightarrow 1dm^3$

$X \rightarrow 1dm^3$

$2\times10^{-4}/1dm^3$

~~After~~ After mixing

$2\times10^{-4}/1.1dm^3$

$2\times10^{-4} \rightarrow 1.1$

$X \rightarrow 1$

After mixing $= 1.82\times10^{-4}$

inition concentration of

~~Ca~~ $Ba = 9.09\times10^{-4}$

$SO_4 = 1.82\times10^{-2}$

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

~~Qsp =~~

$Qsp = (9.09\times10^{-4})(1.82\times10^{-2})$

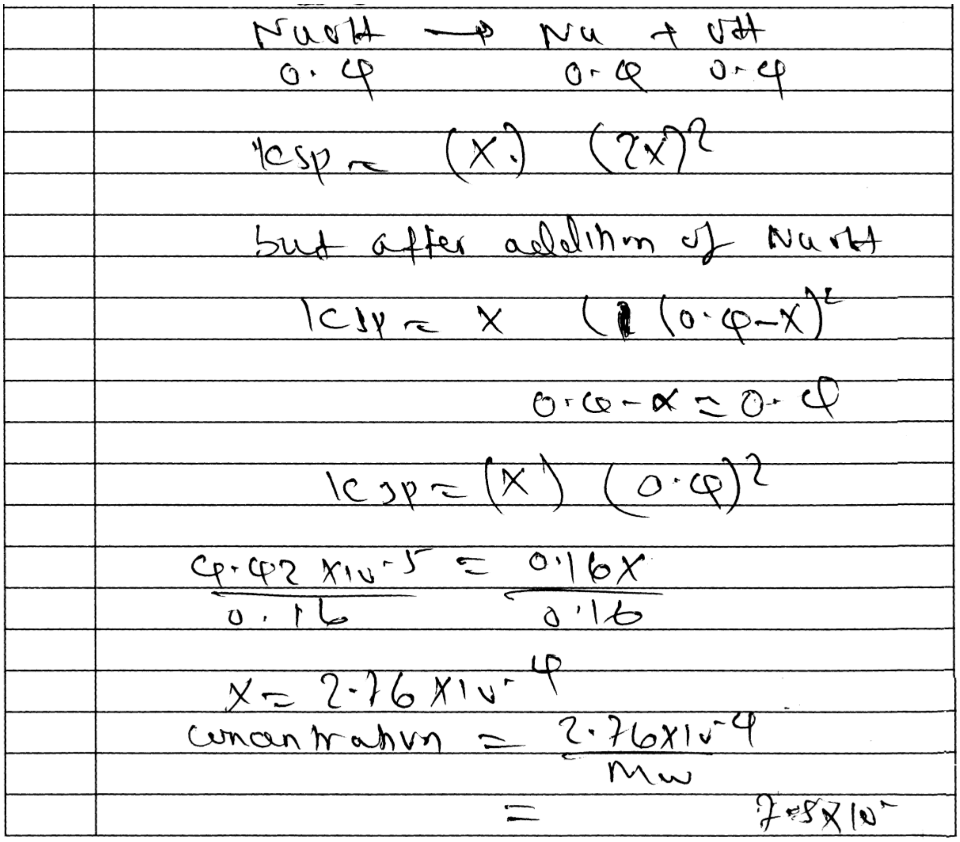
$Qsp = 1.654\times10^{-5}$

Compare Qsp and Ksp

Since Qsp is larger than Ksp precipitate will Not occur.

(ii) ~~Cons~~ consider

$Ca(OH)_2 \rightarrow Ca + 2OH^-$



$NaOH \rightarrow Na + OH$

$0.4 \quad 0.4 \quad 0.4$

$Ksp = (X)(2X)^2$

but after addition of NaOH

$Ksp = X\ (\ (0.4-X)^2$

$0.4 - x \simeq 0.4$

$Ksp = (X)(0.4)^2$

$\frac{4.42\times10^{-5}}{0.16} = \frac{0.16X}{0.16}$

$X = 2.76\times10^{-4}$

$\text{concentration} = \frac{2.76\times10^{-4}}{Mw}$

$= 7.8\times10^{-}$

Extract 2.2 indicates an example of the candidate's poor response. The candidate failed to calculate the ionic product which led to wrong response in stating whether a precipitate will occur or not. She/he failed to calculate the mass of Ca(OH) precipitated.

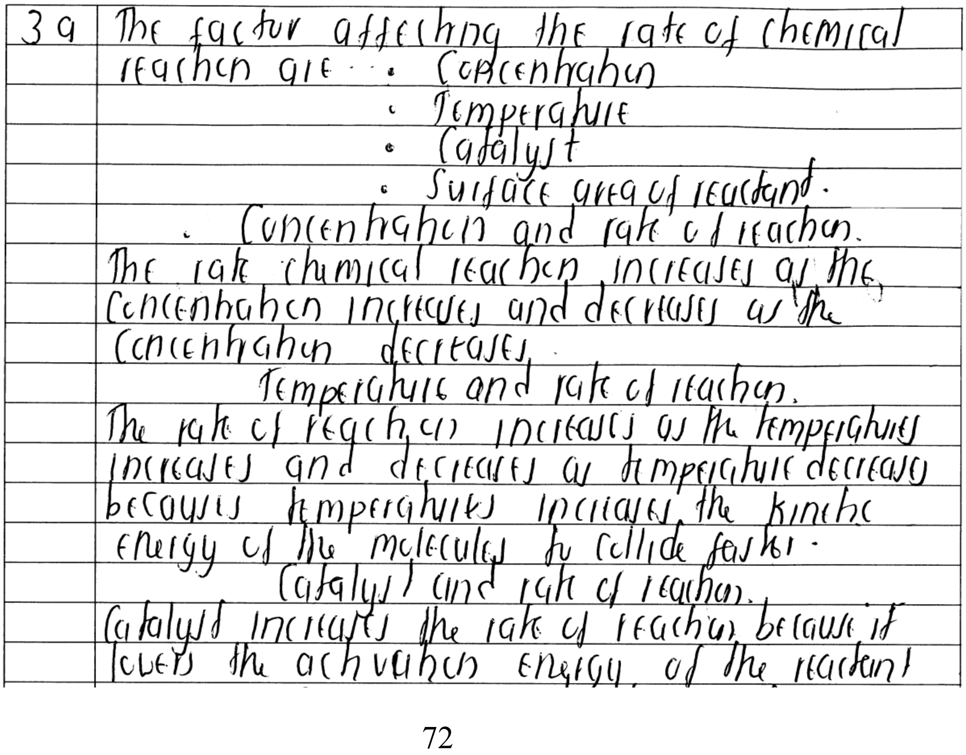
2.2.3 Question 3: Chemical Kinetics

In part (a), the candidates were required to explain four factors that can affect the rate of a chemical reaction. In part (b), they were provided with the rate constant for the first order reaction as 3.46 x $10^{-2}s^{-1}$ at 298K and were required to calculate the rate constant at 350K if the activation energy for the reaction is $50.2kJmol^{-1}$. In part (c), they were provided with the equation for a reaction between nitrogen dioxide and fluorine to produce nitryl fluoride (NO_2F) as $2NO_{2(g)} + F_{2(g)} \rightarrow 2NO_2F_{(g)}$. They were then required to write the reaction in terms of rate of formation of NO_2F and disappearance of F_2 and NO_2respectively. In part (d), they were provided with data in tabular form.Thus hydrolysis of ethyl acetate by NaOH using equal concentration of the reactants by titrating $25cm^3$ of the reaction mixture at different interval of time was studied by titrating $25cm^3$ of the reaction mixture of different intervals against standard acid. The volumes of acid used at 0, 5, 15 and 25 minutes were 16.00, 10.24, 6.13 and 4.32 cm^3 respectively. The candidates were then required to establish that the reaction is a second order.

Many (60.2%)candidates opted for this question, out of which 64.9 percent scored from 6 to 20 marks. The candidate who scored from 6.5 to 10 markswere31.6 percent, 20.2percent scored from 10.5 to 15 marks and 8.3percent scored from 15.5 to 20 marks. However, 35.1 percent scored below 6 marks with 0.1 percent scoring a zero mark. This trend of statistics indicates that, the performance in this question was good.

The candidates who scored high marks explained properly four factors that can affect the rate of a chemical reaction, calculated correctly the rate constant required and wrote properly the rate expression for the reaction $2NO_{2(g)} + F_{(g)} \rightarrow 2NO_2F_{(g)}$ in terms of formation of $NO_2 F_{(g)}$, disappearance of F_2 and NO_2. Finally they managed to establish that, hydrolysis of ethyl acetate by NaOH is a second order reaction. Extract 3.1 is a candidates' response with a good score.

Extract 3.1



3a The factor affecting the rate of chemical
reaction are · Concentration
· Temperature
· Catalyst
· Surface area of reactant.
· Concentration and rate of reaction.
The rate chemical reaction increases as the
concentration increases and decreases as the
concentration decreases.
Temperature and rate of reaction.
The rate of reaction increases as the temperatures
increases and decreases as temperature decreases
becauses temperatures increases the kinetic
energy of the molecules to collide faster.
Catalyst and rate of reaction.
Catalyst increases the rate of reaction because it
lowers the activation energy of the reactant

- Surface area and rate of reaction

The rate of reaction is fast to the reaction which provide large area of the reaction to take place

3b Solution

Data

Let

K - be rate constant

$K_1 = 3.46 \times 10^{-2} s^{-1}$ at $T_1 = 298K$

$K_2 = ?$ at $T_2 = 350K$

Let activation energy be - E

$E = 50.2 \, kJmol^{-1}$

$E = 50200 \, J$

From

$$K = Ae^{-E/RT}$$

3b applying ln.

$$\ln K = \ln A - \frac{E}{RT} \ln e$$

$$\ln k = \frac{-E}{RT} + \ln A$$

$$\ln k_1 = \frac{-E}{RT_1} + \ln A \quad -(i)$$

$$\ln k_2 = \frac{-E}{RT_2} + \ln A \quad -(ii)$$

equation (ii) - (i)

$$\ln k_2 - \ln k_1 = \frac{-E}{RT_2} + \frac{E}{RT_1}$$

$$\ln\left(\frac{k_2}{k_1}\right) = \frac{E}{R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$$

$$\ln\left(\frac{k_2}{3.46 \times 10^{-2}}\right) = \frac{50200}{8.31}\left[\frac{1}{298} - \frac{1}{350}\right]$$

$$\ln\left(\frac{k_2}{3.46 \times 10^{-2}}\right) = 3.011769484$$

$$K_2 = 20.32332993 \times 3.46 \times 10^{-2}$$

$$\therefore \underline{K_2 = 0.703187215\ s^{-1}}$$

3c from

$$2NO_{2(g)} + F_{2(g)} \rightarrow 2NO_2F_{(g)}$$

3ci Rate in terms of formation of NO_2F $= \frac{1}{2}\frac{d[NO_2F]}{dt}$

3cii Rate in terms of disappearance of F_2 is

$$Rate = -\frac{d[F_{2(g)}]}{dt}$$

3ciii Rate in terms of disappearance of NO_2 is $Rate = -\frac{1}{2}\frac{d[NO_{2(g)}]}{dt}$

3d · Solution

Let A be amount

from second order.

$$\frac{dA}{dt} = -kA^2$$

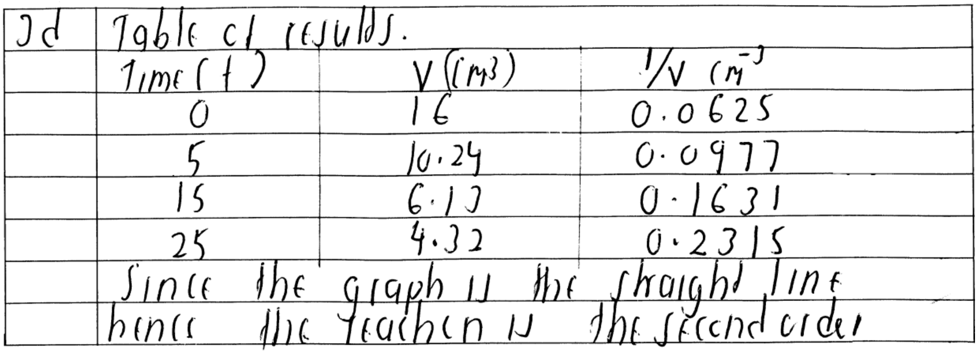
$$\int_{A_0}^{A} \frac{dA}{[A]^2} = -k\int_0^t dt$$

$$\frac{1}{A} - \frac{1}{A_0} = kt$$

$$\frac{1}{A} = kt + \frac{1}{A_0}$$

but $A = V$

$$\frac{1}{V} = kt + \frac{1}{V_0}$$

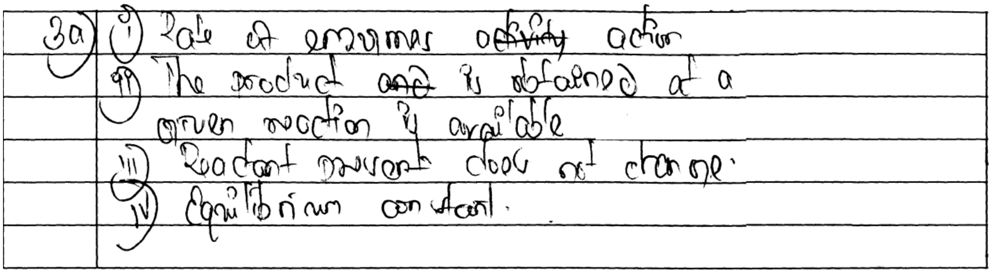


3d	Table of results.		
	Time (t)	V (cm³)	1/V (cm⁻³
	0	16	0.0625
	5	10.24	0.0977
	15	6.13	0.1631
	25	4.32	0.2315
	Since the graph is the straight line		
	hence the reaction is the second order		

In Extract 3.1, the candidate gave correct factors that affect the rate of a chemical reaction, calculated correctly the rate constant and wrote properly the rate expressionsand established that, the hydrolysis of ethyl acetate by NaOH is a second order.

Some of the candidates with lower marks failed to explain factors affecting the rate of a chemical reaction while others failed to applythe Arrhenius equation to determine rate constant from two different temperature conditions.Some candidates failed to differentiate between natural logarithms and common logarithm in the equation. This is an indication of inadequate mathematical skills. However, other candidates confused the meaning of the word formation and disappearance as used in rate of reaction; hence they wrote the equations with wrong sign. For example, the rate of formation of NO_2F was given negative sign as $R = \frac{-d[NO_2F]}{dt}$ instead of $R = \frac{d[(NO_2F)]}{dt}$ and for the disappearance of $F_2$was given positive sign as $R = \frac{\Delta[F]}{\Delta t}$ instead of $R' = -\frac{\Delta[F_2]}{\Delta t}$.In part (d),some candidates failed to recall the equation: $K = \frac{1}{t}\frac{x}{a(a-x)}$ hence drew a wrong graph and supplied wrong procedures of determination of the order of reaction which led to incorrect order of reaction. Extract 3.2 illustrate the case.

Extract 3.2



3a) (i) Rate of enzymes ~~activity~~ action
(ii) The product ~~one~~ is obtained at a given reaction is available
(iii) Reactant present does not change.
(iv) Equilibrium constant.

In Extract 3.2, the candidate attempted only part 3(a) of the question, of which he/she responded incorrectly. This implies that, the candidate had insufficient knowledge on Chemical Kinetics.

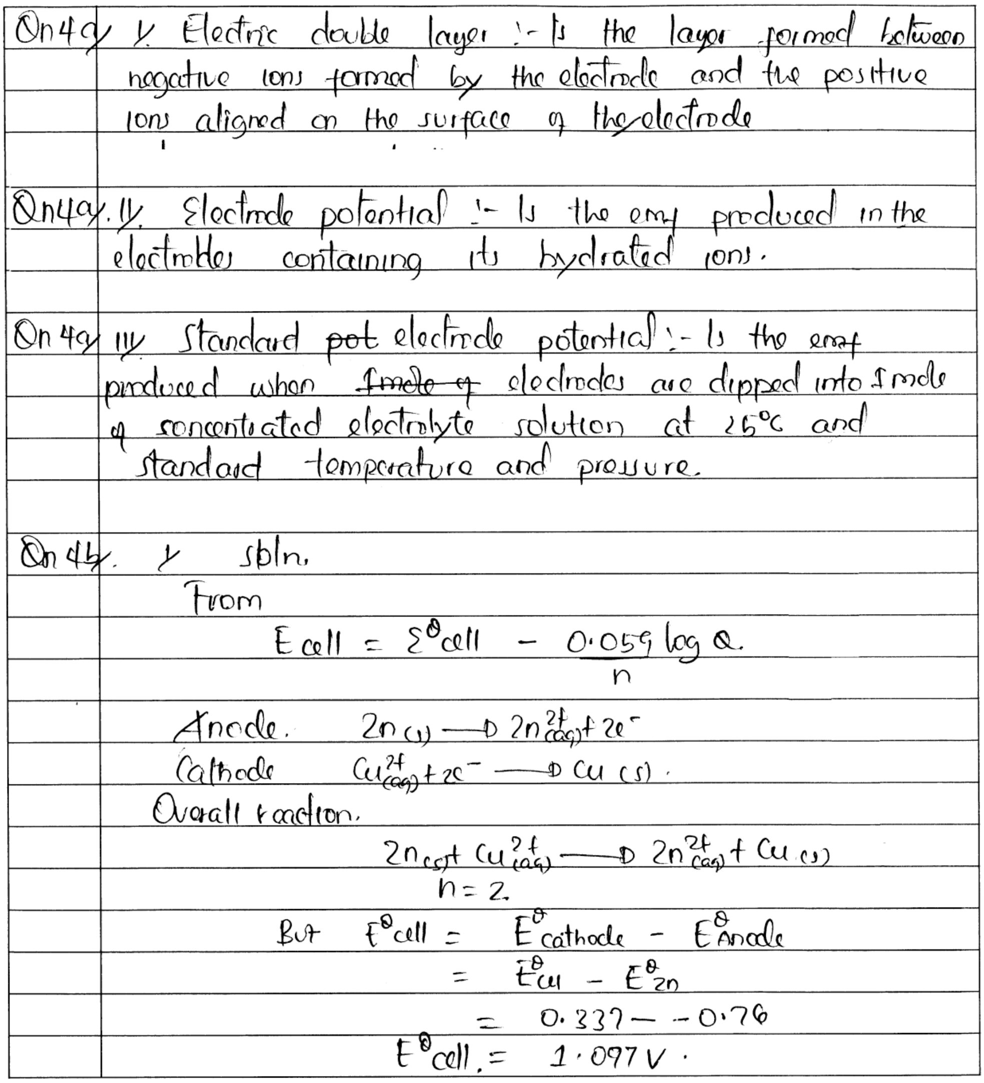
2.2.4 Question 4: Electrochemistry

In part (a), the candidates were required to define the terms: Electric double layer, Electrode potential and Standard electrode potential. In part (b), candidates were provided with the electrode system; $Zn^{2+}/Zn \quad E^{\theta} = -0.76\,V$ and $Cu^{2+}/Cu \quad E^{\theta} = 0.337\,V$. They were required to;Calculate the e.m.f of the cell, explain briefly what would be the effects on the e.m.f. if $[Zn^{2+}]$ or $[Cu^{2+}]$ is altered, Find the e.m.f of the cell if zinc electrode system is replaced by silver electrode system given that $Ag^{+}/Ag \quad E^{\theta} = 0.80\,V$. In part (c), they were required to;State Faraday's laws of electrolysis, List at least two importance of the second law of electrolysis, Find the weights of silver and iodine which will be liberated when 2g of copper are being deposited by passing an electric current through three cells in series containing solutions of copper sulphate, silver nitrate and potassium iodide respectively.

The question was opted by 63.9 percent of the candidates, out of which 39.0 percent scored below 6 out of 20 marks of which 1.2 percent scored a zero mark. A large number (40.6 %) of the candidates scored from 6 to 10 marks. The candidates who scored from 10.5 to 15 markswere 19.2 percent. A few candidates (1.2 %) scored from 15.5 to 18.0 marks;however, there were no any candidate who scored all marks allocated in this question. Generally, the performance of the candidates in this question was good.

The candidates who performed well in this question were able to define the asked terms. They were also able to calculate the e.m.f. of the cell, gave good explanation on how the e.m.f. is affected when the cell is altered and they calculated correctly the e.m.f. of the cell. They also stated well the Faraday's laws of electrolysis and listed well the two importance of the second law of electrolysis. The weight of silver and iodine liberated were correctly calculated by integrating with the known weight of deposited copper. Extract 4.1 illustrates the case.

Extract 4.1



Qn 4a/ i/ Electric double layer :- Is the layer formed between negative ions formed by the electrode and the positive ions aligned on the surface of the electrode

Qn4a/. ii/ Electrode potential :- Is the emf produced in the electrodes containing its hydrated ions.

Qn 4a/ iii/ Standard ~~pot~~ electrode potential :- Is the emf produced when ~~1 mole of~~ electrodes are dipped into 1 mole of concentrated electrolyte solution at 25°C and standard temperature and pressure.

Qn 4b/. i/ soln.

From

$$E_{cell} = E^{\theta}_{cell} - \frac{0.059}{n}\log Q.$$

Anode. $Zn_{(s)} \longrightarrow Zn^{2+}_{(aq)} + 2e^-$

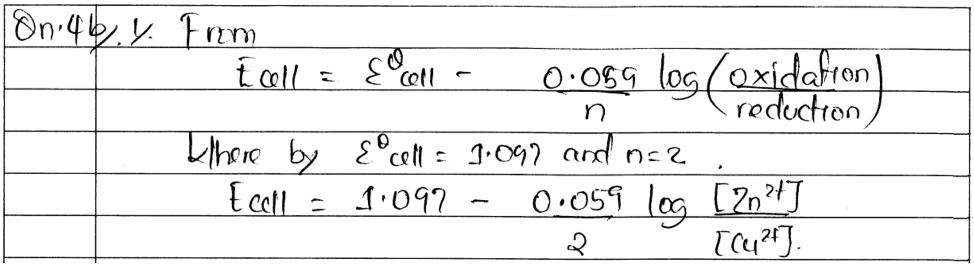
Cathode $Cu^{2+}_{(aq)} + 2e^- \longrightarrow Cu_{(s)}$.

Overall reaction.

$$Zn_{(s)} + Cu^{2+}_{(aq)} \longrightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$$

$n = 2.$

$$\text{But } E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{Anode}$$
$$= E^{\theta}_{Cu} - E^{\theta}_{Zn}$$
$$= 0.337 - -0.76$$
$$E^{\theta}_{cell} = 1.097\,V.$$



Qn.4b/. i/ From

$$E_{cell} = E^{\theta}_{cell} - \frac{0.059}{n}\log\left(\frac{\text{oxidation}}{\text{reduction}}\right)$$

Where by $E^{\theta}_{cell} = 1.097$ and $n = 2$.

$$E_{cell} = 1.097 - \frac{0.059}{2}\log\frac{[Zn^{2+}]}{[Cu^{2+}]}.$$

$$E_{cell} = 1{\cdot}097 - 0{\cdot}0295 \log \frac{[Zn^{2+}]}{[Cu^{2+}]}$$

NOTE: The concentration of $[Zn^{2+}]$ and $[Cu^{2+}]$ are not provided

$$\therefore E^{\theta}_{cell} = 1{\cdot}097V.$$

and $E_{cell} = 1{\cdot}097 - 0{\cdot}0295 \log \frac{[Zn^{2+}]}{[Cu^{2+}]}$

NOTE:
There is a difference between emf of the cell and standard emf of a cell.

Qn4b) iv. If the $[Zn^{2+}]$ or $[Cu^{2+}]$ is altered from the cathodic and anodic equation,

Cathode : $Cu^{2+}_{(aq)} + 2e^- \longrightarrow Cu_{(s)}$ — eqn(i)
Anode : $Zn_{(s)} \longrightarrow Zn^{2+}_{(aq)} + 2e^-$ — eqn(ii)

Consider Anodic reaction
If the concentration of Zn^{2+} is increased the reaction at anode will favour backward reaction and hence emf of the cell will be lowered but when $[Zn^{2+}]$ is reduced the reaction will shift more foward to produce enough $[Zn^{2+}]$ and hence emf of the cell is increased.

Also

Consider Cathodic reaction
If the concentration of Cu^{2+} is increased the reaction will shift more forward and hence the emf of the cell will

Qn.4b) iv) raised but if the $[Cu^{2+}]$ is decreased the reaction will shift more backward and hence the emf of the cell will be lowered

Qn4b) iv. soln.

When Zn electrode is replaced with Ag electrod the galvanic cell will change and Copper electrod will be at anode and silver at cathode since copper is more reactive than silver
Hence

$$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}.$$

Consider reactions.

Cathode: $Ag^{+}_{(aq)} + e^{-} \longrightarrow Ag_{(s)}$ 0.80V.

Anode: $Cu_{(s)} \longrightarrow Cu^{2+}_{(aq)} + 2e^{-}$ 0.337V

Overall reaction: $2Ag^{+}_{(aq)} + Cu_{(s)} \longrightarrow 2Ag_{(s)} + Cu^{2+}_{(aq)}$.

$$E^{\theta}_{cell} = (0.80 - 0.337)V$$
$$E^{\theta}_{cell} = 0.463V$$

$$\therefore \underline{\underline{E^{\theta}_{cell} = 0.463V}}$$

$$E_{cell} = E^{\theta}_{cell} - \frac{0.059}{n} \log \frac{[Cu^{2+}]}{[Ag^{+}]^2}$$

$$n = 2$$

$$= 0.4630 - \frac{0.059}{2} \log \frac{[Cu^{2+}]}{[Ag^{+}]^2}$$

$$E_{cell} = 0.463 - 0.0295 \log \frac{[Cu^{2+}]}{[Ag^{2+}]^2}$$

NOTE: There is a difference between emf of the cell and standard emf of the cell. $[Cu^{2+}]$ and $[Ag^{+}]$ are not gi

Qn4c) i/ 1st Faraday's law of electrolysis states that, "The amount of mass liberated during electrolysis process is directly proportional to the quantity of electricity passed

ie $m \propto Q$.

$m \propto It$

2nd Faraday's law of electrolysis states that, When the same quantity of electricity is passed through the same electrodes but different electrolytes, the amount of ~~substance~~ mass liberated is directly proportional to it equivalent weight

ie $m \propto E$

Qn4c) ii) TWO IMPORTANCE OF THE 2nd LAW OF ELECTROLYSIS.

→ It helps to determine the amount of substance liberated when its equivalent is known.

→ It give the amount of quantity liberated by using faraday's constant

Qn4c) iii) soln.

Given $M_{copper} = 2g$.

Solutions

$CuSO_4$, $AgNO_3$ and KI.

From 2nd law of faraday's electrolysis.

$$m \propto E$$

$$m = KE$$

$$\frac{m}{E} = K \text{ (constant of proportionality)}$$

$$\frac{M_{copper}}{E_{copper}} = \frac{M_{silver}}{E_{silver}}$$

$$\frac{M_{copper}}{M_{silver}} = \frac{E_{copper}}{E_{silver}}$$

But $E_{copper} = \frac{Mr}{charge} = \frac{63.5}{2} = 31.75$

$E_{silver} = \frac{Mr}{charge} = \frac{108}{1} = 108$

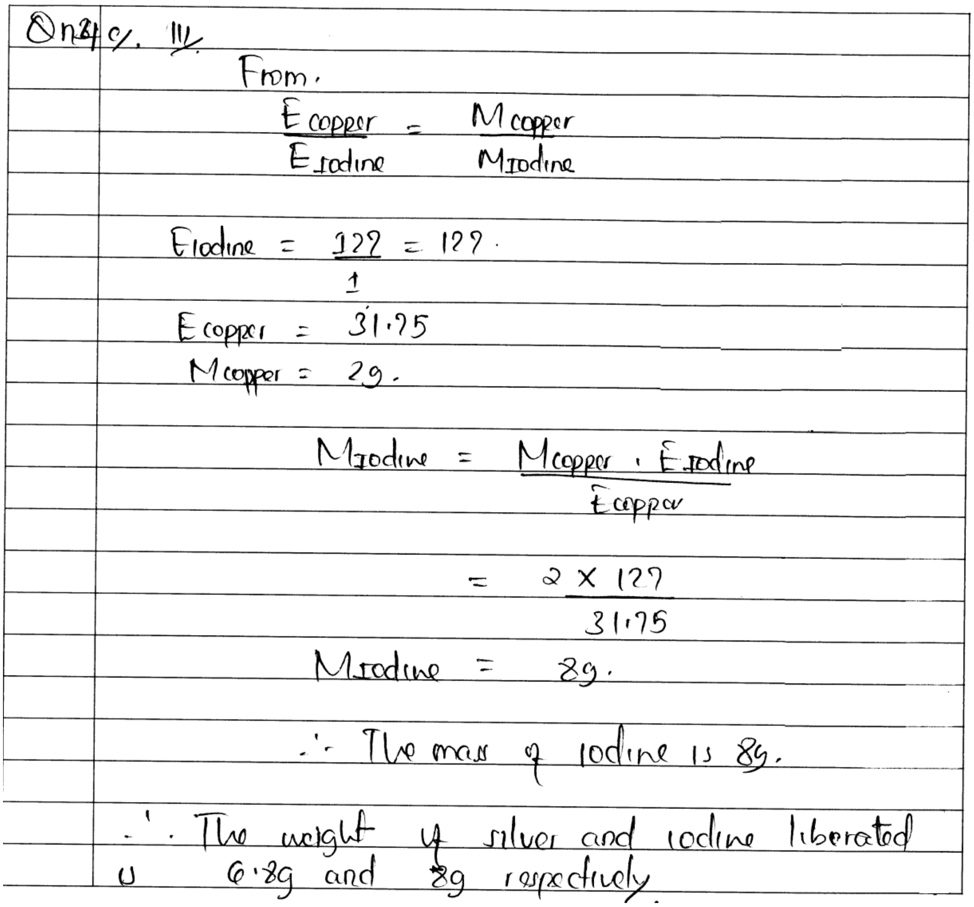
$M_{copper} = 2$

$$M_{silver} = \frac{M_{copper} \cdot E_{silver}}{E_{copper}}$$

$$= \frac{2 \times 108}{31.75}$$

$M_{silver} = 6.8g$.

∴ The mass of silver is 6.8g.



Qn4 c). iii).

From.

$$\frac{E_{copper}}{E_{Iodine}} = \frac{M_{copper}}{M_{Iodine}}$$

$$E_{Iodine} = \frac{127}{1} = 127.$$

$$E_{copper} = 31.75$$

$$M_{copper} = 2g.$$

$$M_{Iodine} = \frac{M_{copper} \cdot E_{Iodine}}{E_{copper}}$$

$$= \frac{2 \times 127}{31.75}$$

$$M_{Iodine} = 8g.$$

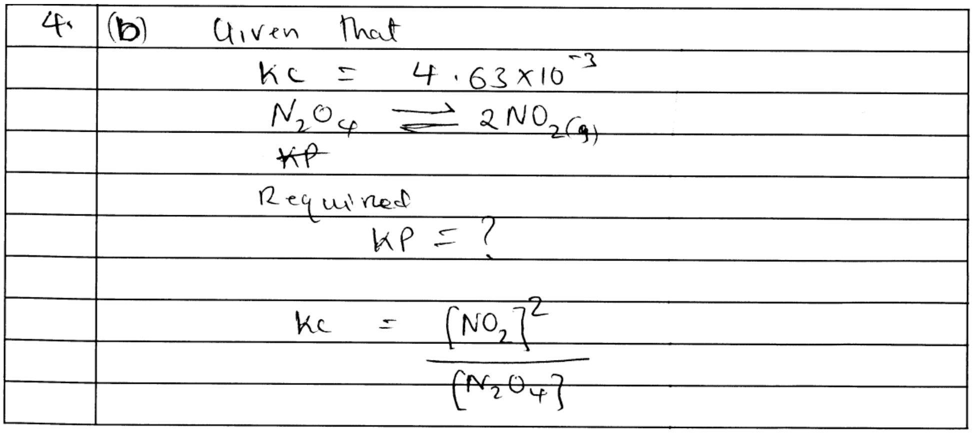
∴ The mass of iodine is 8g.

∴ The weight of silver and iodine liberated is 6.8g and 8g respectively.

The answer in Extract 4.1 is an indication that the candidate had clear knowledge on Electrochemistry, since all parts of the question are presented accurate answers clearly according to the requirement of the question.

However, the candidates who performed poorly failed to define the asked terms. They also failed to calculate the e.m.f. of the cell and failed to explain the effect of altering concentration of the cell, for example one candidate wrote “the e.m.f. of [Zn^{2+}] or [Cu^{2+}] will lose 2 electrons to become solid which is incorrect. Extract 4.2 represents a candidate who scored low.

Extract 4.2



4. (b) Given That

$Kc = 4.63\times10^{-3}$

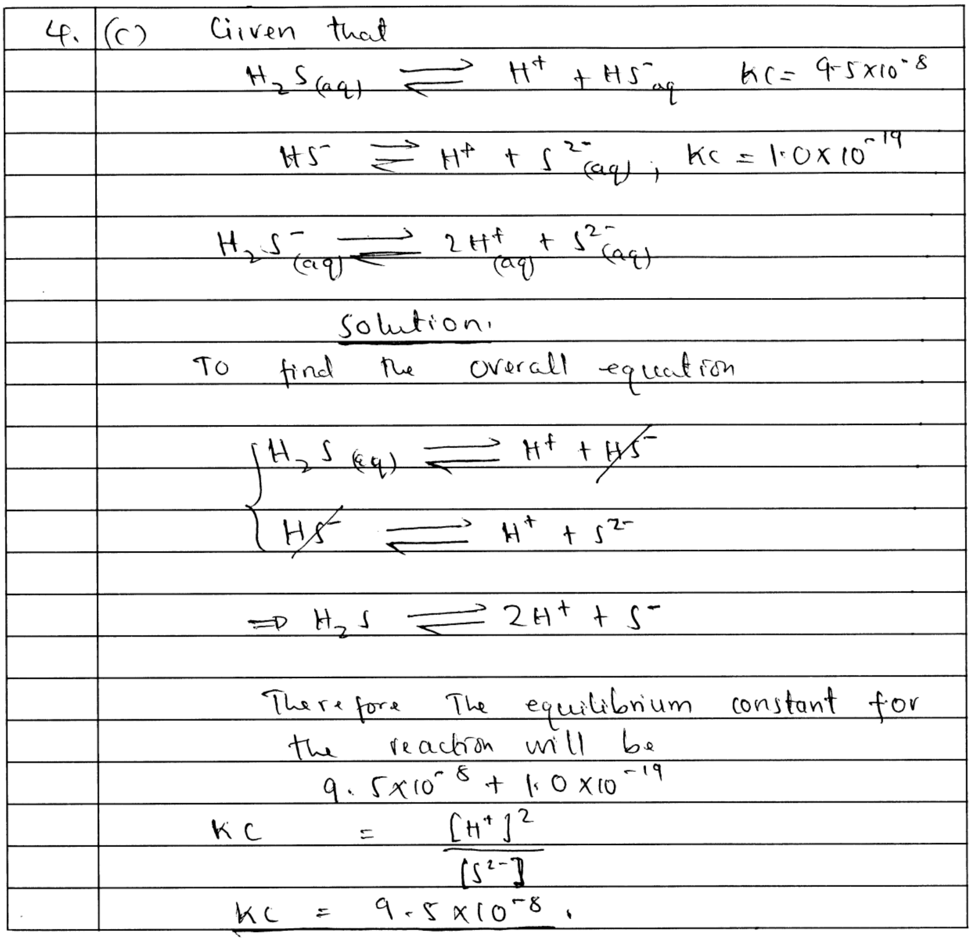
$N_2O_4 \rightleftharpoons 2NO_{2(g)}$

~~KP~~

Required

$KP = ?$

$Kc = \frac{[NO_2]^2}{[N_2O_4]}$



4. (c) Given that

$H_2S_{(aq)} \rightleftharpoons H^+ + HS^-_{aq}$ $\quad Kc = 9.5\times10^{-8}$

$HS^- \rightleftharpoons H^+ + S^{2-}_{(aq)}$; $\quad Kc = 1.0\times10^{-19}$

$H_2S^-_{(aq)} \rightleftharpoons 2H^+_{(aq)} + S^{2-}_{(aq)}$

Solution.

To find the overall equation

$$\begin{cases} H_2S_{(aq)} \rightleftharpoons H^+ + \cancel{HS^-} \\ \cancel{HS^-} \rightleftharpoons H^+ + S^{2-} \end{cases}$$

$\Rightarrow H_2S \rightleftharpoons 2H^+ + S^-$

Therefore The equilibrium constant for the reaction will be

$9.5\times10^{-8} + 1.0\times10^{-19}$

$Kc = \frac{[H^+]^2}{[S^{2-}]}$

$Kc = 9.5\times10^{-8}$.

In Extract 4.2 the candidate failed to answer correctly any part of the question. The candidate failed to calculate correctly the e.m.f. of the cell and was unable to explain how the e.m.f. is affected when alternation of concentration is made.

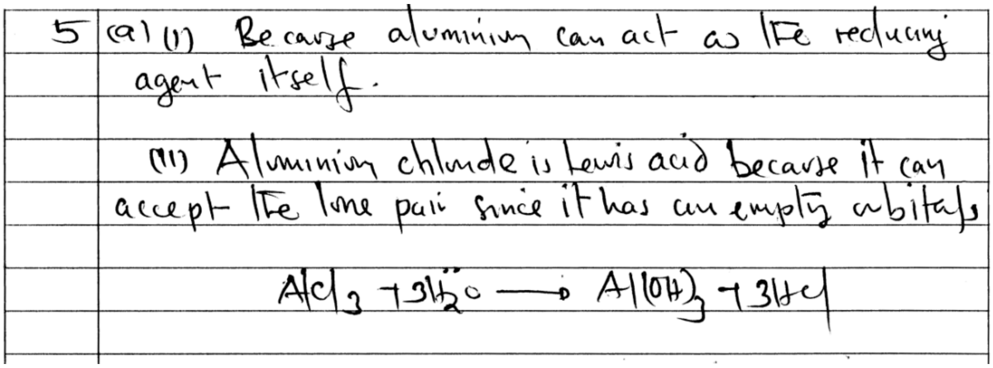
2.2.5 Question 5: Extraction of Metals and Selected Compounds of Metals

Part (a) of the question required the candidates to explain with the aid of chemical equations the phenomena that; Common reductants are useless in the manufacture of aluminium from its ore, Aluminium chloride is a good Lewis acid, Molecular mass of $AlCl_3$ in vapour state is twice the expected value and Aluminium oxide shows basic properties by reacting with HCl. Part (b) of the question required the candidates to describe the process of aluminium extraction starting with bauxite under the stages of purification of the ore from impurities and electrolysis of aluminium. Part (c) required the candidates to evaluate any four uses of aluminium which reflect its physical and chemical properties.

The question was opted by 67.5 percent of the candidates and their performance was good as 82.8 percent scored from 6 to 20 marks. The candidates who scored from 6.5 to 10 markswere 33.5 percent and from 10.5 to 15 marks were 38.6 percent. Only 7.3 percent scored from 15.5 to 20 marks with one candidate who scored fully marks. On the other hand, 17.2 percent scored below 6 marks with 0.4 percent scoring a zero mark.

The candidates who performed well in this question had enough knowledge on the concept of extraction of metals. They described properly the process of aluminium extraction by considering purification of the ore and electrolysis of pure aluminium oxide. They also evaluated precisely the four uses of aluminium which reflect its physical and chemical properties. Extract 5.1 shows a sample of answer candidate with good performance.

Extract 5.1

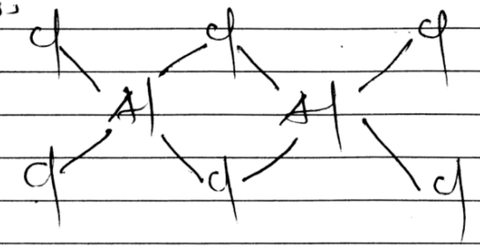


5 (a) (i) Because aluminium can act as the reducing agent itself.

(ii) Aluminium chloride is Lewis acid because it can accept the lone pair since it has an empty orbitals

$AlCl_3 + 3H_2O \longrightarrow Al(OH)_3 + 3HCl$

(iii) Molecular mass of $AlCl_3$ in vapour state is twice of the expected because in the vapour state $AlCl_3$ undergo dimerization which results to the increase of its mass



5 (a) (iv) Aluminium oxide shows basic property by reacting with HCl because Aluminium oxide react with HCl to produce salt and water

$Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + 3H_2O$

5 (b) Aluminium extraction by using bauxite

(i) Purification of the ore from impurities

(a) Removal of water from the ore. The ore is heated to remove water

$$Al_2O_3 \cdot 2H_2O \xrightarrow[\Delta]{} Al_2O_3 + 2H_2O$$

(b) The ore is reacted with concentrated sodium hydroxide (NaOH) to form sodium tetrahydroxo aluminate

$$NaOH + Al_2O_3 \rightarrow Na[Al(OH)_4]$$

but silica and ferric which are impurities of ~~Al~~ Bauxite doesnt react with conc. NaOH

(c) The mixture of $Na[Al(OH)_4]$ was filtered to obtain the filtrate the silica (SiO_2) and (FeO) ferric remain as residue

(d) The filltrate is passed is pure carbondioxide CO_2. form ~~Sodium~~ Aluminium hydroxide

$CO_2 + Na[Al(OH)_4] \longrightarrow Al(OH)_3 + Na_2CO_3$

5 (b)(ii) The aluminium hydroxide is heated to produce solid Aluminium oxide

$Al(OH)_3 \longrightarrow Al_2O_3$

5 (b) (iii) Electrolysis of aluminium

The molten Aluminium oxide introduce into electrolytic furnance inorder to melt. The aluminium oxide melt at the temperature of 3000°c. Inorder to decrease the temperature of Al_2O_3 cryolite is added.

The Electrolytic cell's temperature should not exceed 1000°c. If the temperature will exceed cryollite can melt the cryolite Lower the temperature to about 900°c This cause the aluminium oxide to decompose

$Al_2O_3 \longrightarrow 2Al^{3+} + 3O^{2-}$

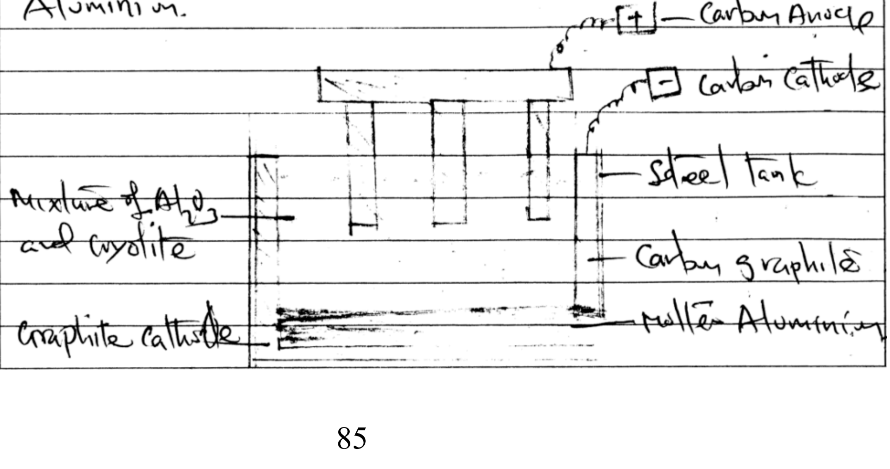
- Reaction at the cathode

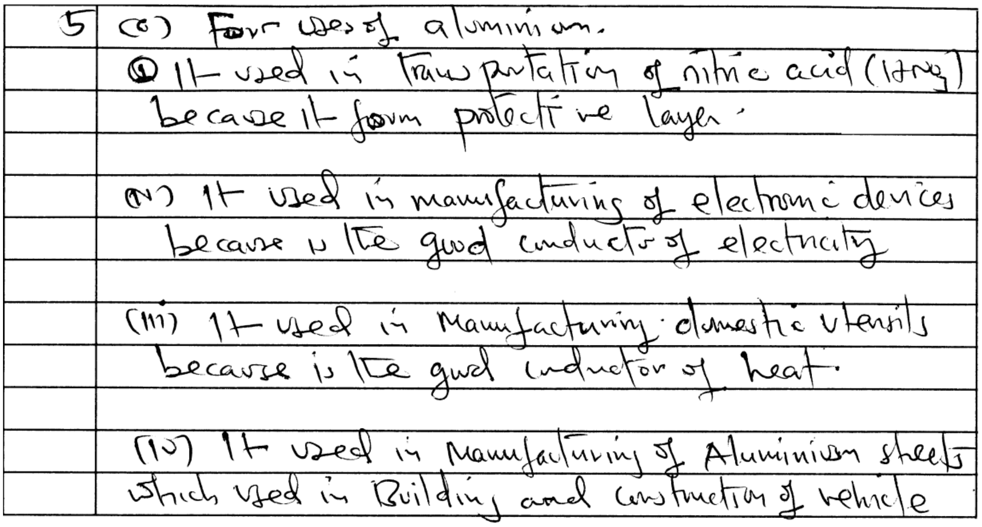
$2Al^{3+} + 6e^- \longrightarrow 2Al$

- Reaction at the anode

$3O^{2-} + 6e^- \longrightarrow 3/2\, O_2$

Diagram of electrolytic cell (Bayer's cell). ~~of~~ Aluminium.





5 (c) Four uses of aluminium.

① It used in transportation of nitric acid (HNO_3) because it form protective layer.

(ii) It used in manufacturing of electronic devices because is the good conductor of electricity

(iii) It used in Manufacturing domestic utensils because is the good conductor of heat.

(iv) It used in Manufacturing of Aluminium sheets which used in Building and construction of vehicle

Extract 5.1 shows a sample of responses of candidate who managed to perform well all parts of the question.

However, some of the few candidates (17.2%) who scored low marks failed to describe the process of aluminium extraction as instructed. Other candidates failed to evaluate the uses of aluminium reflecting its physical and chemical properties. For example, one candidate wrote the uses of aluminium as, "*it is used for making the salt at the laboratory, it is used for studying by different way about calcium, it is used for by plant for growth and maintenance*" all of which are incorrect responses as no one reflects the physical property of aluminium. This implies that such candidates had inadequate knowledge about uses of aluminium in relation to physical and chemical properties of the metal. Extract 5.2 is a response from a candidate with low marks.

Extract 5.2

5 (a)(ii) Aluminim chloride is a good lewis acid

$AlCl_2 \rightarrow Al + Cl_2$

It is a good Lewis acid since it is a electron donor

(iii) Molecular mass of $AlCl_3$ in vapour state is twice the expected value because it is the molecular mass of metal and metal and they are strong metal.

$AlCl_3 \rightarrow$.

(iv) $AlO + 2HCl \rightarrow AlCl_2 + H_2O$

~~At~~ It is true since the $AlOH$ has reacted with $2HCl$ and produce $AlCl_2$ and H_2O

(b) Aluminium is extracted from the orea known as Aluminium Oxide Ore.

(ii) Electrolysis of aluminium

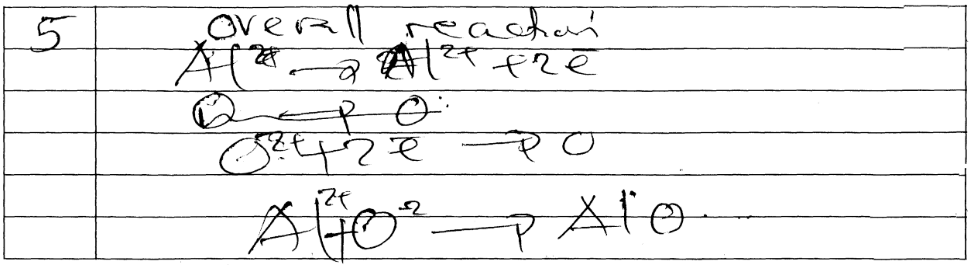
$AlO \rightarrow Al^{+} + O^{-}$

At the cathode

$Al^{+} \rightarrow Al^{2+} + 2e$

At anode

$O^{2-} \rightarrow O^{2} + 2e$



5 overall reaction

$Al \rightarrow Al^{2+} + 2\bar{e}$

$O \rightarrow O:$

$O^{2+} + 2\bar{e} \rightarrow O$

$Al^{2+} + O^{-2} \rightarrow AlO$

In Extract 5.2, the candidate failed to explain the prescribe phenomena and she/he gave incorrect description of the process of extraction of aluminium.

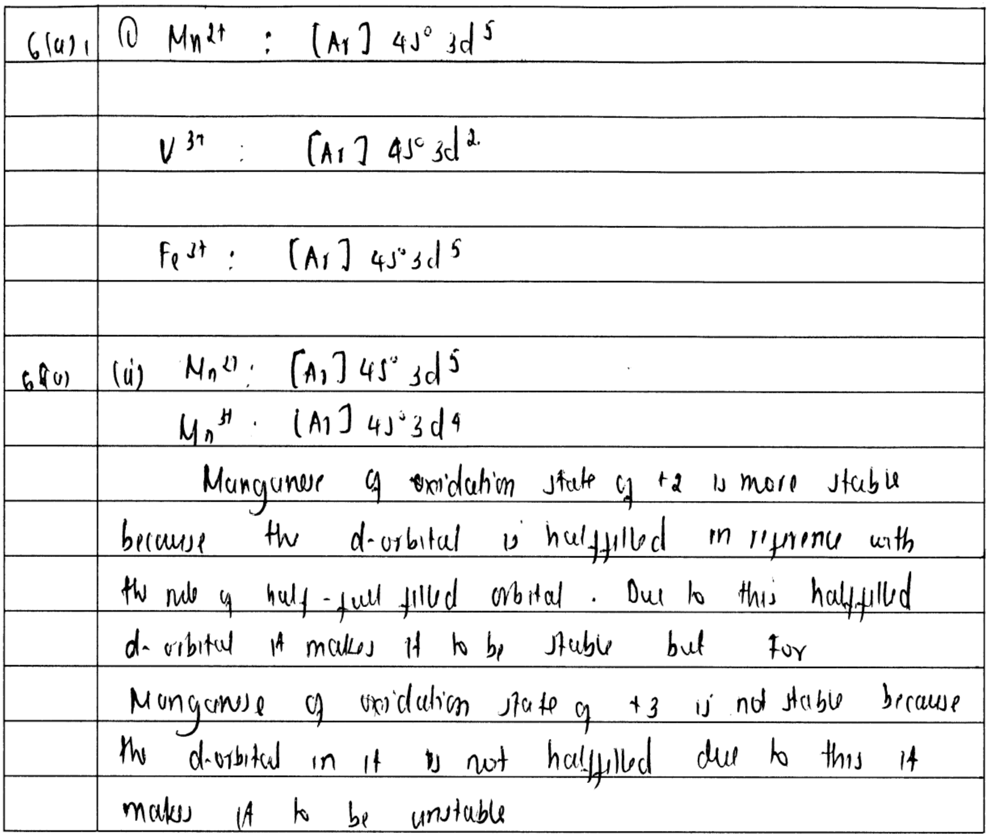
2.2.6 Question 6: Transition Elements

In part (a),the candidates were required to write the electronic configuration of Mn^{2+} , V^{3+} and Fe^{3+} and give reason(s) why in manganese the oxidation state of +2 is more stable than the oxidation state of +3. In part (b),they were required to explainbriefly the phenomena that; the radii of Fe, Co and Ni show a much smaller variation in size than those of Na, Mg and Al, cadmium has two electrons in the outermost shell as magnesium but they are not classified in the same group, and Iron element exhibits magnetic properties while zinc element does not. In part (c),they were required to;Account for the different coordination numbers between $[FeCl_4]^{2-}$and $[FeF_6]^{4-}$, Explain the origin of magnetism in transition elements, use the 3d electron configuration in cobalt(III) ions to explain why $[CoF_6]^{3-}$ is paramagnetic while $[Co(CN)_6]^{3-}$is diamagnetic and finally they were required to explain briefly why $[Fe(CN)_6]^{4-}$is said to be an inner orbital complex while $[CoF_6]^{3-}$is said to be an outer orbital complex. Furthermore they were required to determine the type of hybridization exhibited by each of the two complexes.

The question was opted by 34.8 percent of the candidates and out which 61.5 percent scored from 6 to 19 marks. The candidates who scored from 6.5 to 10 markswere 33.6 percent scored and from 10.5 to 15 marks were 21.1 percent. A few (1.3%) candidates scored from 15.5 to 19, but there was no any candidate who scored all the allocated marks. However, 38.5 percent scored below 6 marks with 5.9 percent scoring a zero mark. In brief, these data indicate that the performance of the candidates in this question was good.

The candidates who scored high marks wrote correct electronic configurations of the prescribed species and gave appropriate reasons for whymanganese when in oxidation state of +2 is more stable than when in oxidation state of +3. They accounted well for the differences in coordination numbers between $[FeCl_4]^{2-}$ and $[FeF_6]^{4-}$.They produced correct reasons for the origin of magnetism in transition elements and explained well why $[CoF_6]^{3-}$ is paramagnetic while $[Co(CN)_6]^{3-}$ is diamagnetic. They also gave correct reasons for $[Fe(CN)_6]^{4-}$ is an inner orbital complex while $[CoF_6]^{3-}$ is an outer orbital and determined correctly the hybridization exhibited by the two complexes. Extract 6.1 show a sample of good responses.

Extract 6.1



6(a) i	(i) Mn^{2+} : $[Ar]\ 4s^0\ 3d^5$
	V^{3+} : $[Ar]\ 4s^0\ 3d^2$.
	Fe^{3+} : $[Ar]\ 4s^0 3d^5$
6(a)	(ii) Mn^{2+}: $[Ar]\ 4s^0\ 3d^5$
	Mn^{3+} · $[Ar]\ 4s^0 3d^4$
	Manganese of oxidation state of +2 is more stable
	because the d-orbital is halffilled in respence with
	the rule of half-full filled orbital. Due to this halffilled
	d-orbital it makes it to be stable but for
	Manganese of oxidation state of +3 is not stable because
	the d-orbital in it is not halffilled due to this it
	makes it to be unstable

6(b) (i) The radii of Fe, Co and Ni show small variation because first these elements are transitional elements due to these the difference is atomic number (charge) in them is counterbalance ~~th~~ by the effect of screening effect since electrons are added in the same d-orbital hence making their radii not to very much but for Na, Mg and Al are elements in ~~group~~ period three and in each element the outermost electron is in different orbital as the result the effect of increase in atomic number (charge) is not counterbalanced hence making their radii to vary much because of different factors affecting it.

6(b) (ii) Cadium is not classified in the same group as magnesium despite of having same number of electrons in the valence shell it is because magnesium has large metallic character as group 2 elements but cadmium has low metallic character due to these it makes it not to belong to group 2 and this is as a result of strong inert pair effect it experience hence it cannot release its electrons and s electrons cannot participate in a reaction due to poor screening effect caused by presence of d and f orbital

6(b) (iii) Fe : [Ar] $\overset{4s^2}{\boxed{\uparrow\downarrow}}$ $\overset{3d^6}{\boxed{\uparrow\downarrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}}$

Zn : [Ar] $\overset{4s^2}{\boxed{\uparrow\downarrow}}$ $\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}$

Iron element exhibit magnetic properties due to presence of unpaired electrons due to this induces magnetic effect (field) but for Zn its d orbitals electron are fully paired as a result it makes it not have magnetic properties

6(c) (i) $[FeCl_4]^{2-}$ and $[FeF_6]^{4-}$ have different coordination number due to the factor of steric hindrance caused by bulkness of a ligands. For $[FeCl_4]^{2-}$ the ligand chloro has high molecular weight due to this it uses coordination number of 4 so as to reduce bulkness hence avoiding steric hindrance but for $[FeF_6]^{4-}$ fluoro is a light ligand hence uses high coordination number. since it

6(c) doesnot affect the central metal atom interms of steric hindrance and bulkness ~~hot~~ as a result making it stable

6(c) (ii) Transitional elements are elements with partially filled electrons in the d orbitals due to this most elements in their d-orbitals consist of unpaired electrons hence creating magnetic field as the result it makes it to have magnetic properties with exception to Zinc

6(c) (iii) Co: $[Ar]\ 4s^2\ 3d^7$

Co^{3+}: $[Ar]\ 4s^0\ 3d^6$.

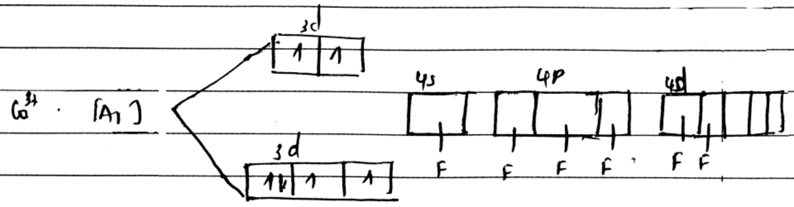
$[CoF_6]^{3-}$

In addition of a ligand the d orbital splits to form trible and double group. depending whether a strong ligand or weak ligand is added. In presence of weak ligand the two groups will have equivalent energy but for strong ligand two groups formed will have different energy

for $[CoF_6]^{3-}$

ligand added is fluoro which is a weak ligand hence d orbital will split to form trible and double group which will have equivalent energy. hence adding of electrons will follow Hunds rule

6(c) | (iii)

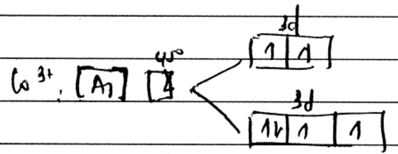


Hence forming unpaired electrons as the result it is paramagnetic

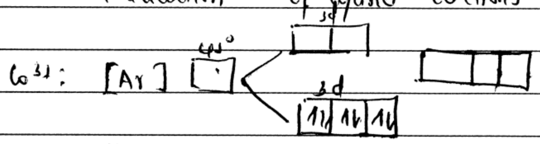
6(c) For $[Co(CN)_6]^{3-}$

Cyano is a strong ligand hence making the d orbital to split and form double and treble group of different energies.

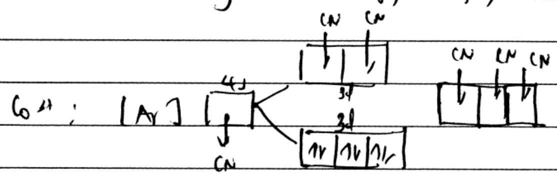
Since cyano is a strong ligand it makes unpaired electrons to pair up and hence filling begins



On addition of cyano electrons pair up



Hence ligands occupy empty orbital



Due to these, there is no unpaired electrons hence making it diamagnetic

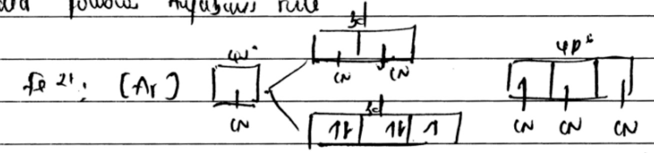
4(c) (iv) $[Fe(CN)_6]^{4-}$ consist of strong ligand due to this it will force the unpaired electrons in d orbital to pair up and hence ~~fop~~ occupy the empty d orbital left first then the s orbital due to this it makes it an inner orbital Complex but for $[CoF_6]^{3-}$ consist of weak ligand and it cannot force unpaired electrons to pair up hence no empty Orbital will be present as a result it will occupy the 4s orbital then followed by other orbitals which are empty due to this it makes it outer orbital complex

For $[Fe(CN)_6]^{4-}$

$Fe : [Ar]\ 4s^2 3d^6$

$Fe^{2+} : [Ar]\ 4s^0 3d^5$

On addition of ligand it splits since a strong ligand is added follows Aufbau's rule



Hence d orbital is filled first followed by orbital

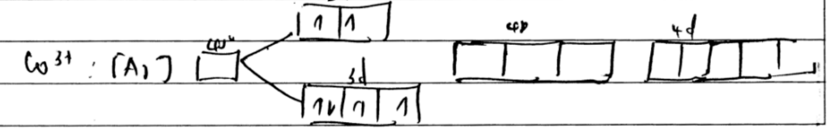
Hence hybridization is d^2sp^3 hybridization

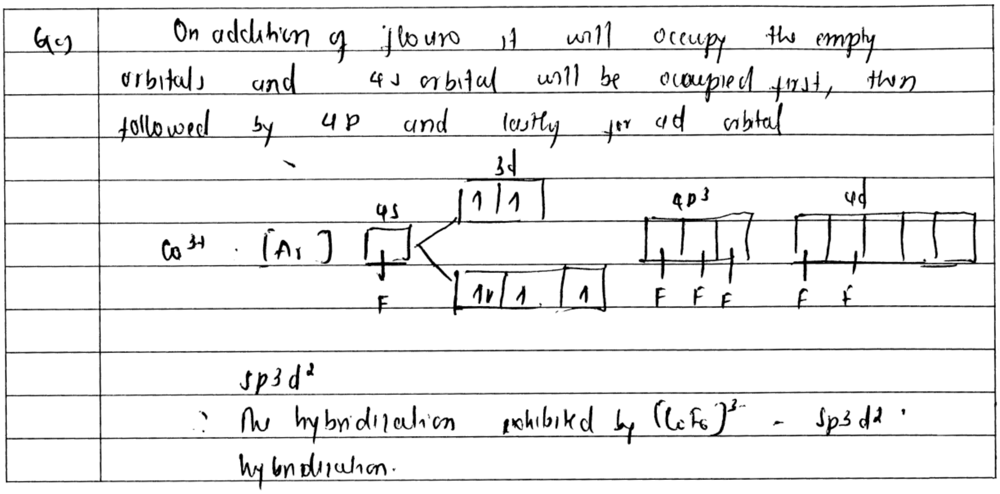
For $[CoF_6]^{3-}$

$Co : [Ar]\ 4s^2 3d^7$ at ground state

$Co^{3+} : [Ar]\ 4s^0 3d^6$ at excited state

On addition of flouro (weak ligand) it splits and addition of electrons will follow hund's rule





6(c) On addition of flouro it will occupy the empty orbitals and 4s orbital will be occupied first, then followed by 4p and lastly for 4d orbital

sp3d²

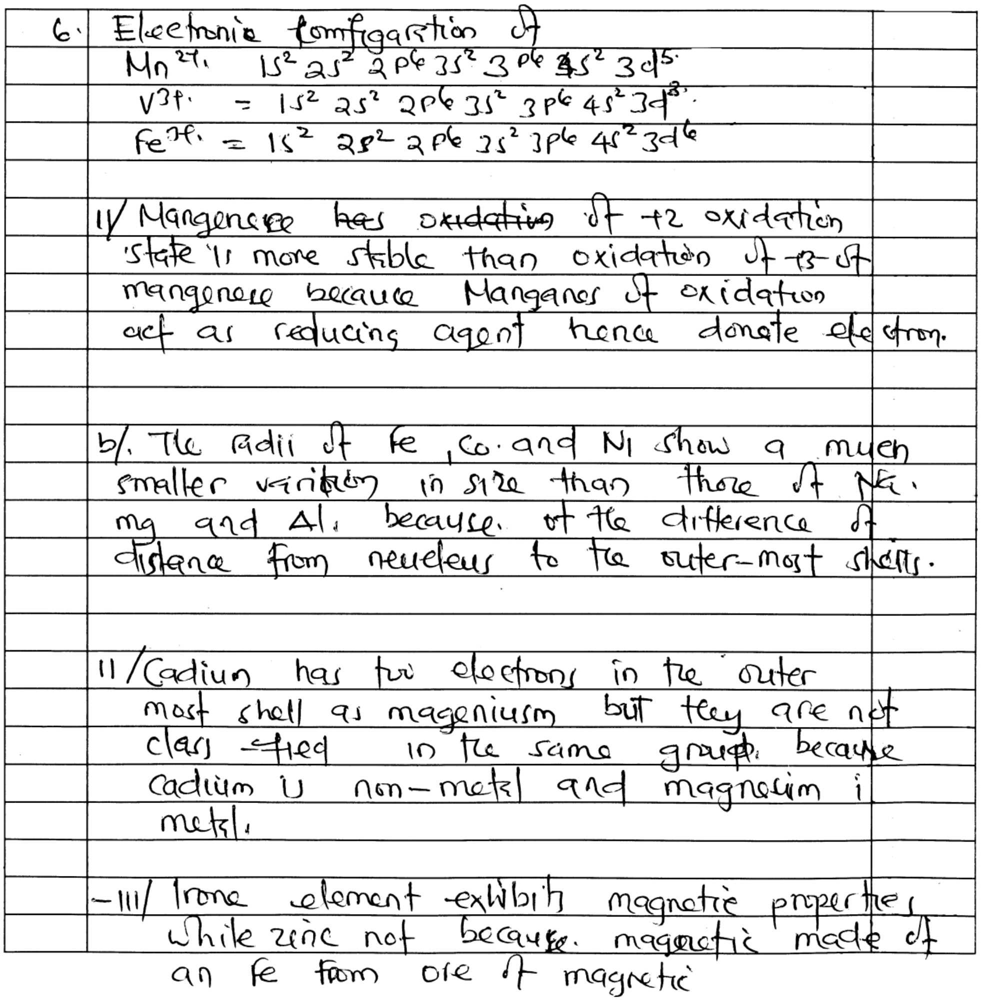
∴ The hybridization exhibited by [CoF6]³⁻ - sp3d² hybridization.

Extract 6.1 shows a sample of a response of a candidate who had sufficient knowledge in transitional elements. The candidate gave proper and clear explanations according to the requirement of the question. However, the candidate failed to give concrete explanation why Mn^{2+} is more stable than Mn^{3+}which led to failure to score full marks.

The candidates who performed poor in this question failed to; write the correct electronic configuration of the prescribed species according to Aufbau principle which is Mn^{2+} = [Ar]$3d^5$, V^{3+}=[Ar]$3d^2$ and Fe^{3+} = [Ar]$3d^5$ instead they wrote *Mn^{2+}= 2.8.8.1, V^{3+}= 2.8.8.8, and Fe^{3+}= 2.8.8.3*. It was difficult for them to; give reasons why $[CoF_6]^{3-}$ is paramagnetic while $[Co(CN)_6]^{3-}$is diamagnetic. The candidates failed because they could not establish that, CN- is a strong ligand so it will force the remaining d-electrons to pair up which cause diamagnetic property in $[Co(CN)_6]^{3-}$.They also failed to give reasons for cadmium and magnesium being not placed in the same group despite both having two electrons in the outer most shell. This indicates inadequate skills in elements configuration. Other candidates failed to account for iron to exhibit magnetic properties compared to zinc of which does not. For example, one candidate wrote, "*Due to iron element have two electrons in Fe^{2+} state and three electrons in Fe^{3+} state while zinc have only 2 electrons*".Suchresponses are indication of insufficient knowledge in the concept of Paramagnetic and diamagnetic of transitional element in relation to electronics.

Moreover, other candidates failed to determine the hybridization exhibited by each of the given two complexes, for example one candidate responded as, “$[Fe(CN)_6]^{2+}$ *is sp³ hybridization* instead of d^2sp^3 while in $[CoF_6]^{3-}$ as p^3 instead of sp^3d^2 hybridization. A similar example is presented in Extract 6.2.

Extract 6.2



6. Electronic tomfigartion of

Mn^{2+}. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^5$.

V^{3+}. $= 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$.

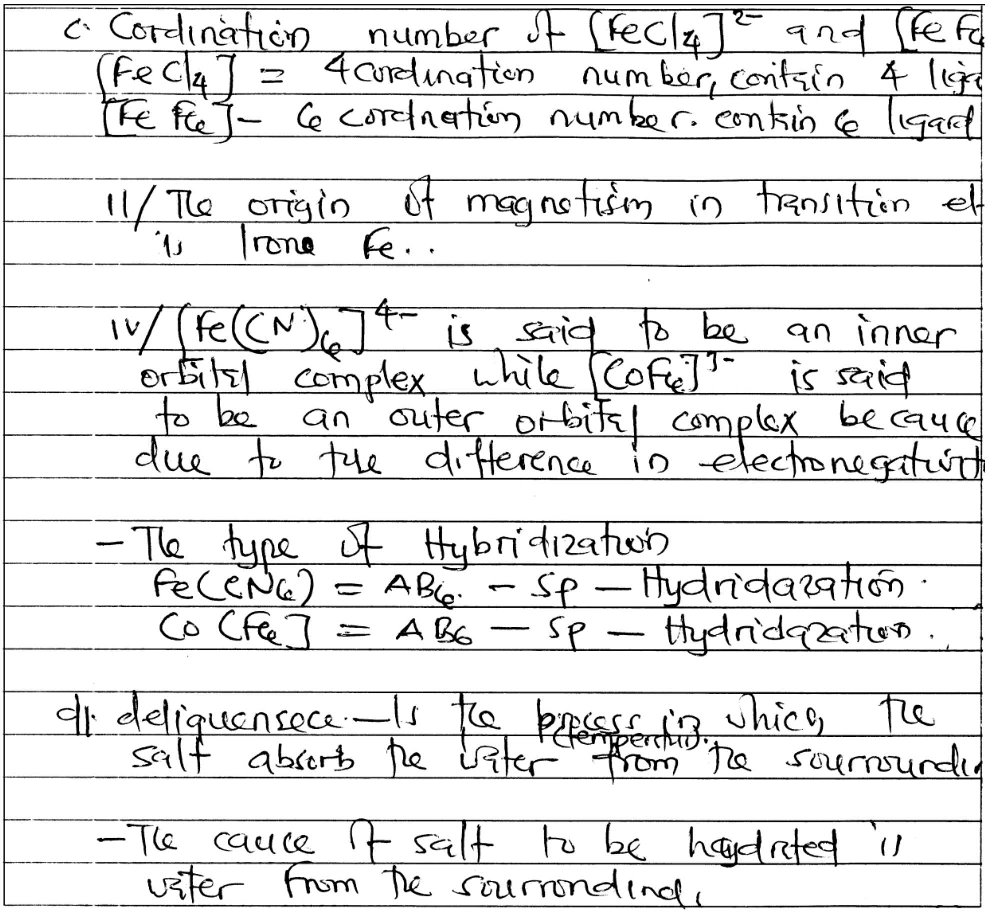
Fe^{3+}. $= 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$

ii/ Mangenese ~~has~~ ~~oxidation~~ of +2 oxidation state is more stable than oxidation of ~~+3~~ of mangenese because Manganes of oxidation act as reducing agent hence donate electron.

b/. The radii of Fe, Co. and Ni show a much smaller varition in size than those of Na. mg and Al. because of the difference of distance from neuleus to the outer-most shells.

ii/ Cadium has two electrons in the outer most shell as mageniusm but they are not class-fied in the same group. because cadium is non-metal and magnesim is metal.

-iii/ Irone element exhibits magnetic properties while zinc not because. magnetic made of an Fe from ore of magnetic



c· Cordination number of $[FeCl_4]^{2-}$ and [Fe F

$[FeCl_4]$ = 4 cordination number, contain 4 lig

$[FeF_6]$– 6 cordnation number. contain 6 ligard

ii/ The origin of magnetism in transition el
is irone Fe..

iv/ $[Fe(CN)_6]^{4-}$ is said to be an inner orbital complex while $[CoF_6]^{3-}$ is said to be an outer orbital complex becauce due to the difference in electronegativit

–The type of Hybridization
$Fe(CN_6)$ = AB_6. – Sp – Hydridazation·
$Co(F_6]$ = AB_6 – Sp – Hydridazation.

d/ deliquensece.—is the process (temperature) in which the salt absorb the water from the sourroundi

–The cauce of salt to be hagdrated is water from the sourronding,

In Extract 6.2, the candidate wrote incorrect electronic configurationswhich are the bases of establishing answers for most part of the question.

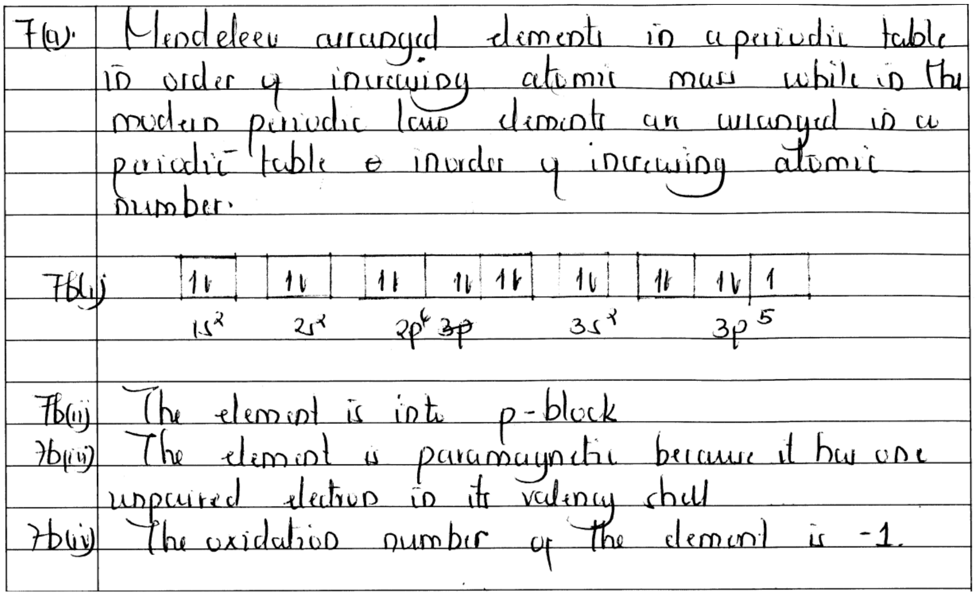
2.2.7 Question 7: Periodic Classification

In Part (a), the candidate were required to write the basic difference between Mendeleev's periodic law and Modern periodic law. In part (b), they were given a statement that, a neutral atom of a certain element has 17 electrons, and they were required to; write its ground state electronic configuration, classify the element into s, p, d or f block, determine whether it is diamagnetic or paramagnetic and write the principal oxidation number of the element. In part (c), they were required to study the hypothetical elements placed in various groups and periods of part of the periodic table and then required to; identify with reasons; an element which is most likely to have the highest electron affinity, most likely to have the highest electronegativity, an element which is likely to have least first ionization energy, a pair of elements which is likely to form the strongest electrovalent bond, two elements which are likely to have strongest reducing properties and two elements which form neither negative nor positive ions. In part (d), they were required to define the term deliquescence and explain what makes a hydrated salt to deliquesce, explain the discontinuities shown on the provided sketch of solubility curve of calcium chloride in water, and explain briefly at least three hazards associated with the useful application of sulphur and lead or their compounds.

The question was opted by 31.3 percent of the candidates and their performance was good as 60.6 percent scored from 6 to 19 marks,42.2 percent scored from 6.5 to 10, 9.7 percent from 10.5 to 15 and 0.2 percent scored from 15.5 to 19 marks. Besides, there was no any candidate who scored all the allocated marks. However, 39.4 percent scored below 6 marks with 0.8 percent scoring a zero mark.

The candidates who scored high marks demonstrated clear understanding on answering the question. They were able toapply different concepts pertaining Periodic Classification such as diamagnetic, paramagnetic, ionization energy, electron affinity and electronegativity properly. Extract 7.1 illustrates a sample of good responses.

Extract 7.1



7(a).	Mendeleev arranged elements in a periodic table in order of increasing atomic mass while in the modern periodic law elements are arranged in a periodic table inorder of increasing atomic number.
7b(i)	↿⇂ ↿⇂ ↿⇂ ↿⇂ ↿⇂ ↿⇂ ↿⇂ ↿⇂ ↿ $1s^2$ $2s^2$ $2p^6$ ~~3p~~ $3s^2$ $3p^5$
7b(ii)	The element is into p-block
7b(iii)	The element is paramagnetic because it has one unpaired electron in its valency shell
7b(iv)	The oxidation number of the element is -1.

7c(i) G

Reasons

1. It is has a small size that results into great nuclear charge that increase its electron affinity

2. Has only one electron to fullfill its valency orbital hence has greater affinity for electron.

7c(ii) G

Reason.

It has small atomic size which result into strong nuclear effective charge hence increase the tendency of electrons towards its self.

7c(iii) I

Reasons

1. It has large atomic size which decrease the effective nuclear charge to attract electrons hence make electron easy to be lost

7c(iv) I and G

1. This is because I has large atomic size hence can easyl lose electrons and G has smallest size hence has high affinity for electron

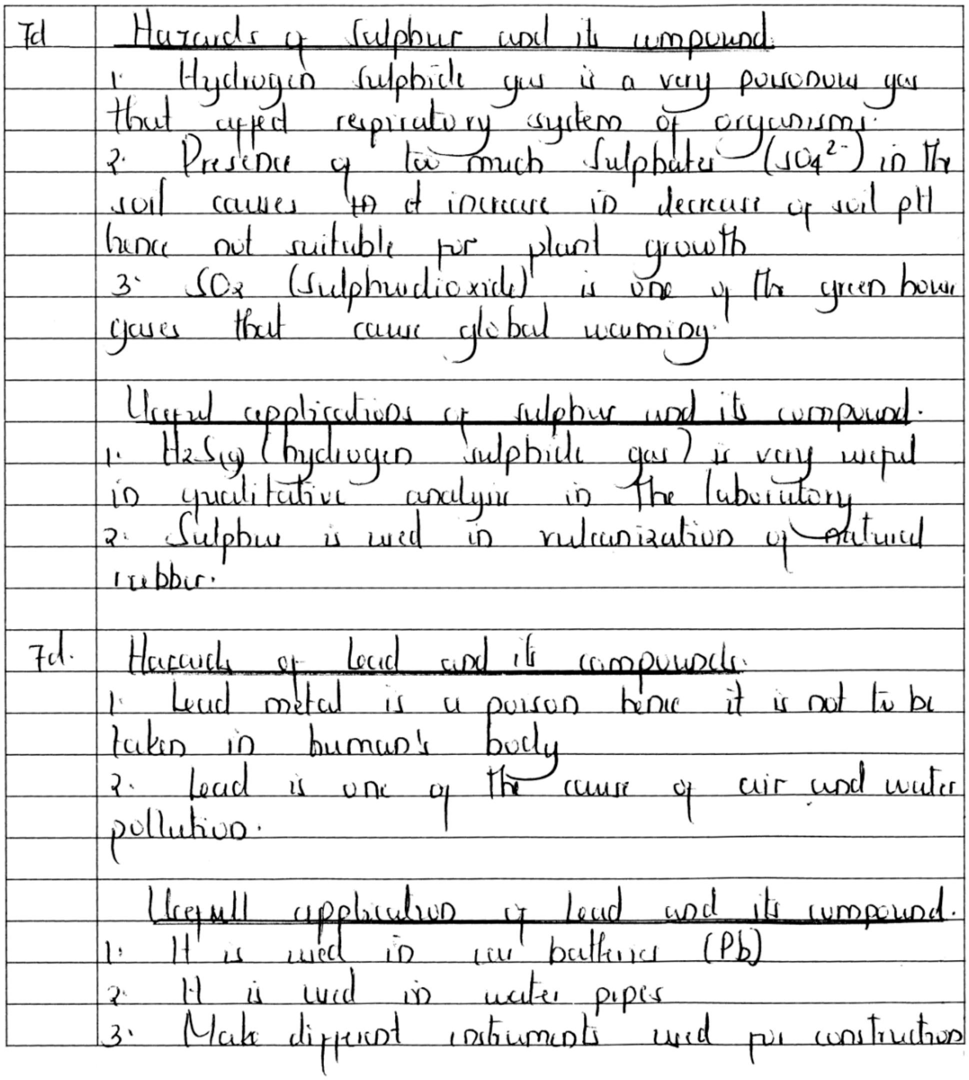
2. The difference in electronegativity between the two element is so great that favours the formation of strong electrovalent bond.

7c(v). A and I

This is because of their large size which reduce the effective nuclear charge effect hence can easily lose electrons and reduce other substances in a chemical reaction

7c(vi) H and P

This is because their valence shell is full of electrons hence cannot gain and form negative ion or lose electrons and form positive ions



7d Hazards of Sulphur and its compound.

1. Hydrogen sulphide gas is a very poisonous gas that affect respiratory system of organisms.
2. Presence of too much sulphates (SO_4^{2-}) in the soil causes ~~to~~ a increase in decrease of soil pH hence not suitable for plant growth
3. SO_2 (Sulphurdioxide) is one of the green house gases that cause global warming.

Useful applications of sulphur and its compound.

1. $H_2S_{(g)}$ (hydrogen sulphide gas) is very useful in qualitative analysis in the laboratory
2. Sulphur is used in vulcanization of natural rubber.

7d. Hazards of lead and its compounds.

1. Lead metal is a poison hence it is not to be taken in human's body
2. lead is one of the cause of air and water pollution.

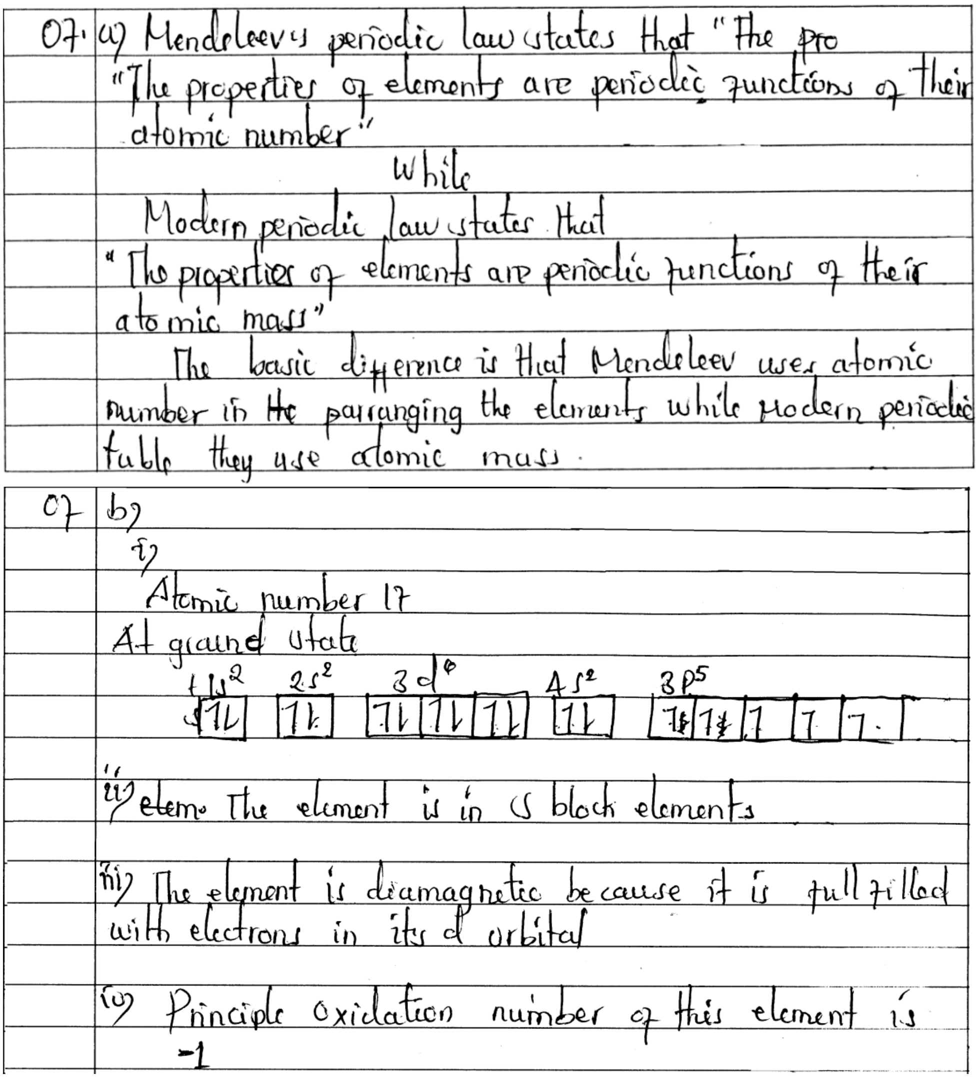
Usefull application of lead and its compound.

1. It is used in car batteries (Pb)
2. It is used in water pipes
3. Make different instruments used for construction

In Extract 7.1, the candidate presented correctly the difference between Mendeleev's periodic law and modern periodic law. She/he wrote correctly the electronic configuration of the given elements and managed to classify them. Likewise, he/she was able toexplain the uses of sulphur and lead or their compounds.

The candidates who performed poorly, particularly, those who scored a zero mark failed to differentiate Mendeleev's periodic law from Modern periodic law. In the same way, they failed to write ground state electronic configuration of the given element and to determine the principal oxidation number of that element, for example one candidate wrote; *Principal oxidation stateis -1*, instead of 0. Similarly, in part (c), they failed to identify properties of hypothetical elements from the provided periodic table. This was attributed by lack of adequate knowledge on Periodic classification of elements. Likewise, they gave incorrect hazards and useful application of sulphur and lead or their compounds implying lack of knowledge on selected compounds of metals. Extract 7.2 illustrates the example of a poor response.

Extract 7.2



07. a) Mendeleev's periodic law states that "The pro

"The properties of elements are periodic functions of their atomic number"

While

Modern periodic law states that

"The properties of elements are periodic functions of their atomic mass"

The basic difference is that Mendeleev uses atomic number in the parranging the elements while Modern periodic table they use atomic mass.

07 b)

i)

Atomic number 17

At graund state

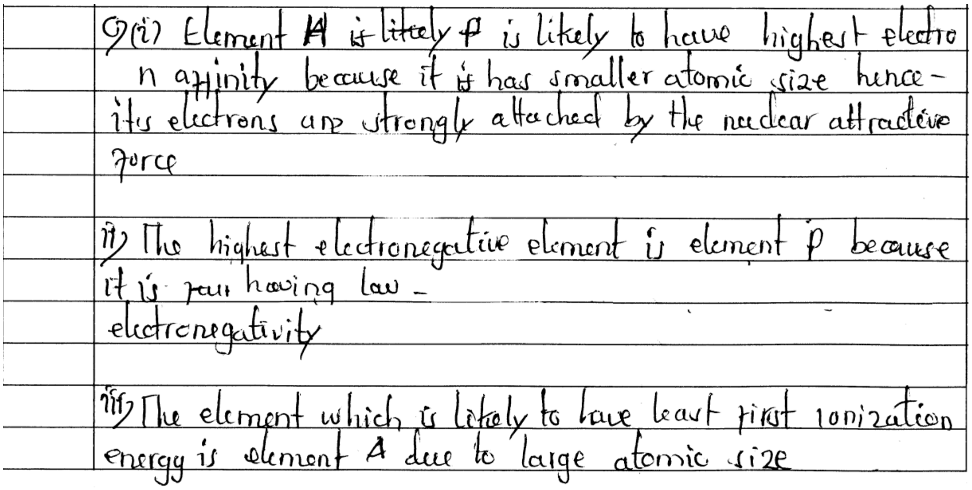
$1s^2$ $2s^2$ $3d^6$ $4s^2$ $3p^5$

[↑↓] [↑↓] [↑↓][↑↓][↑↓] [↑↓] [↑↓][↑↓][↑][↑][↑]

ii) elem. The element is in S block elements

iii) The element is diamagnetic because it is full filled with electrons in its d orbital

iv) Principle oxidation number of this element is -1



9(i) Element ~~A~~ ~~is likely~~ P is likely to have highest electro n affinity because it ~~is~~ has smaller atomic size hence its electrons are strongly attached by the nuclear attractive force

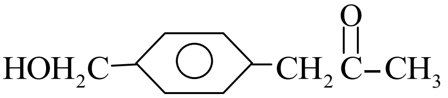
ii) The highest electronegative element is element P because it is ~~~~ having law electronegativity

iii) The element which is likely to have least first ionization energy is element A due to large atomic size

In Extract 7.2, the candidate interchanged the concept of Mendeleev's periodic law with that of Modern periodic law. She/he presented wrong ground state electronic configuration of a neutral atom. Similarly, the candidate failed to identify an element with highest electron affinity and least first ionization energy.

2.2.8 Question 8: Hydroxyl Compounds and Carbonyl Compounds

In part (a), the candidates were required to give the structures and the names of two functional isomers for C_3H_6O, $C_2H_4O_2$ and C_2H_6O. In Part (b), they were provided with the compound,



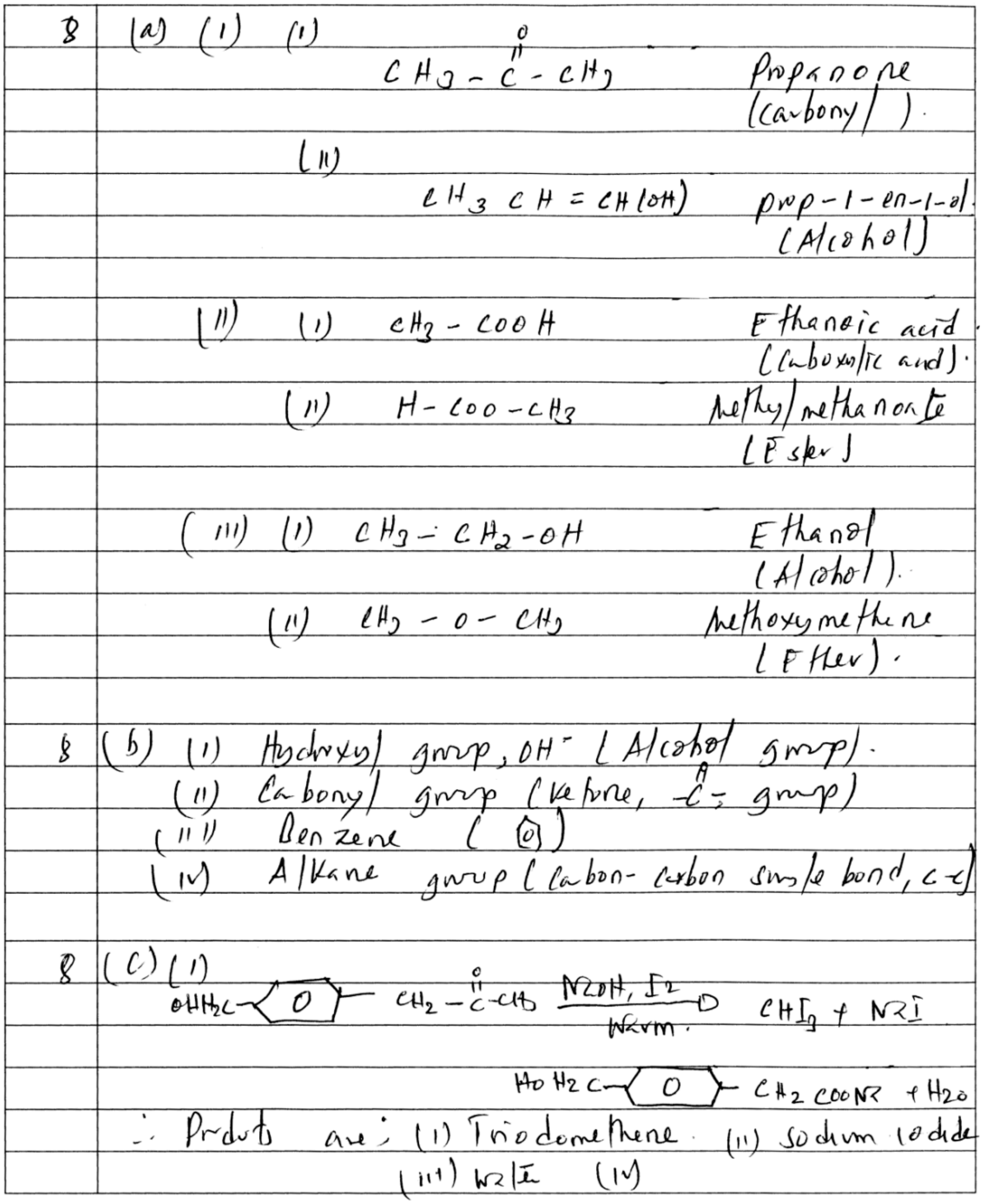
$HOH_2C-C_6H_4-CH_2\overset{O}{\overset{||}{C}}-CH_3$

and they were required to name all the functional groups present in the compound. In part (c), they were required to predict the product(s) formed when the compound in (b) above reacts with; warm mixture of iodine and NaOH, sulphur dichloride oxide, acidified $K_2Cr_2O_7$ at 60ºC - 80ºC, and $H_{2(g)}$ and nickel at 140ºC.

The question was opted by 33.4 percent of the candidates and their performance was good as 85.4 percent scored from 6 to 20 marks. The candidates who scored from 6.5 to 10 markswere 25.3 percent, from 10.5 to 15 marks were 45.6 percent and from 15.5 to 20 marks were 12.4 percent. However, 14.6 percent scored below 6 marks with 0.8 percent scoring a zero mark.

The candidates who scored high marks were able to give structures and the names of the two functional isomers of the given organic compounds. They presented correctly the names of functional groups present in the organic compound. They predicted correctly the products required to be formed in part 8 (b). Extract 8.1 shows one of the good answers from one of the candidates.

Extract 8.1



8 (a) (i) (i) $CH_3-\overset{O}{\overset{\|}{C}}-CH_3$ Propanone (Carbonyl).

(ii) $CH_3CH=CH(OH)$ prop-1-en-1-ol. (Alcohol)

(ii) (i) CH_3-COOH Ethanoic acid. (Carboxylic acid).

(ii) $H-COO-CH_3$ Methylmethanoate (Ester)

(iii) (i) CH_3-CH_2-OH Ethanol (Alcohol).

(ii) CH_3-O-CH_3 Methoxymethene (Ether).

8 (b) (i) Hydroxyl group, OH^- (Alcohol group).

(ii) Carbonyl group (ketone, $-\overset{O}{\overset{\|}{C}}-$ group)

(iii) Benzene (⌬)

(iv) Alkane group (carbon-carbon single bond, C-C)

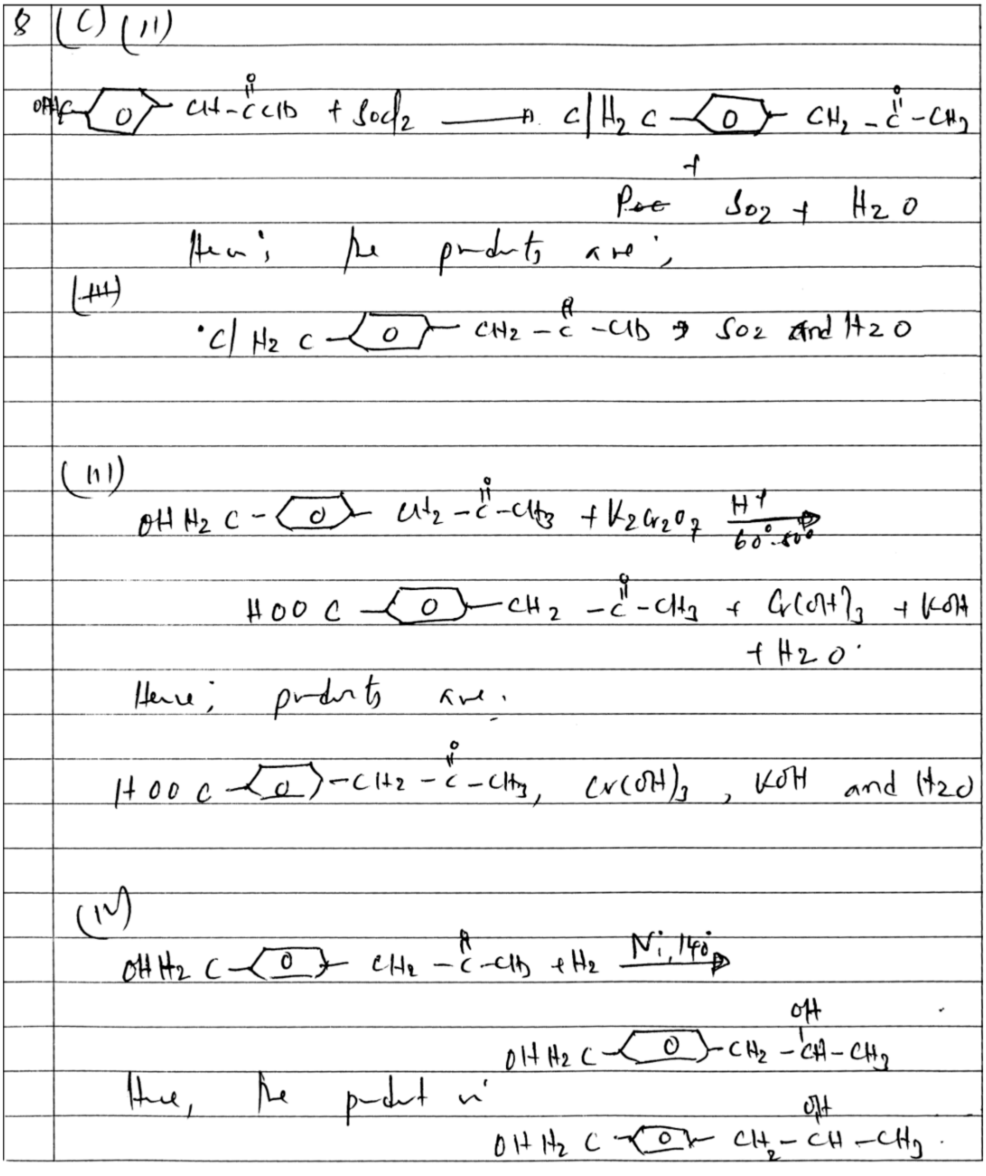
8 (c) (i)

OHH_2C-⌬$-CH_2-\overset{O}{\overset{\|}{C}}-CH_3 \xrightarrow[\text{Warm.}]{NaOH,\ I_2} CHI_3 + NaI$

HOH_2C-⌬$-CH_2COONa + H_2O$

∴ Products are; (i) Triodomethene. (ii) sodium iodide

(iii) Water (iv)



8 (c) (ii)

$OHH_2C-\langle O \rangle-CH-\overset{O}{\overset{\|}{C}}-CH_3 + SOCl_2 \longrightarrow ClH_2C-\langle O \rangle-CH_2-\overset{O}{\overset{\|}{C}}-CH_3$

$+$

~~Poc~~ $SO_2 + H_2O$

Here; the products are;

~~(iii)~~

$\cdot ClH_2C-\langle O \rangle-CH_2-\overset{O}{\overset{\|}{C}}-CH_3$, SO_2 and H_2O

(iii)

$OHH_2C-\langle O \rangle-CH_2-\overset{O}{\overset{\|}{C}}-CH_3 + K_2Cr_2O_7 \xrightarrow[60°-80°]{H^+}$

$HOOC-\langle O \rangle-CH_2-\overset{O}{\overset{\|}{C}}-CH_3 + Cr(OH)_3 + KOH + H_2O$.

Here; products are.

$HOOC-\langle O \rangle-CH_2-\overset{O}{\overset{\|}{C}}-CH_3$, $Cr(OH)_3$, KOH and H_2O

(iv)

$OHH_2C-\langle O \rangle-CH_2-\overset{O}{\overset{\|}{C}}-CH_3 + H_2 \xrightarrow{Ni, 140°}$

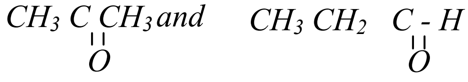
$OHH_2C-\langle O \rangle-CH_2-\overset{OH}{\overset{|}{CH}}-CH_3$

Here, the product is

$OHH_2C-\langle O \rangle-CH_2-\overset{OH}{\overset{|}{CH}}-CH_3$.

Extract 8.1 shows a sample answer from one of the candidates who managed to perform all parts of the question correctly.

The candidates who scored poorly failed to understand the meaning of the term "functional isomer" which was the root for the requirements of the question. For example, one candidate wrote as follows: *the names for the functional isomers of C_3H_6O are hydroxyl group and methyl group instead of the isomers of*

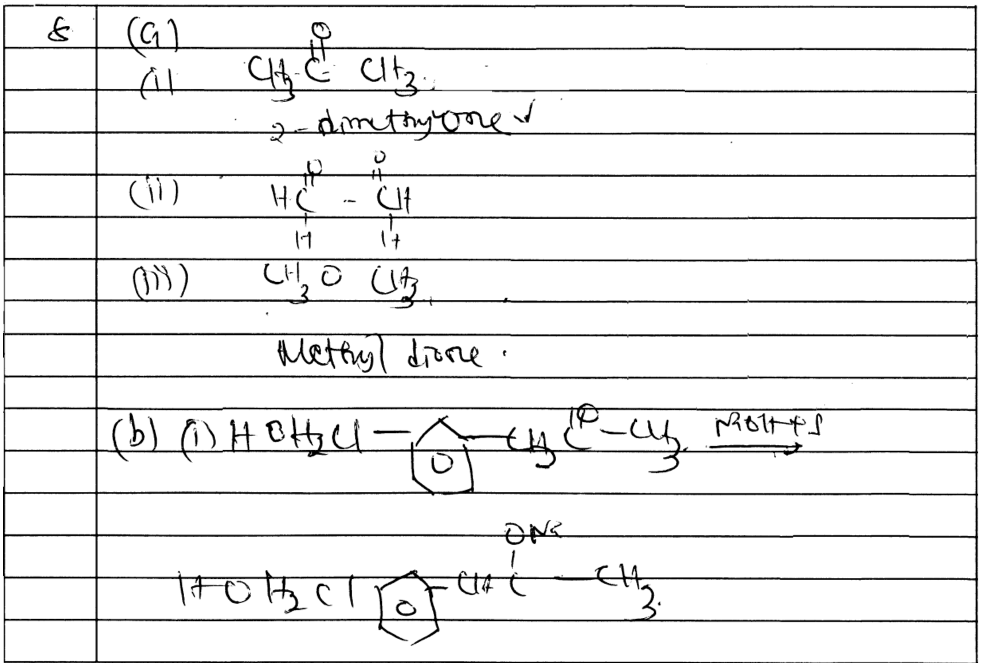


$CH_3\underset{O}{\underset{\|}{C}}CH_3$ *and* $CH_3CH_2\underset{O}{\underset{\|}{C}}-H$

propanone *propanal*

The response given show that, the candidate was not aware of functional isomers as well as functional isomerism. Similarly, other candidates failed to identify the reacting part of the compound under the given reagents and conditions which led to incorrect prediction of the products in part 8(c). Extract 8.2 indicates an example of the candidate's poor response.

Extract 8.2



8 (a)

(i) $CH_3-\overset{O}{\overset{\|}{C}}-CH_3$

2-dimethyone ✓

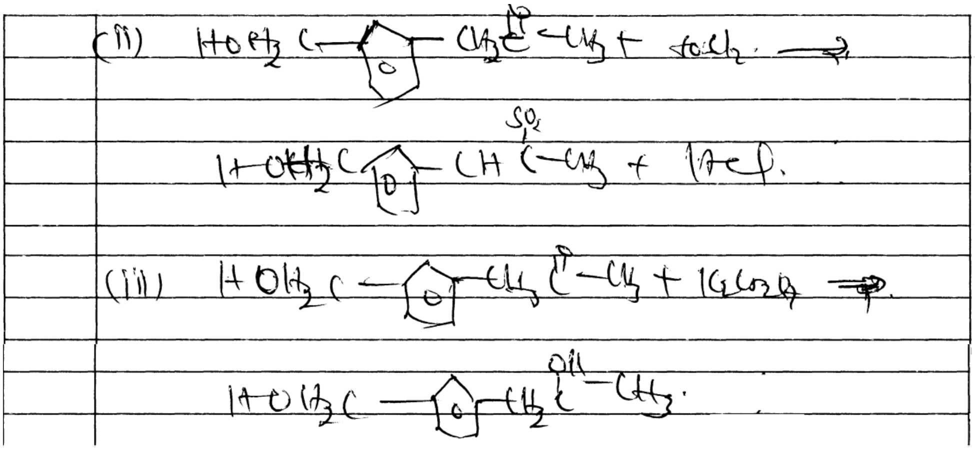
(ii) $H\overset{O}{\overset{\|}{C}}-\overset{O}{\overset{\|}{C}}H$

(iii) $CH_3\,O\,CH_3$

Methyl dione.

(b) (i) HOH_2C- ⬡ $-CH_2\overset{O}{\overset{\|}{C}}-CH_3 \xrightarrow{NaOH+I_2}$

HOH_2Cl ⬡ $-CH_2\overset{ONa}{\overset{|}{C}}-CH_3$

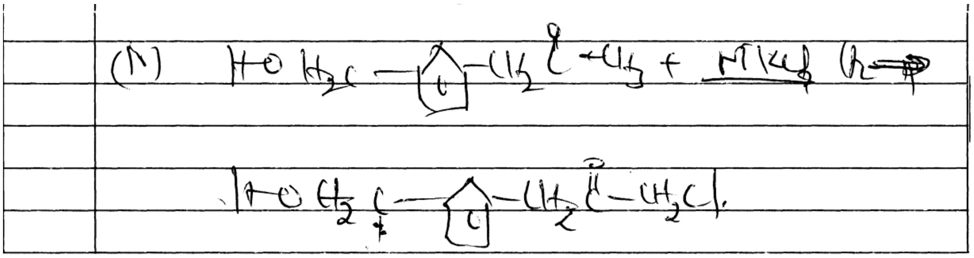


(ii) HOH_2C- ⬡ $-CH_2\overset{O}{\overset{\|}{C}}-CH_3 + SOCl_2 \rightarrow$

HOH_2C ⬡ $-CH\overset{SO_2}{\overset{|}{C}}-CH_3 + HCl.$

(iii) HOH_2C- ⬡ $-CH_2\overset{O}{\overset{\|}{C}}-CH_3 + K_2Cr_2O_7 \rightarrow$

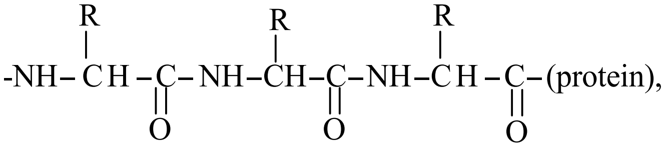
HOH_2C- ⬡ $-CH_2\overset{OH}{\overset{|}{C}}-CH_3.$



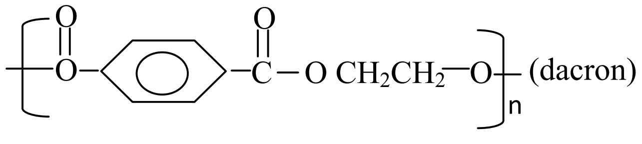
In Extract 8.2, the candidate wrote incorrect structures and names of functional isomers of organic substances. She/he presented wrong names of the functional groups present in the given organic compound and incorrect products formed on the reaction of the compound with the listed reagents.

2.2.9 Question 9: Polymers

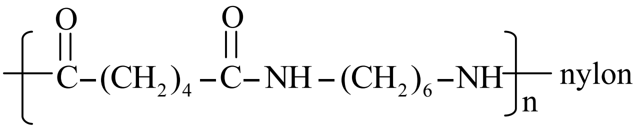
In part (a), the candidates were required to define the terms, polymer, additional polymerization and condensation polymerization. In part (b), they were required to; name at least four common natural polymers and differentiate thermosetting polymer from thermoplastic polymer with examples. In part (c), they were required to show the initiation step, propagation step and termination step for polymerization of vinyl chloride to form PVC. In part (d), they were required to draw the complete structures of monomers which were used to prepare:



$$-NH-\overset{R}{\overset{|}{C}}H-\underset{\underset{O}{\|}}{C}-NH-\overset{R}{\overset{|}{C}}H-\underset{\underset{O}{\|}}{C}-NH-\overset{R}{\overset{|}{C}}H-\underset{\underset{O}{\|}}{C}-\text{(protein)},$$



and

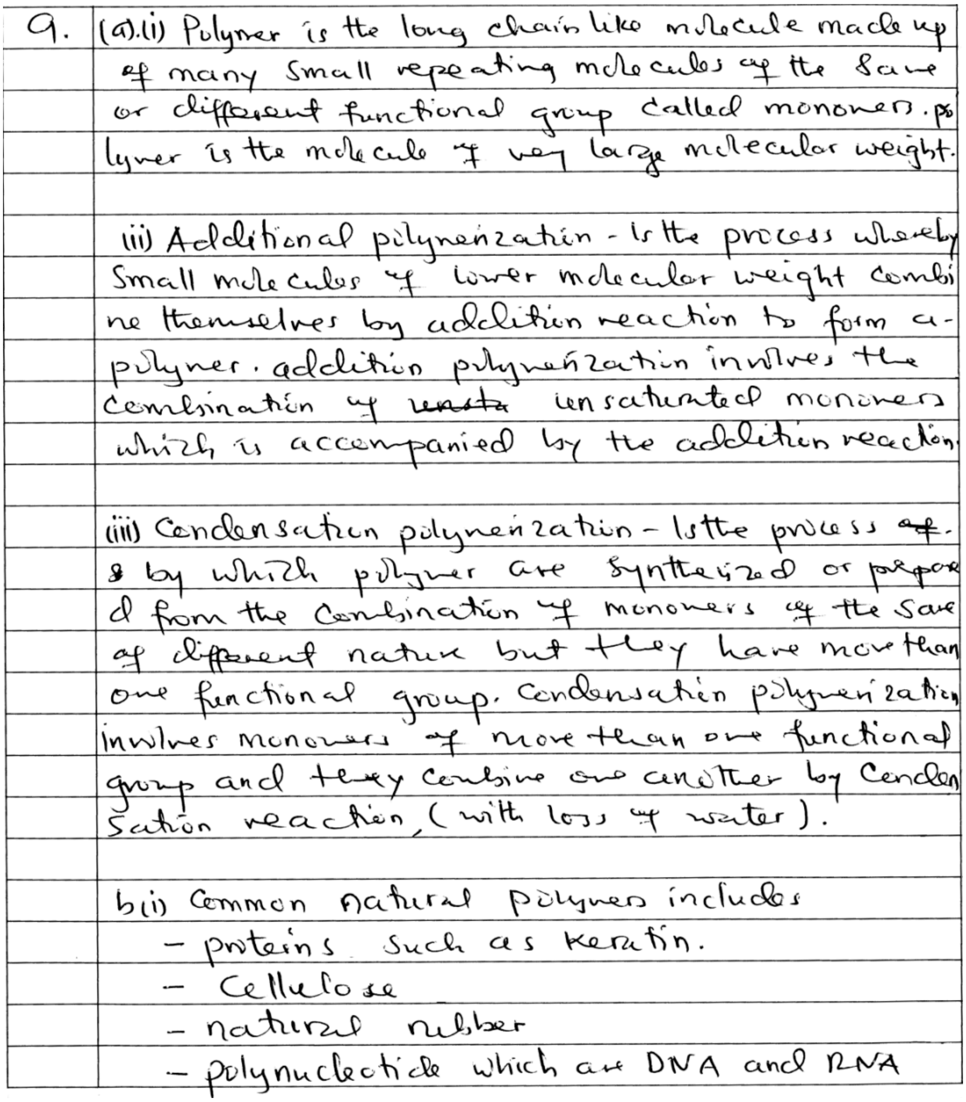


$$-\!\!\left[\overset{O}{\overset{\|}{C}}-(CH_2)_4-\overset{O}{\overset{\|}{C}}-NH-(CH_2)_6-NH\right]_n\text{ nylon}$$

The question was opted by 69.6 percent of the candidates and their performance was good as 90.4 percent scored from 6 to 20 marks. The candidates who scored from 6.5 to 10 markswere 11.9 percent, from 10.5 to 15 marks were 37.0 percent and from 15.5 to 20 marks were 38.9 percent. However, 9.6 percent scored below 6 marks with 0.2 percent scoring a zero mark.

The candidates who scored high marks were able to define precisely the terms provided, named four common natural polymers and differentiated a thermosetting polymer from a thermoplastic polymer. Moreover, they showed clearly the mechanisms of polymerization of vinyl chloride and drew properly the structures of monomers which were used to prepare the named polymers in (d). Extract 9.1 shows a sample of the candidates' good responses.

Extract 9.1



9. (a).(i) Polymer is the long chain like molecule made up of many Small repeating molecules of the Same or different functional group called monomers. polymer is the molecule of very large molecular weight.

(ii) Additional polymerization - Is the process whereby Small molecules of lower molecular weight combine themselves by addition reaction to form a polymer. addition polymerization involves the combination of ~~reacta~~ unsaturated monomers which is accompanied by the addition reaction.

(iii) Condensation polymerization - Is the process ~~of~~ by which polymer are synthesized or prepared from the Combination of monomers of the Same of different nature but they have more than one functional group. Condensation polymerization involves monomers of more than one functional group and they combine one another by Condensation reaction, (with loss of water).

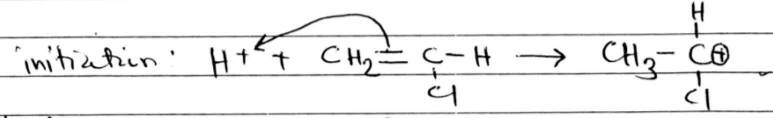
b(i) Common natural polymers includes
- proteins such as keratin.
- Cellulose
- natural rubber
- polynucleotide which are DNA and RNA

Difference between thermosetting and thermoplastics.

Thermosetting polymer	Thermoplastic polymer.
a - example of thermosetting include bakelite	- example of thermoplastic polymer is nylon 6,6
b - Cross-linking between its chains which makes it strong and tough so that it is insoluble	- no cross linking between its chains which make it soft and soluble in organic solvent to form colloidal solution
c → Once moulded, can not be remoulded again on heating or cooling	→ Thermoplastic polymer can be moulded into different shapes on heating and cooling effect

(c).(i) Initiation step

- The first step during polymerization involves the initiation of the monomers by the use of the initiator molecules or ions; for the case of PVC, the initiator involved is H+ from HCl but other initiators may be used also.

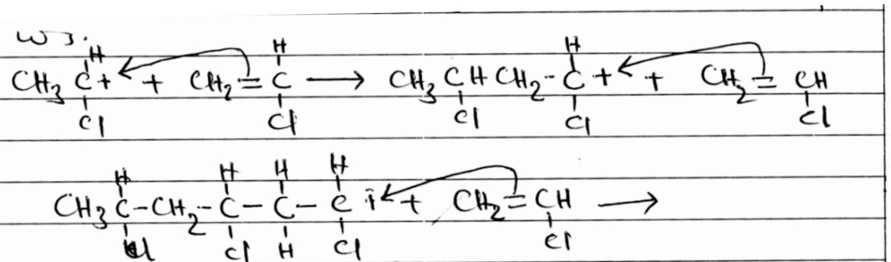


initiation: $H^+ + CH_2{=}\underset{Cl}{C}-H \longrightarrow CH_3-\overset{H}{\underset{Cl}{C}}\oplus$

hydrogen ions H+, aproach to the monomers where it results the bond (pie bond) to break and it react with one molecule of the vinyl chloride make it to acquire positive charge.

(ii) Propagation Step:

- The positively charge molecule formed from the initiation step results more combination of the monomers by the addition reaction which involves the breaking of pie bonds. as follows.



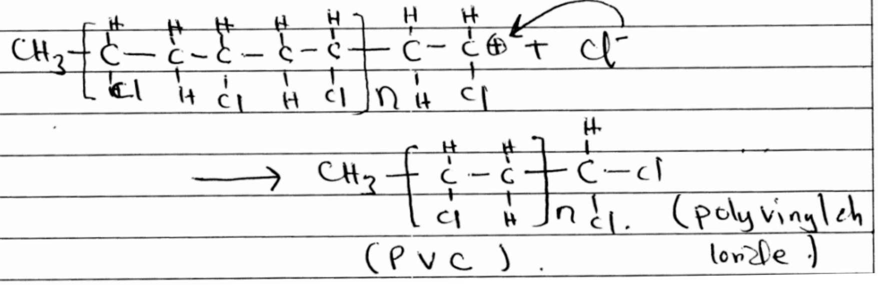
$$CH_3\overset{H}{\underset{Cl}{C}}^{+} + CH_2=\overset{H}{\underset{Cl}{C}} \longrightarrow CH_3\underset{Cl}{C}HCH_2-\overset{H}{\underset{Cl}{C}}^{+} + CH_2=\underset{Cl}{C}H$$

$$CH_3\overset{H}{\underset{Cl}{C}}-CH_2-\overset{H}{\underset{Cl}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{Cl}{C}}^{+} + CH_2=\underset{Cl}{C}H \longrightarrow$$

the Chain continous to be propagated by the addition reaction.

(iii) Termination step.

-This is the last step during polymerisation of the monomers where by, the growing chain which is positively charged react with the negative ion (anion) which mark the end of the polymerisation, as in case of polyvinyl chloride seen below. (terminator Cl^-)

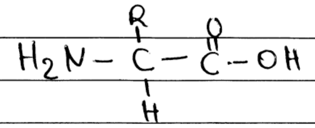


$$CH_3\left[\overset{H}{\underset{Cl}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{Cl}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{Cl}{C}}\right]_n-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{Cl}{C}}^{\oplus} + Cl^-$$

$$\longrightarrow CH_3\left[\overset{H}{\underset{Cl}{C}}-\overset{H}{\underset{H}{C}}\right]_n\overset{H}{\underset{Cl}{C}}-Cl$$

(polyvinyl chloride) (PVC).

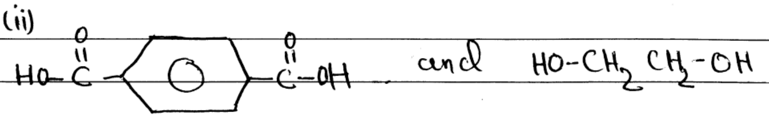
(d).(i)



$$H_2N-\overset{R}{\underset{H}{C}}-\overset{O}{\overset{\|}{C}}-OH$$

(amino acid).

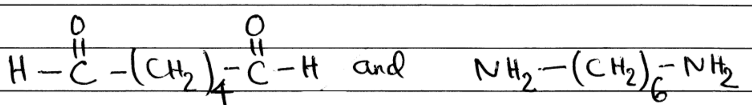
(ii)



$$HO-\overset{O}{\overset{\|}{C}}-C_6H_4-\overset{O}{\overset{\|}{C}}-OH \text{ and } HO-CH_2CH_2-OH$$

1,4-benzene dioic acid Ethan-1,2-diol

(iii)



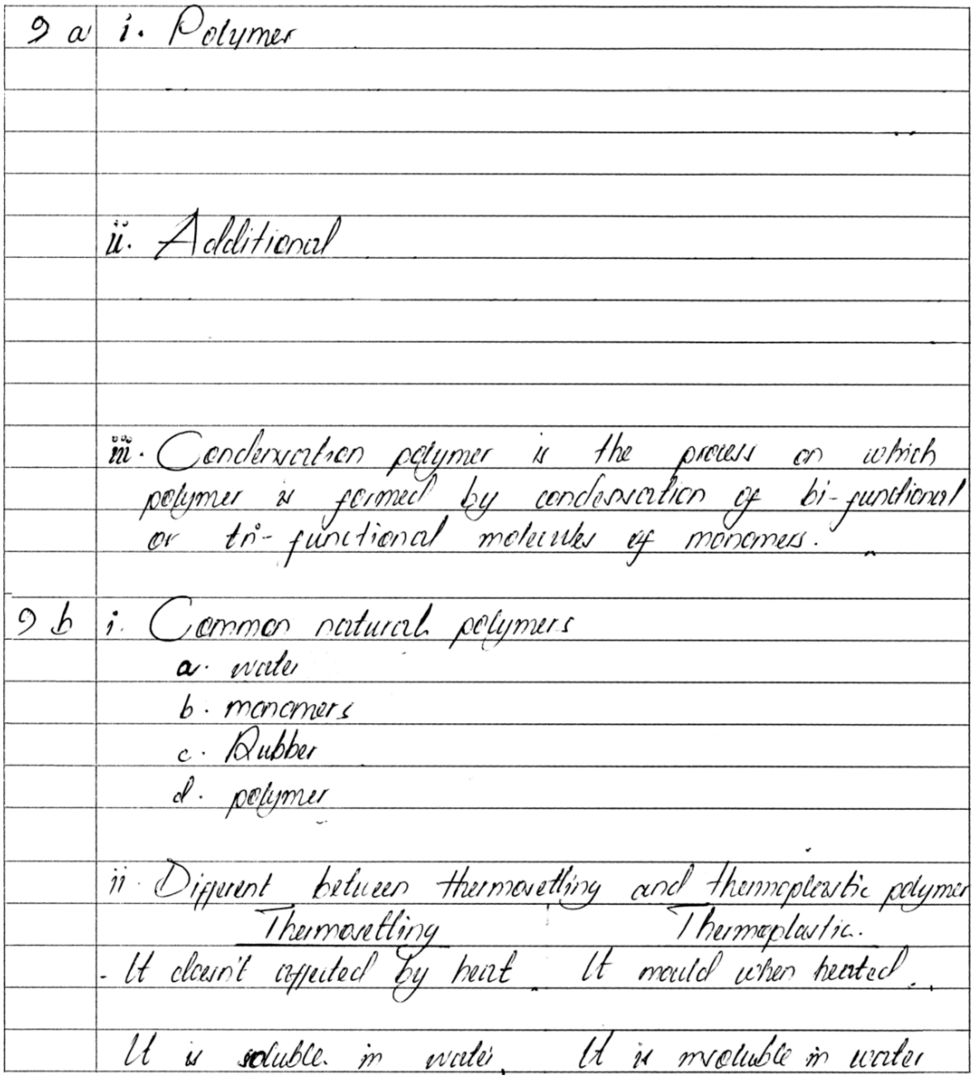
$$H-\overset{O}{\overset{\|}{C}}-(CH_2)_4-\overset{O}{\overset{\|}{C}}-H \text{ and } NH_2-(CH_2)_6-NH_2$$

In Extract 9.1, the candidates presented accurate answers clearly according to the requirement of the question. She/he differentiated a thermosetting polymer from a thermoplastic polymer correctly.

Moreover, common natural polymers and mechanisms of polymerization of vinyl chloride are accurately presented.

However, a few candidates (9.6%) who had low scores in this question failed to differentiate thermosetting polymer from thermoplastic polymer. Some also failed to name the common natural polymers while others failed to show the mechanisms of polymerization of vinyl chloride. In addition, other candidates gave the structure of monomers of proteinwhich was incorrect, indicating that the candidates had insufficient knowledge on Polymerization concept. Extract 9.2 illustrates the example of a poor response.

Extract 9.2



9 a i. Polymer

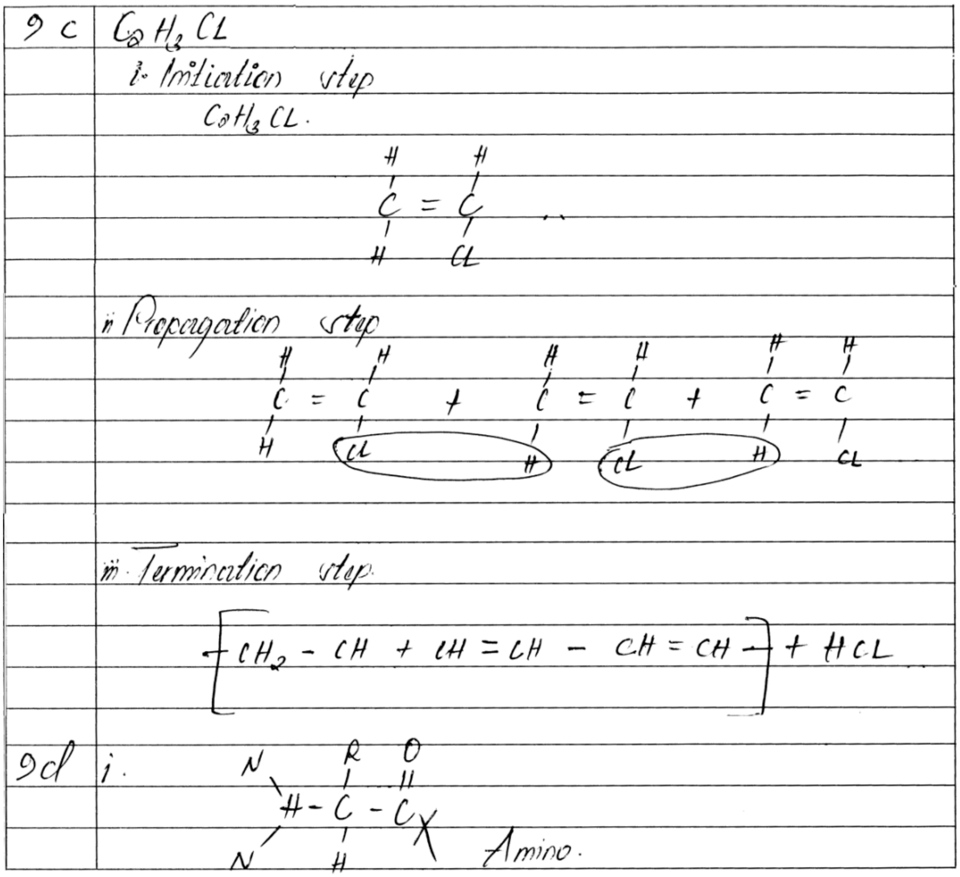
ii. Additional

iii. Condensation polymer is the process on which polymer is formed by condensation of bi-functional or tri-functional molecules of monomers.

9 b i. Common natural polymers
a. water
b. monomers
c. Rubber
d. polymer

ii. Different between thermosetting and thermoplastic polymer

Thermosetting	Thermoplastic.
- It doesn't affected by heat	It mould when heated.
It is soluble in water,	It is insoluble in water



9 c C_2H_3CL

i. Initiation step

C_2H_3CL.

$\overset{H}{\underset{H}{C}} = \overset{H}{\underset{CL}{C}}$ ..

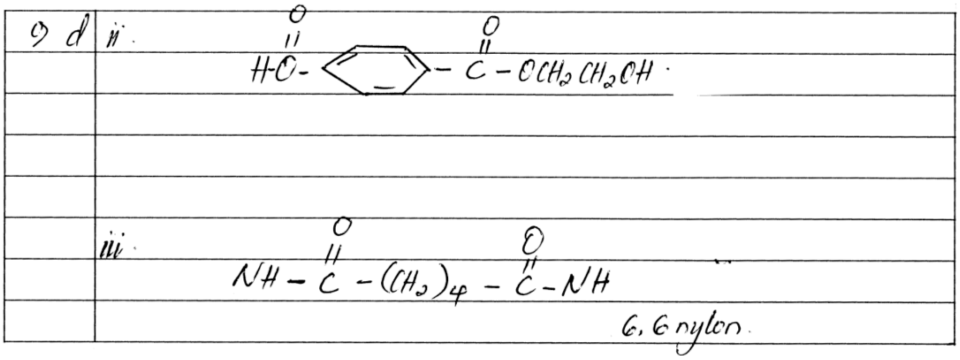
ii Propagation step

$\overset{H}{\underset{H}{C}} = \overset{H}{\underset{CL}{C}} + \overset{H}{\underset{H}{C}} = \overset{H}{\underset{CL}{C}} + \overset{H}{\underset{H}{C}} = \overset{H}{\underset{CL}{C}}$

iii. Termination step.

$-[CH_2 - CH + CH = CH - CH = CH -]- + HCL$

9d i. $\overset{N}{} \; H - \overset{R}{\underset{H}{C}} - \overset{O}{\overset{\|}{C}} \; \overset{}{N}$ Amino.



9 d ii. $H-\overset{O}{\overset{\|}{C}}-C_6H_4-\overset{O}{\overset{\|}{C}}-OCH_2CH_2OH$.

iii. $NH-\overset{O}{\overset{\|}{C}}-(CH_2)_4-\overset{O}{\overset{\|}{C}}-NH$

6, 6 nylon.

The response in Extract 9.2 could be an indication that the candidate did not had any idea about polymer and addition polymerization since theseconcept were left unanswered. In addition, she/he failed to differentiate a thermosetting polymer from a thermoplastic polymer and gave the structure of amino acid (monomers) of proteinwhich was completely wrong.

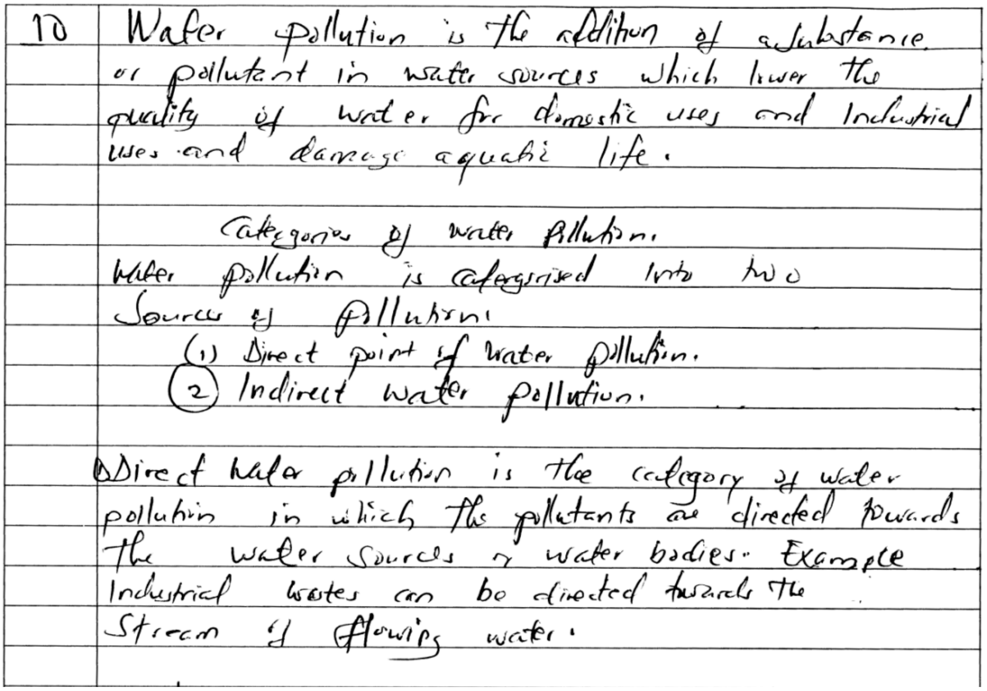
2.2.10 Question 10: Environmental Chemistry

The candidates were provided with the statement that, "*Conservation of water against pollution is of paramount importance for human health and development*". They were then required to discuss this statement using the sub headings; categories of water pollution, four causes of water pollution, four effects of water pollution and four control measures to be taken.

A large number (67.7%) of the candidates opted for the question and their performance was good as 96.9 percent scored from 6 to 20 marks. The candidates who scored from 6.5 to 10 markswere 28.3 percent and from 10.5 to 15 marks were 53.6 percent and from 15.5 to 20 marks were 13.7 percent. On the other hand, 3.1 percent of the candidates scored below 6 marks with 0.1 percent scoring a zero mark.

The candidates who scored high marks presented correct answers to most parts of the question. They gave correct explanations for the conservation of water against pollution. They precisely categorized water pollution. They also identified the causes of water pollution, discussed well the effects of water pollution and finally suggested proper control measures to be taken. Extract 10.1 illustrates the case.

Extract 10.1



10 Water pollution is the addition of a substance or pollutant in water sources which lower the quality of water for domestic uses and Industrial uses and damage aquatic life.

Categories of water pollution.

Water pollution is categorised into two sources of pollution.

(1) Direct point of water pollution.

② Indirect water pollution.

Direct water pollution is the category of water pollution in which the pollutants are directed towards the water sources or water bodies. Example Industrial wastes can be directed towards the Stream of flowing water.

(i) Indirect Water pollution. Here the pollutants are not directed to the water sources or water bodies instead other agents can take the pollutants to water bodies. example, the use of artificial fertilisers on farms can be leached and when the rainfall comes down, it wash way the fertisers and go toward the flow of water to the water bodies like lakes, river or sea.

Causes of Water pollution:

(i) Industrial Wastes: These are wastes from Industrial activities such as zinc mercury and Sulphur compounds like metal sulphides. This can be directed to water sources such

10 as river and lakes which the cause water pollution to an extent also may cause marine organisms like fishes to die.

(ii) Artificial Fertilisers; application of artificial fertilizers and herbicides or pesticides on agricultural activities may cause water pollution. When fertiliser such as UREA is used on farms, it dissolves in the soil but when the current of flowing water passes, it can be washed away along with water which causes the water pollution.

(iii) Fishing and Marine transportation activities may cause water pollution. example during fishing some poor methods can be used example uses of toxic grenades to kill Fishes. This is not only killing fishes but also ~~kills~~ pollutes water. since toxic is used. for Marine transportation, the huge ships may leak oil ~~Subst~~ Substances which may cause ~~ot~~ Oil spills on water and hence water pollution.

(iv) Improper ~~Water~~ Waste disposal. Some people especially in populated Cities. tend to dispose the home waste product in water bodies. This wastes consists of rotten fruits and Meals, kitchen wastes plastics and other toxic substances. This cause water pollution

10(iii) Effects of Water pollution

(1) Health Hazards due to the eruption of epidemic deseases such as cholera typhoid. This is due to Contaminated water.

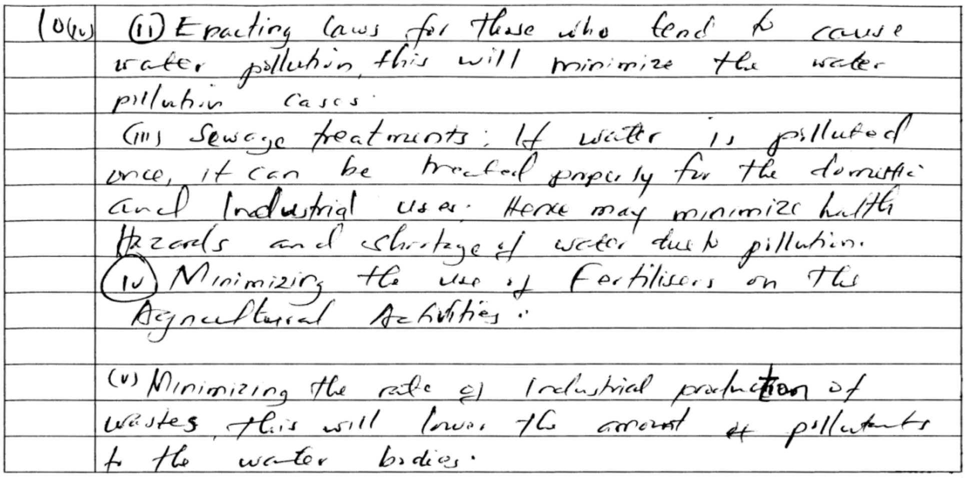
(2) Destruction of Marine life and ecosystem. Some toxic Substance such as Mercury cause death on aquatic organism this destruct the aquatic ecosystem

(3) Lack of water for Industrial and Domestic Uses If water is very polluted, It can't be useful in Domestic and and Industrial uses, If It proceeds, It results in shortage of water which has Quality for the uses.

(4) Marine Eutrophication: If Costant water pollution will ~~occ~~ occur due to artificial fertilisers, Marine plants such as weeds will grow rapidly, a process known as Eutrophication, these plants has the ~~dis~~ disadvantage because the Inhibit the penetration of Solar or Sun light to the water and also lower the amount of oxygen that dissolves in water..

(iv) Control Measures to be taken.

(1) Establishement of proper waste disposal; This is by establishing the permanent place for wastes to be distracted. Instead of Directing them to water bodies.



10(iv) (ii) Enacting laws for those who tend to cause water pollution, this will minimize the water pollution cases.

(iii) Sewage treatments; If water is polluted once, it can be treated properly for the domestic and Industrial use. Hence may minimize health hazards and shortage of water due to pollution.

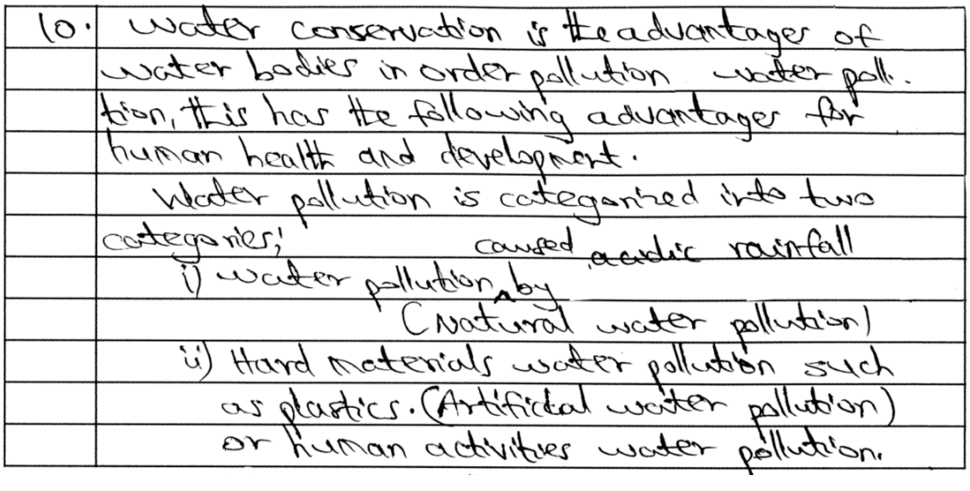
(iv) Minimizing the use of Fertilisers on the Agricultural Activities.

(v) Minimizing the rate of Industrial production of wastes, this will lower the amount of pollutants to the water bodies.

In Extract 10.1, the candidate presented accurate answers according to the requirement of the question. The candidate gave correct explanations for the conservation of water against pollution. Precisely categorized water pollution and identified the causes of water pollution, its effects to human health and finally, suggested the control measures.

However, a few candidates (3.1%) who performed poorly in this question had difficulties in discussing the issue of conservation of water under the given sub headings. Other candidates failed to present their responses in essay form as required, instead they pointed out the mere responses lacking elaboration. Unsatisfactory responses of the candidates might have been caused by inadequate skills in writing essays and mastery of knowledge about water pollution. Extract 10.2 illustrates the case.

Extract 10.2



10. Water conservation is the advantages of water bodies in order pollution water pollution, this has the following advantages for human health and development.

Water pollution is categorized into two categories; caused acidic rainfall

i) water pollution by (Natural water pollution)

ii) Hard materials water pollution such as plastics. (Artificial water pollution) or human activities water pollution.

In Extract 10.2, the candidate gave incorrect meaning of water conservation and presented wrong categories of water pollution. In addition, the candidate had poor language command.

3.0 PERFORMANCE OF CANDIDATES IN DIFFERENT TOPICS

A total of 20 topics were examined in the year 2015 from both 132/1 Chemistry 1 and 132/2 Chemistry 2 papers and performance in many topics was good. The analysis revealed that, 18 topics were performed well as majority of candidates scored an average of between 50.4% and 94.9%. These topics include: *Environmental Chemistry, Polymers, Hydroxyl Compounds and Carbonyl Compounds, Chemical Equilibrium, Extraction of Metals and Selected Compounds of Metals, Energetics, Chemical Bonding, Halogens Derivatives of Hydrocarbons, The Atom, Solubility, Solubility Product and Ionic Product, Gases, Acids, Bases and Salts, Chemical Kinetics, Aliphatic Hydrocarbons, Transition Elements, Electrochemistry, Periodic Classification,* and *Two Component Liquid Systems.* The candidates' good performances in these topics were attributed to good mastering of the concepts asked in the respective topics. However, the topic of Environmental Chemistry had highest performance. This could have been due to the fact that Environmental issues are among the cross-cutting issues which are promoted globally and hence candidates could access the information pertaining environments easily.

The analysis further indicated that, topics which had an average performance were *Aromatic Hydrocarbons* and *Relative Molecular Masses in Solution* which had an average performance which ranged between 46.3% and 44.9%. However, there was no topic with poor performance. The reason for this performance is that, majority of the candidates had no sufficient knowledge on the subject matter of the topics.

In the year 2014 the performance was good in 17 topics out of 18 topics which were examined and their performance ranged between 50.8% and 90.6%. The topic on *Chemical equilibrium* was averagely performed (44.0%). However, the comparison of performance of the candidates in various topics in the year 2014 and 2015 is shown in the appendix.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The question wise analysis of the performance in Chemistry paper one and two for the ACSEE 2015 has shown that overall candidates' performance was good.

However, analysis on individual items indicates that, some candidates had experienced difficulties in answering question items which involved basic mathematics skills based on chemistry principles and also on showing mechanisms of chemical reactions. This is evident from the analysis made in questions from content areas of relative molecular masses in solution and aromatic hydrocarbons.

This performance could be attributed by lack of mathematical skills and inadequate skill of these topics. This insufficiency needs to be dealt with by both teachers and students during the teaching and learning process.

The analysis on how candidates performed in different topics is summarized in the Appendix – (Summary of performance of the candidates' topic-wise). The analysis shows that, 18 topics out of 20 which were examined in paper 1 and 2 had good performance and 2 topics had average performance, however, there was no topic which had poor performance.

It is expected that the feedback given in this report will enable education stakeholders to take appropriate initiatives to improve more performance of candidates in ACSEE in Chemistry, taking into consideration that the subject forms a bridge for many science courses in tertiary level of education.

4.2 Recommendation

On the bases of analysis of candidates' performance in Chemistry subject, the following are recommended to improve more candidates' performance.

(i) Teacher should put more emphasis on mathematical base concepts and practical skills related to specific fields of study. This will improve the ability of candidates to deal with problems related to the concepts.

(ii) There should be common specific textbooks for all schools and these should be stipulated in the syllabus.

(iii) Students should be advised to read the question carefully so as to identify the requirement of the question before attempting it.

(iv) Candidates should be encouraged to improve their ability in reading and writing English language through reading English books, practicing speaking English and involving in essay writing.

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

(vi) Teachers should give special attention to enable students to learn basic concepts involving principles governing writing chemical formula, chemical symbols, chemical names and basic mathematicalskills.

Appendix: Summary of the Performance of Candidates – Topic wise 2014 and 2015

S/N	TOPIC	NO. OF QUESTIONS	2014		2015	
			THE % OF CANDIDATES WHO SCORED AN AVERAGE OF 30 % OR ABOVE	REMARKS	THE % OF CANDIDATES WHO SCORED AN AVERAGE OF 30 % OR ABOVE	REMARKS
1	ENVIRONMENTAL CHEMISTRY	01	*		94.9	GOOD
2	POLYMERS	01	*		90.4	GOOD
3	HYDROXYL COMPOUNDS AND CARBONYL COMPOUNDS	01	90.6	GOOD	85.4	GOOD
4	CHEMICAL EQUILIBRIUM	01	44.0	AVERAGE	84.9	GOOD
5	EXTRACTION OF METALS AND SELECTED COMPOUNDS OF METALS	01	62.8	GOOD	82.8	GOOD
6	ENERGETICS	01	95.7	GOOD	77.9	GOOD
7	CHEMICAL BONDING	01	57.2	GOOD	77.9	GOOD
8	HALOGENS DERIVATIVES OF HYDROCARBONS	01	67.4	GOOD	73.0	GOOD
9	THE ATOM	02	66.6	GOOD	71.7	GOOD
10	SOLUBILITY, SOLUBILITY PRODUCT AND IONIC PRODUCT	01	62.5	GOOD	69.2	GOOD
11	GASES	02	*		67.9	GOOD
12	ACIDS, BASES AND SALTS	01	77.9	GOOD	66.6	GOOD
13	CHEMICAL KINETICS	01	67.7	GOOD	64.9	GOOD
14	ALIPHATIC HYDROCARBONS	01	55.5	GOOD	64.0	GOOD
15	TRANSITION ELEMENTS	01	75.5	GOOD	61.5	GOOD
16	ELECTROCHEMISTRY	01	80.3	GOOD	61.0	GOOD
17	PERIODIC CLASSIFICATION	01	74.5	GOOD	60.6	GOOD
18	TWO COMPONENT LIQUID SYSTEMS	02	56.7	GOOD	50.4	GOOD
19	AROMATIC HYDROCARBONS	02	58.0	GOOD	46.3	AVERAGE
20	RELATIVE MOLECULAR MASSES IN SOLUTION	01	86.1	GOOD	44.9	AVERAGE
21	SOIL CHEMISTRY	1	50.8	GOOD	*