THE NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

EXAMINERS' REPORT ON THE PERFORMANCE OF CANDIDATES

ACSEE, 2014

132 CHEMISTRY

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FOREWORD

The Examiners' Report on the Performance of Candidates in Chemistry subject in the Advanced Certificate of Secondary Education Examination (ACSEE) 2014 was prepared in order to provide feedback to students, teachers, parents, policy makers and the public in general on the performance of 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 the education system in general and education delivery system in particular. Essentially, candidates' responses to the examination questions is a strong indicator of what the education system was able or unable to offer to students in their two years of advanced secondary education.

The analysis presented in this report is intended to contribute towards understanding of some of the reasons behind the performance of candidates in Chemistry subject. The report highlights some of the factors that made the majority of candidates to score high marks and also factors that made a few candidates not to score high marks in the questions. Factors which contributed for some candidates not to score high marks include, general lack of knowledge in relation to a particular concept, failure to interpret the requirement of the questions, and inability to answer questions which demanded explanations and supporting reasons or base on mathematical skills. 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 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.

The Council would like to thank all the Examination officers, Examiners and all others who participated in the preparation of this report.

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 2014 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 four (4) questions. Section B and C had four (4) questions each, of which the candidates were required to answer three (3) questions from each section. Each question carried a total of 10 marks.

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. Each question carried a total of 20 marks.

The analysis of examination results show 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. The results show that, candidates' performance in 2014 has improved as 95.78 percent passed the examination compared to 83.87 percent of the candidates who passed the examination in ACSEE 2013. Hence the performance in 2014 has increased by 11.91% compared to that of 2013.

The following sections provide an analysis of each question starting with the requirements of the question, followed by candidates' performance, and then clarification of the observed candidates' responses. In this analysis a question is graded as poorly performed, averagely performed or good performed if the number of candidates who scored 30 percent or above of the allocated marks is 0 – 29, 30 – 49 or 50 – 100 respectively.

2.0 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION

2.1 132/1-CHEMISTRY 1

2.1.1 Question 1: Chemical Equilibrium

This question consisted of part (a) and part (b). In part (a), the candidates were provided with the information that, nitrogen and oxygen combine endothermically at elevated temperature as per equation $2N_{2(g)}+O_{2(g)} \rightleftharpoons 2NO_{2(g)}$ and the equilibrium constant for the reaction was 4.2 x 10^3 at 3000 ^{0}C and 1 atmosphere. They were then required to calculate the composition of each gas in the equilibrium if 2 moles of each nitrogen and oxygen were heated. In part (b) they were required to calculate the partial pressure of each gas in equilibrium given that 20.85g of PCl_5 were heated in a 4 dm^3 sealed tube whereby the pressure in the vessel was found to be 1.5 atmospheres and at this pressure PCl_5 had been dissociated to 80%.

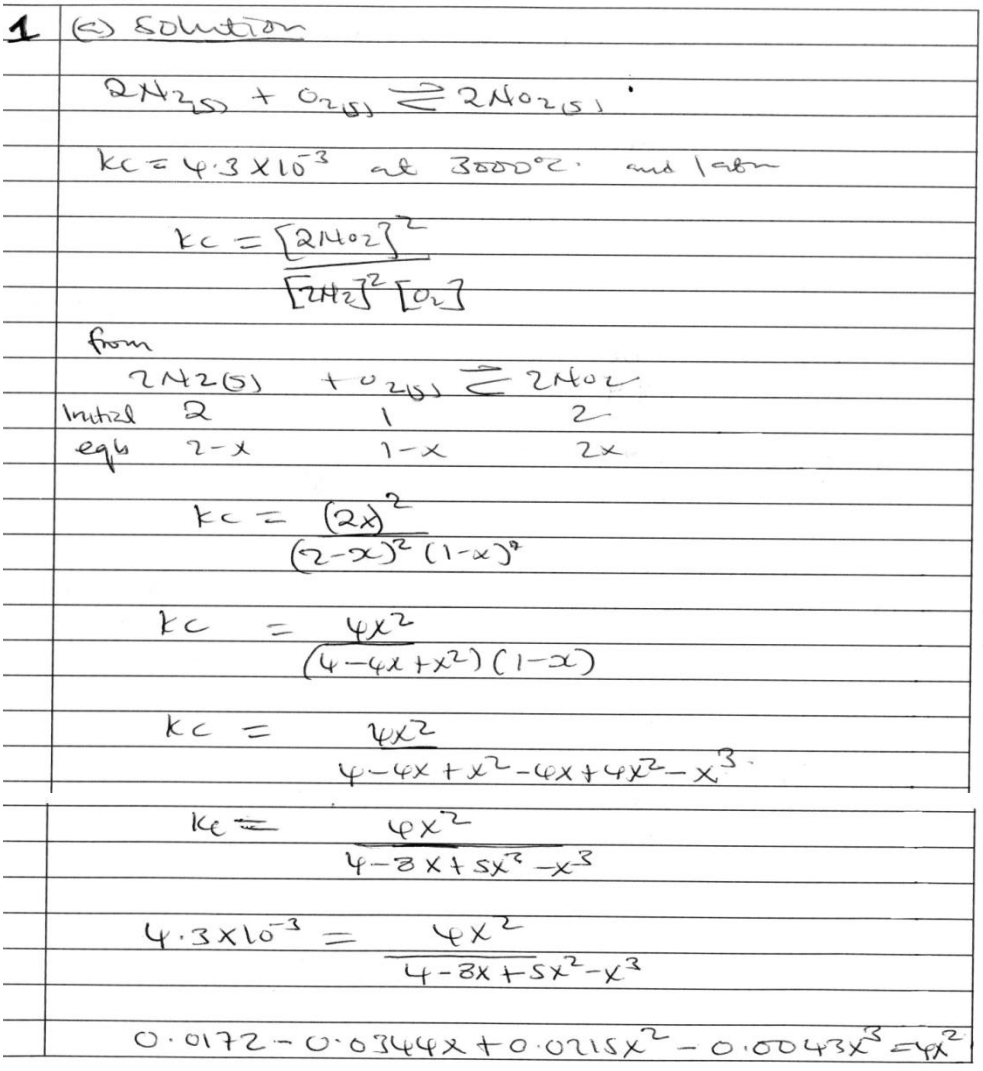
This question was opted by 42.9 percent of the candidates. The percentage of candidates who scored 0 to 2.5 marks was 94.2 out of which 24.9 percent scored 0 marks. 4.6 percent scored 3 to 4.5 marks and few (1.2%) candidates scored 5 to 8.5 marks. There was no candidate who scored all the 10 marks allocated to this question. This trend signifies poor performance in this question.

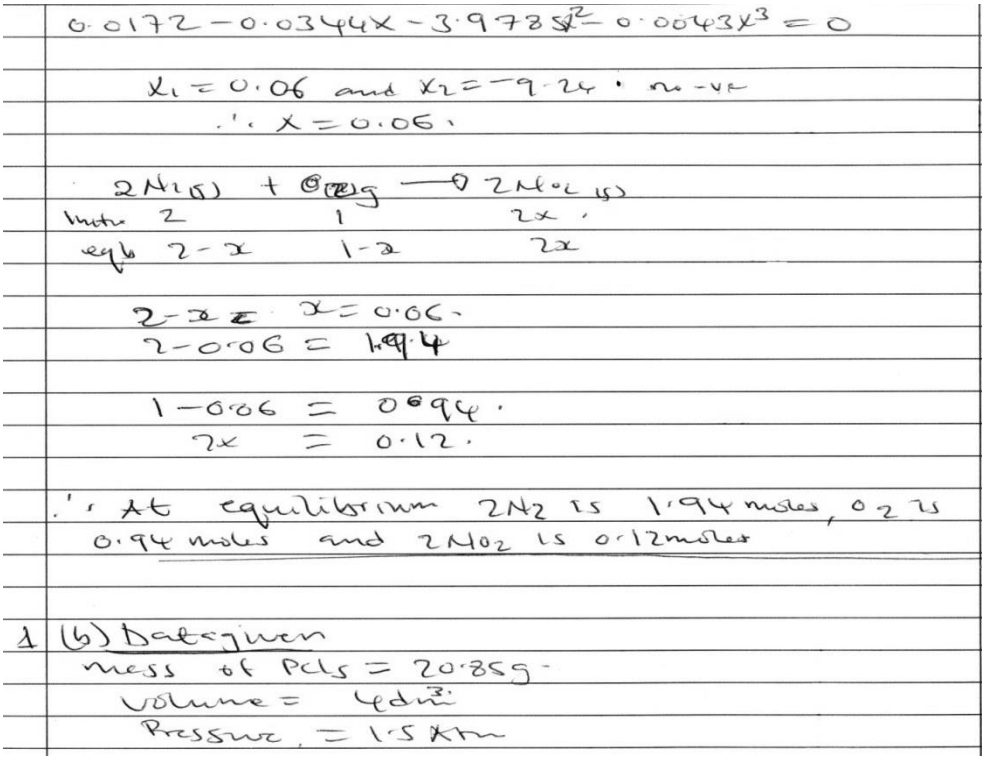
Poor performance was attributed by poor knowledge of most candidates on writing the Kp expression and failure to realise that equilibrium constant can be given either in terms of partial pressure (Kp) or molar concentrations (Kc). Some candidates opted for Kc expression instead of Kp expression, $Kp = \frac{[P^1NO_2]^2}{[P^1N_2]^2[P^1O_2]}$ as per equation provided in part (a). In part (b), some candidates failed to show the initial moles of the reactants as they could not calculate the number of moles from the given mass of PCl_5, instead, they relied on theoretical stoichiometric initial moles of PCl_5 before equilibrium. For example one candidate wrote as follows:

	$PCl_{5\ (g)}$	$\rightarrow PCl_{3(g)}$	$+ Cl_{2(g)}$
Initial moles	1	0	0
Instead of	0.1	0	0.

Most candidates had incorrect understanding of the terms ‘dissociated to’ as opposed to ‘dissociated by’ in which the degree of dissociation in the former is 20% and the latter is 80%. A problem of English Language mastery might have led to such discrepancy. Extract 1.1 shows sample answers from the candidate which did not meet the requirements of the question.

Extract 1.1

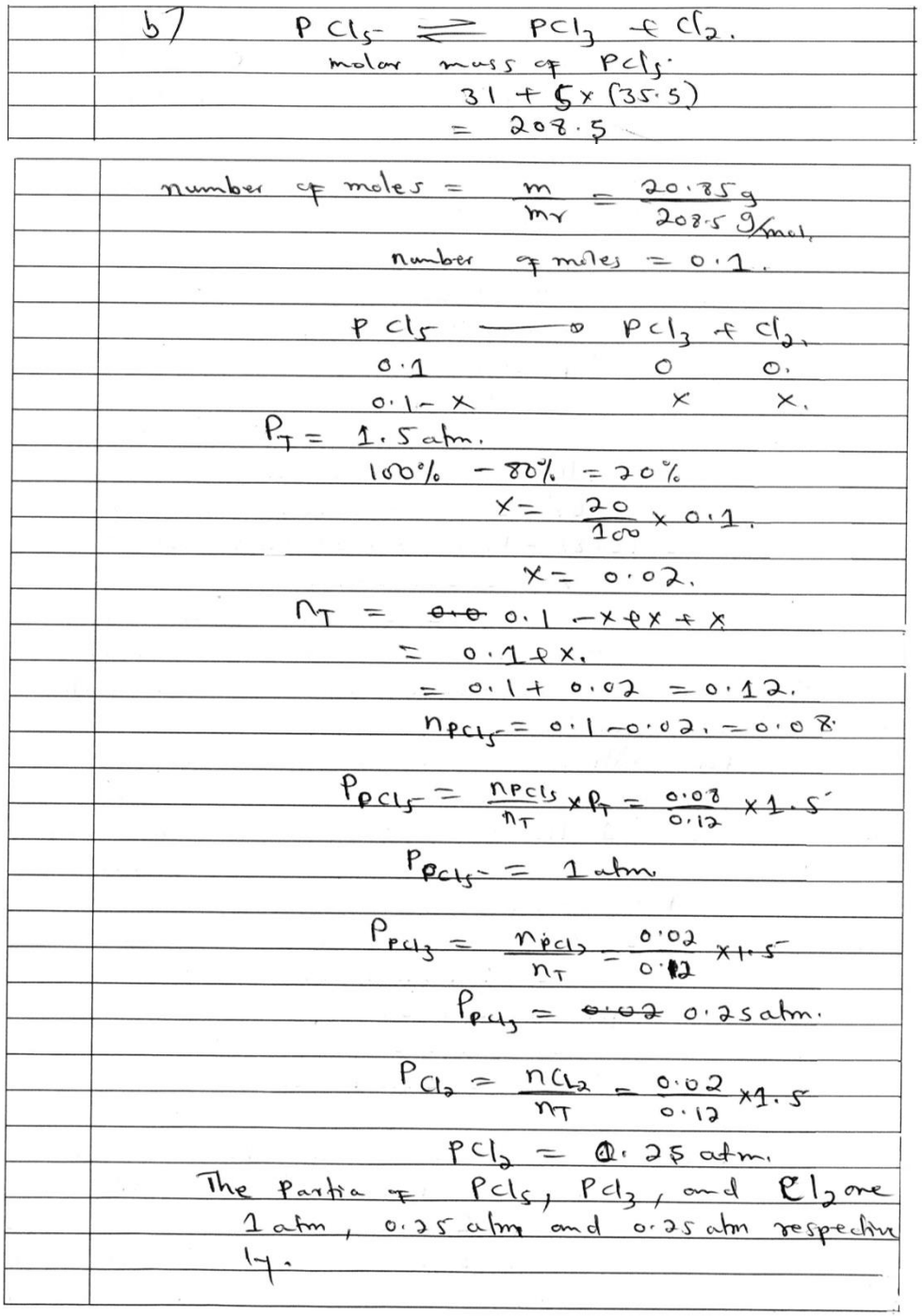




In extract 1.1 the candidate failed to identify that the equilibrium constant was to be given in terms of partial pressure. She/he presented incorrect expression for Kc and hence could not proceed with the calculations in part (a). In part (b) the candidate ended up copying the data from the question.

On the other hand, the candidates who performed well in this question managed to write correctly the formulae for the composition of each gas in the equilibrium reaction. However, they showed low mathematical skills on solving equation whose highest power is 3 (polynomial) and as a result they failed to find the composition of each gas in the equilibrium hence they could not score all marks in part (a). In part (b) they managed to calculate the partial pressure of each gas in the equilibrium after the dissociation of PCl_5 at provided quantities and conditions. Extract 1.2 shows sample answers from a candidate who managed to answer part (b) correctly.

Extract 1.2



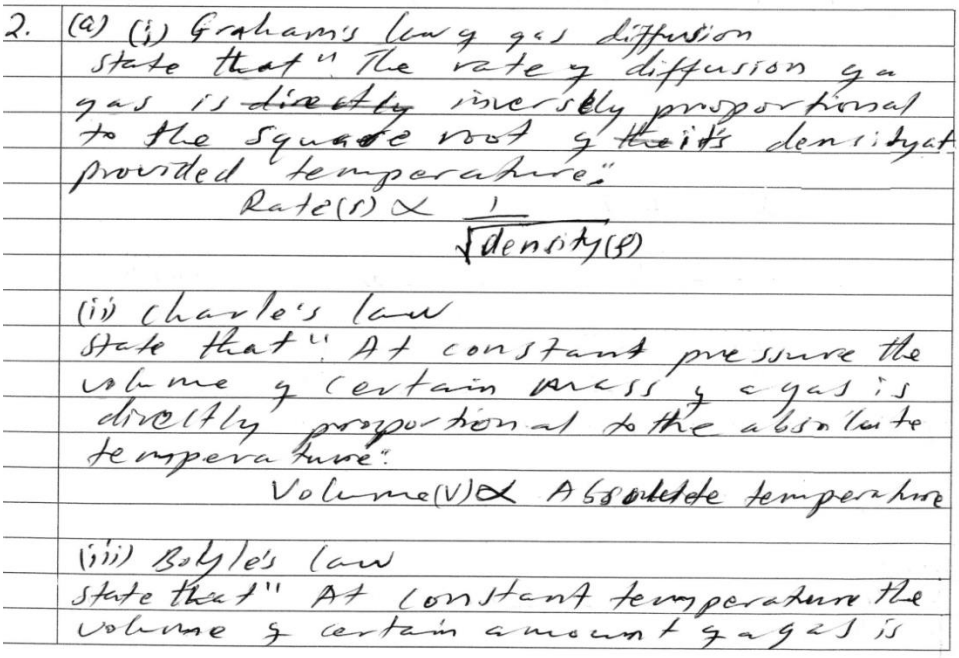
Extract 1.2 is an example of a well presented answer for part 1 (b). The candidate wrote necessary formulae and equations, plugged in the given data correctly and finally calculated the partial pressure of each gas.

2.1.2 Question 2: Gases

In part (a) of the question, candidates were required to state Grahams' law of gas diffusion, Charle's and Boyle's laws and in part (b) they were required to identify and show how two of the laws among those mentioned in part (a) can be combined to give a single gas equation. Part (c) stated that, "*a chloride of phosphorus is found to diffuse in the gaseous state more slowly by a factor of 2.216 than that of nitrogen under the same conditions*". Candidates were then required to calculate the relative molecular mass of the chloride and write the molecular formula of the chloride given that chloride molecule contains one atom of phosphorus.

The question was opted by majority of the candidates (95%) of whom 7 percent scored 0 to 2.5 marks. 54.5 percent scored 3 to 5 marks and 29.9 percent scored 6 to 10 with 0.9 percent scoring all the 10 marks allocated for this question. This trend indicates a good performance for this question. The candidates who performed well managed to state clearly the laws and derived the ideal gas equation which is a combination of Boyle's and Charle's laws. Furthermore, they successfully calculated the relative molecular mass of the chloride and wrote correctly its formula. Extract 2.1 illustrates one of the good responses from the candidates.

Extract 2.1


2. (a) (i) Graham's law of gas diffusion
state that " The rate of diffusion of a gas is ~~directly~~ inversely proportional to the square root of its density at provided temperature"
Rate(r) $\propto \frac{1}{\sqrt{\text{density}(\rho)}}$

(ii) Charle's law
state that " At constant pressure the volume of certain mass of a gas is directly proportional to the absolute temperature"
Volume(V) $\propto$ Absolute temperature

(iii) Boyle's law
state that " At constant temperature the volume of certain amount of a gas is

2.(a) (iii) inversely proportional to the pressure"

Volume (V) $\propto \frac{1}{\text{pressure } (P)}$

(b) 1. Charle's law

Volume (V) $\propto$ Absolute temperature

$V \propto T$ - - - - (i)

~~$V = K$~~

2. Boyle's law

Volume (V) $\propto \frac{1}{\text{pressure } (P)}$

$V \propto \frac{1}{P}$ - - - - (ii)

By combining these two equation (i) and (ii)

$V \propto T$

$V \propto \frac{1}{P}$

$V \propto \frac{T}{P}$

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

$PV = KT$, $K \rightarrow$ proportional constant

$K = R$ (universal gas constant)

$PV = RT$ - For one mole

$PV = nRT$ - for numbers of moles.

Hence, gase equation is

$$PV = nRT$$

(c) Given,

Rate of chloride of phosphorus (R_{PCl}) $= 2.216\ R_{PCl}$

Rate of nitrogen (R_N) $= 2.216 R_N$

2.(b) (i) Relative molecular mass of chloride.

from, Grahem's law of diffusion

Rate (R) $\propto \frac{1}{\sqrt{\text{Molecular mass}}}$

$R \propto \frac{1}{\sqrt{M_r}}$, Molecular mass of Nitrogen (M_{rN}) = 28

$R_{Cl} = \frac{K}{\sqrt{M_{r_{PCl}}}}$

$R_N = \frac{K}{\sqrt{M_{rN}}}$

$$\frac{R_{Cl}}{R_N} = \frac{\sqrt{M_{rN}}}{\sqrt{M_{rPCl}}} = \sqrt{\frac{M_{rN}}{M_{rPCl}}}$$

$$\left(\frac{R_{Cl}}{R_N}\right)^2 = \frac{M_{rN}}{M_{rPCl}}$$

$$M_{rPCl} = \left(\frac{R_N}{R_{PCl}}\right)^2 \times M_{rN}$$

$$= \left(\frac{2.216 R_{PCl}}{R_{PCl}}\right)^2 \times 28$$

$$= (2.216)^2 \times 28$$

$$M_{rPCl} = 637.498 \approx 137.5$$

$$M_{rPCl} = 137.5$$

from

$M_{rCl} + M_{rP} = M_{rPCl}$, M_{rP} → relative molecular mass

$$M_{rCl} = M_{rPCl} - M_{rP}$$

$$= 137.5 - 31$$

$$M_{rCl} = 106.5$$

where, M_{rP} = Relative molecular mass of phosphorus

2. (c) M_{rPCl} = Relative molecular mass of chloride of phosphorus

∴ Relative molecular mass of chloride

$(M_{rCl}) = 106.5$

(ii) Required formular

from

1 mole of Cl = 35.5

X = 106.5

$$X = \frac{106.5}{35.5} = 3$$

X = 3

Molecules of chloride = 3

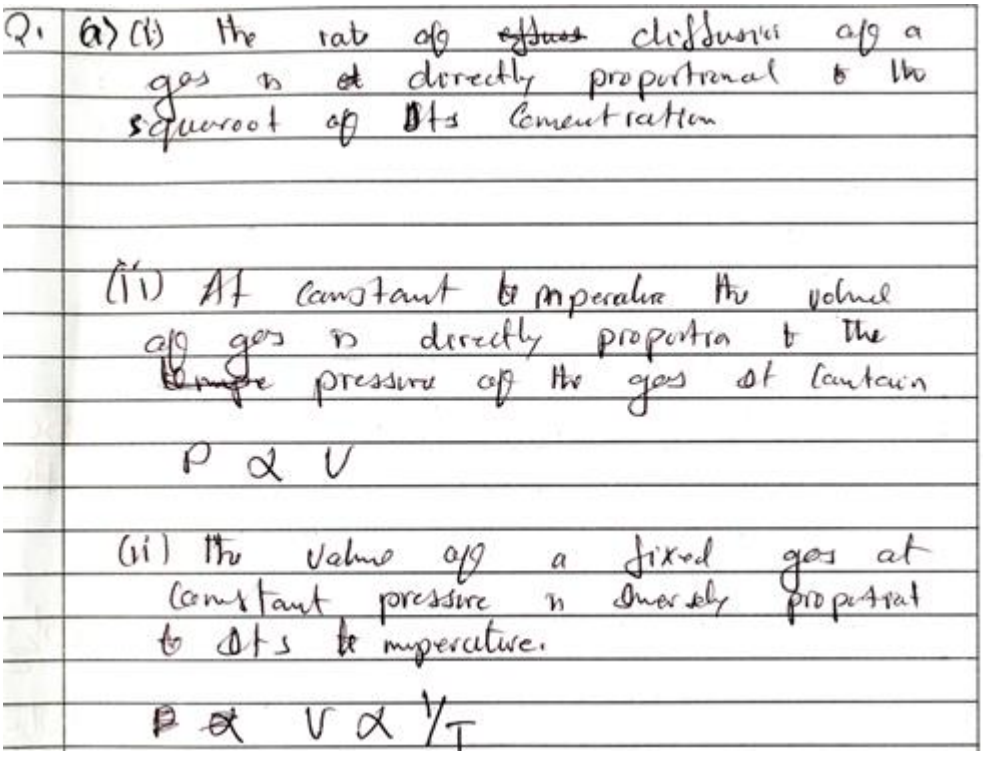
∴ formular = PCl_3

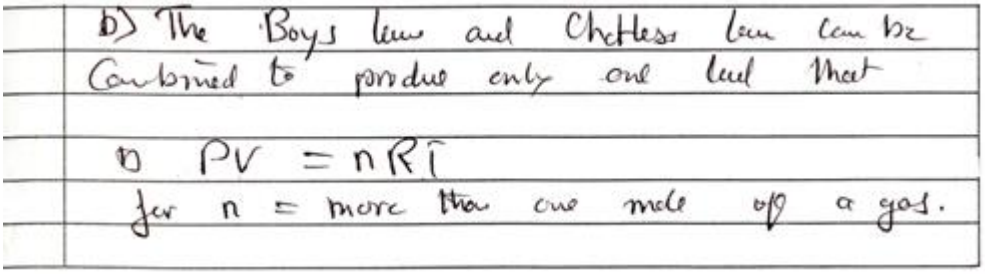
Extract 2.1 shows that, the candidate was able to give answers which were expected. She/he stated clearly the given laws and derived the ideal gas equation which combines Boyle's and Charles's laws. Similarly, she/he calculated correctly the relative molecular mass of the chloride and wrote appropriately its formula.

The candidates who performed poorly could not state the asked laws properly. They could not write the statements of the laws as some of them did not incorporate the key terms of such laws; for example, some candidates omitted the word 'absolute' before temperature in Charles's law.

Moreover, some of the candidates confused the laws and stated interchangeably, as a result they failed to derive the gas equation which combines the laws. In part (c) where they were required to apply Graham's law of gas diffusion, some candidates failed because they were not able to state the law. Those who managed to state the law could not make appropriate substitution of the stated parameters and hence failed to attain the expected answers. Extract 2.2 indicates an example of the candidate's poor response.

Extract 2.2





In extract 2.2 the candidate could not state even a single law correctly. He/she was unable to derive the gas equation from a combination of Boyle's and Charles's laws and also failed to calculate the molar mass of the chloride and to write molecular formula of the chloride as the question required. The candidate omitted part (c), an indication that he/she had inadequate knowledge on the tested item or did not allocate enough time for this part.

2.1.3 Question 3: Relative Molecular Masses in Solution

Part (a) of the question demanded the candidates to define colligative properties and give four examples of those properties. Part (b) stated that; *Nicotine which is extracted from tobacco leaves is completely immiscible with water at temperature below 60ºC.* From this statement, the candidates were asked to find the molality of nicotine in aqueous solution given that the solution freezes at -0.45 ºC and the K_f is 1.86 $^oCm^{-1}$. Furthermore, they were required to calculate the molar mass of nicotine provided that the aqueous solution is prepared by dissolving 1.92 g of nicotine in 48.92 g of water. In addition, they were required to find the molecular formula of nicotine given that nicotine consists of 74.04% C, 8.70% H and 17.27% N by mass.

A total of 13,308 (82.3%) candidates opted for this question. 13.9 percent of the candidates scored 0 to 2.5 marks. The candidate who scored 3 to 5 marks were 29.6 percent and those who scored above 5 marks were 56.5 percent with 6.5 percent of them scoring all the 10 marks.

The candidates who scored high marks had sufficient knowledge about colligative properties and calculated correctly molality of nicotine solution in water which freezes at $-\ 0.45^0$C, molar mass of nicotine from the given data and molecular formula of nicotine. Extract 3.1 shows an example of a good response from one of the candidates.

Extract 3.1

3(a) Colligative properties are the properties of a liquid which does not depend on the ~~number~~ of nature of the solute but the number of the solute added.

Examples of colligative properties are

- Elevation in boiling point.
- Depression in freezing point
- Relative lowering of vapour pressure.
- Osmotic pressure.

3(b) Data given.

- Substance given - Nicotine.
- Temperature - below 60°c.
- Required : calculate.

(i) Molarity of nicotine.

Given :

- $K_f = 1.86\,°C\,m^{-1}$.
- freezing point = -0.45°c.

~~fro~~ soln.

from.

~~$K_f = K$~~

$\Delta T = K_f M$.

where.

ΔT = Depression in freezing point.

K_f = cryoscopic constant.

M = Molarity.

then.

$M = \Delta T / K_f$.

But

ΔT = Initial freezing point - Final freezing point.

= 0°c - (-0.45°c).

= 0.45°c.

Then.

$$M = \frac{0.45^{\circ}C}{1.86^{\circ}CM^{-1}}$$

$$M = 0.24\,M$$

∴ Molarity of nicotine is 0.24M

3(b) (ii) Molar Mass of Nicotine.

Given.

- Mass of nicotine (M_n) = 1.921g.
- Mass of water (M_w) = 48.92g.

Soln.

From.

$$\Delta T = \frac{K_f \times M_n \times 1000g}{Mr_n \times M_w}$$

Where.

ΔT = depression in freezing point.

K_f = Cryoscopic constant

M_n = Mass of nicotine.

Mr_n = Molar Mass of nicotine.

M_w = Mass of water.

Then.

$$Mr_n = \frac{K_f \times M_n \times 1000g}{\Delta T \times M_w}$$

$$= \frac{1.86^{\circ}CM^{-1} \times 1.921g \times 1000g}{0.45^{\circ}C \times 48.92g}$$

$$= 162.39\,g/mol \approx 162\,g/mol$$

∴ Molar Mass of nicotine is 162g/mol

3(b) (iii) Molecular formular of nicotine.

Given.

C = 74.03%

H = 8.70%

N = 17.27%

Soln.

Element	C	H	N
percentage	74.03	8.70	17.27
percentage / Molar mass	$\frac{74.03}{12}$	$\frac{8.70}{1}$	$\frac{17.27}{14}$
	= 6.17	= 8.70	= 1.2
	$\frac{6.17}{1.2}$	$\frac{8.70}{1.2}$	$\frac{1.2}{1.2}$
	= 5	= 7	1

Empirical formula = C_5H_7N.

From.

Molecular formula = (Empirical formula)n.

But

Molar mass of molecular formula = 162 g/mol

Molar mass of empirical formula = 81 g/mol

Then.

$162\ g/mol = (81\ g/mol)\ n$.

$n = \frac{162\ g/mol}{81\ g/mol}$.

$n = 2$.

Then.

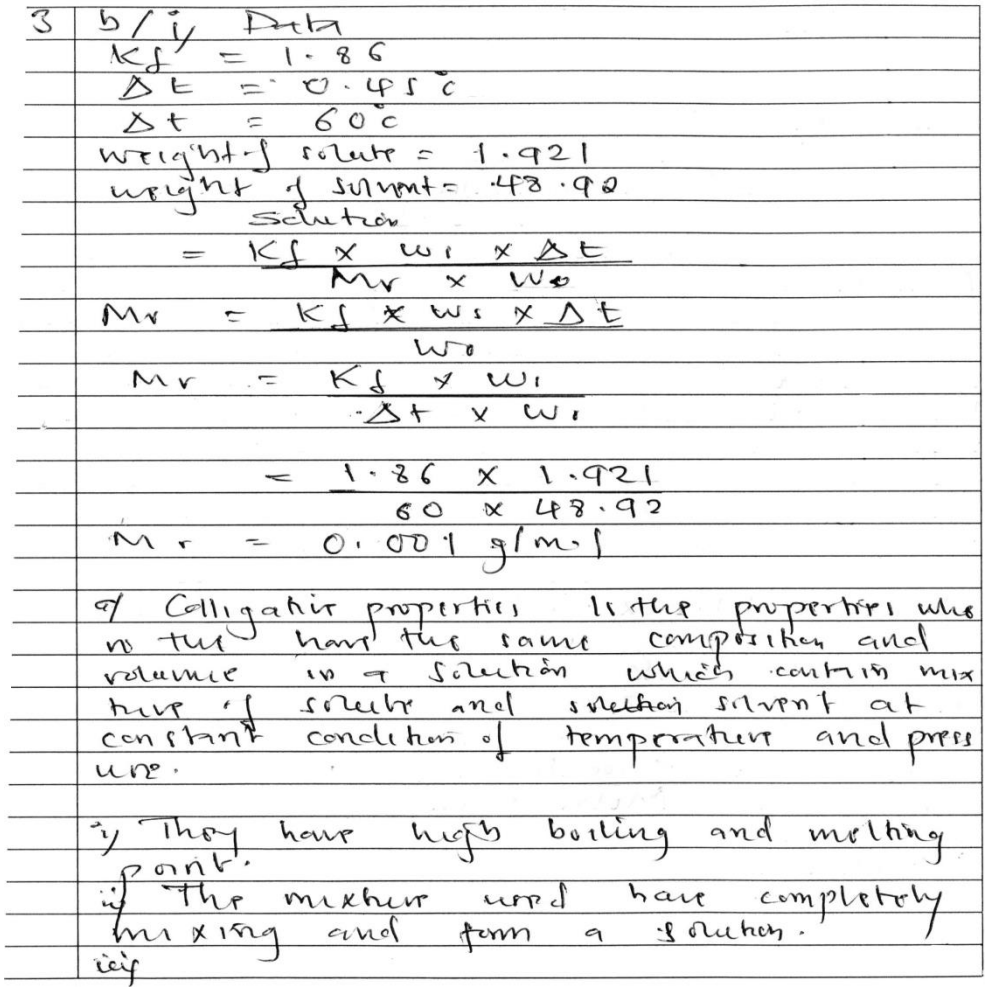
Molecular formula = $(C_5H_7N)2$.

3(b) (iii) ∴ Molecular formula = $C_{10}H_{14}N_2$.

Extract 3.1 shows an example of the answers which indicate candidate's mastering of colligative properties. She/he managed to show correct formulae and did the associated calculations clearly and accurately.

On contrary, the candidates who scored low marks could not define and give examples of colligative properties. They were unable to calculate molality, molar mass, and molecular formula of nicotine from the provided information. Such poor performance was attributed by failure of the candidates to apply the concepts and relate colligative properties with molar mass. Extract 3.2 represents the sample of poor response.

Extract3.2



3 b/ i) Data

$K_f = 1.86$

$\Delta t = 0.45°c$

$\Delta t = 60°c$

weight of solute = 1.921

weight of solvent = 48.92

Solution

$$= \frac{K_f \times w_s \times \Delta t}{M_r \times W_o}$$

$$M_r = \frac{K_f \times w_s \times \Delta t}{W_o}$$

$$M_r = \frac{K_f \times w_s}{\Delta t \times W_o}$$

$$= \frac{1.86 \times 1.921}{60 \times 48.92}$$

$M_r = 0.001$ g/mol

a) Colligative properties is the properties who no the have the same composition and volume in a solution which contain mixture of solute and solution solvent at constant condition of temperature and pressure.

i) They have high boiling and melting point.

ii) The mixture used have completely mixing and form a solution.

iii)

In extract 3.2 the candidate failed to answer correctly any part of the question. In part (a) he/she failed to define and give examples of colligative properties. Moreover, the candidate attempted only one item out of three listed in part (b) but applied incorrect formula and data as a result he/she got it wrong.

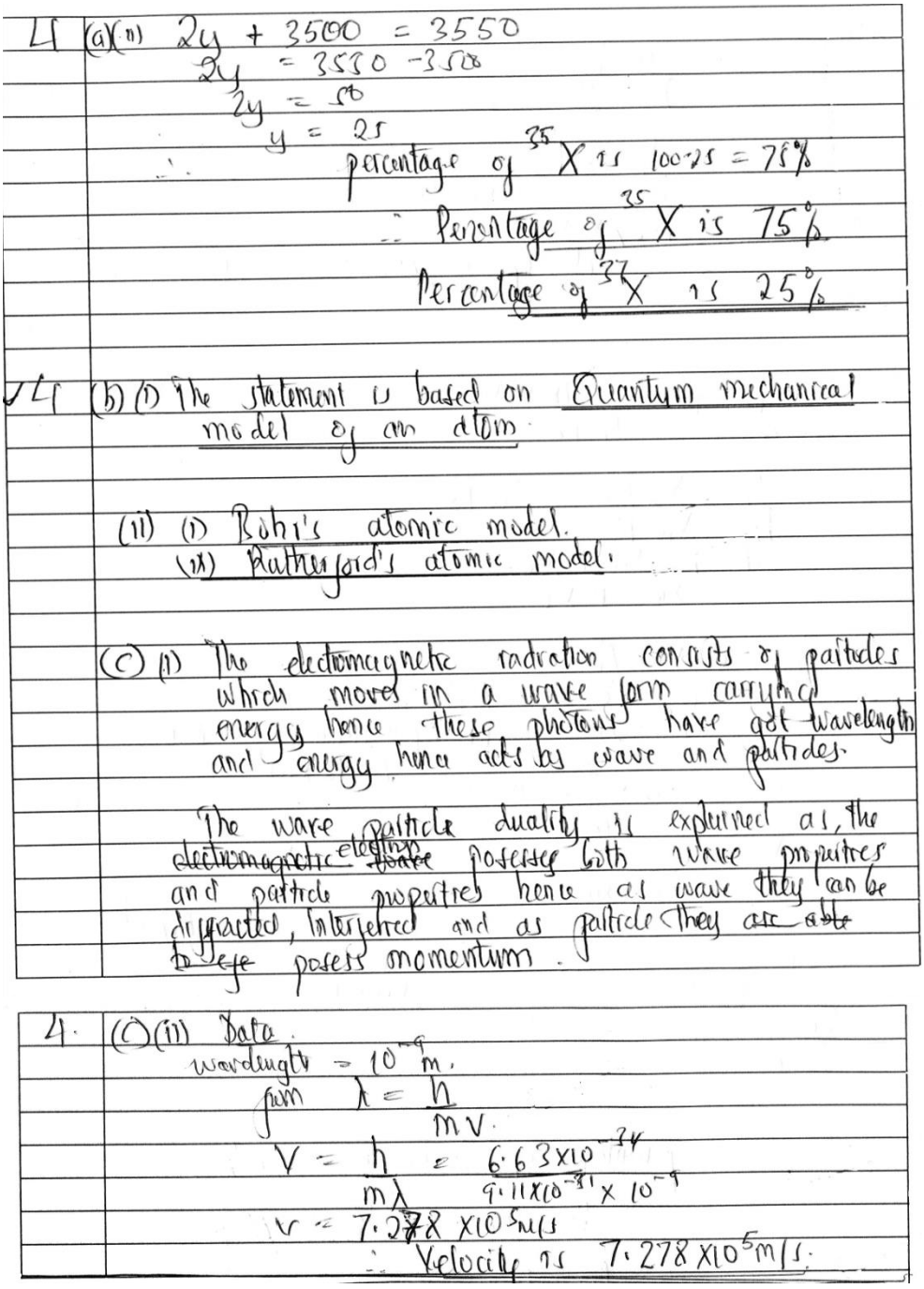
2.1.4 Question 4: The Atom

In part (a) the candidates were required to write the atomic number of an atom with electronic configuration of $1s^2 2s^2 2p^6 3s^2 3p^5$; determine the percentage of ^{35}X and ^{37}X in the sample of element X, where X occurs naturally as ^{37}X and ^{35}X given that the relative atomic mass of X is 35.5. In part (b) they were required to state the atomic model in which the statement '*the motion of the electron in an atom is not a simple rotation around an orbit, but rather a three dimensional standing wave which obeys Schrodinger equation"* is based. They were also required to name other two atomic models that attempt to explain the structure of the atom. In part (c), they were required to describe the dual nature of electromagnetic radiation and wave particle duality. Finally, they were required to calculate the velocity of an electron whose wavelength is 10^{-9} metres.

The question was opted by many candidates (71.0%) and 33.4 percent scored 0 to 2.5 marks out of which 2.2% scored 0 marks. The percentage of candidates who scored 5 to 10 marks was 36.7 implying that the general performance for the question was good.

The candidates who performed well, managed to write the atomic number from the given electronic configuration and calculated accurately the percentage abundance of the given isotopes of sample X. They demonstrated a good knowledge about atomic models as they stated properly the model related to the statements given as *a wave mechanical model* and two other models which explain the structure of an atom. They described well the dual nature of electromagnetic radiation, wave particle duality and calculated correctly the velocity of an electron from the given wavelength. Extract 4.1 illustrates a sample of good response.

Extract 4.1



11 (a)(ii) $2y + 3500 = 3550$

$2y = 3550 - 3500$

$2y = 50$

$y = 25$

∴ percentage of ^{35}X is $100 - 25 = 75\%$

∴ Percentage of ^{35}X is 75%

Percentage of ^{37}X is 25%

(b) (i) The statement is based on Quantum mechanical model of an atom.

(ii) (i) Bohr's atomic model.

(ii) Rutherford's atomic model.

(c) (i) The electromagnetic radiation consists of particles which moves in a wave form carrying energy hence these photons have got wavelength and energy hence acts by wave and particles.

The wave particle duality is explained as, the electromagnetic ~~electron~~ ~~wave~~ posesses both wave properties and particle properties hence as wave they can be diffracted, interfered and as particle they ~~are able to~~ posess momentum.

4. (c)(ii) Data

wavelength = 10^{-9} m.

from $\lambda = \frac{h}{mv}$

$v = \frac{h}{m\lambda} = \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 10^{-9}}$

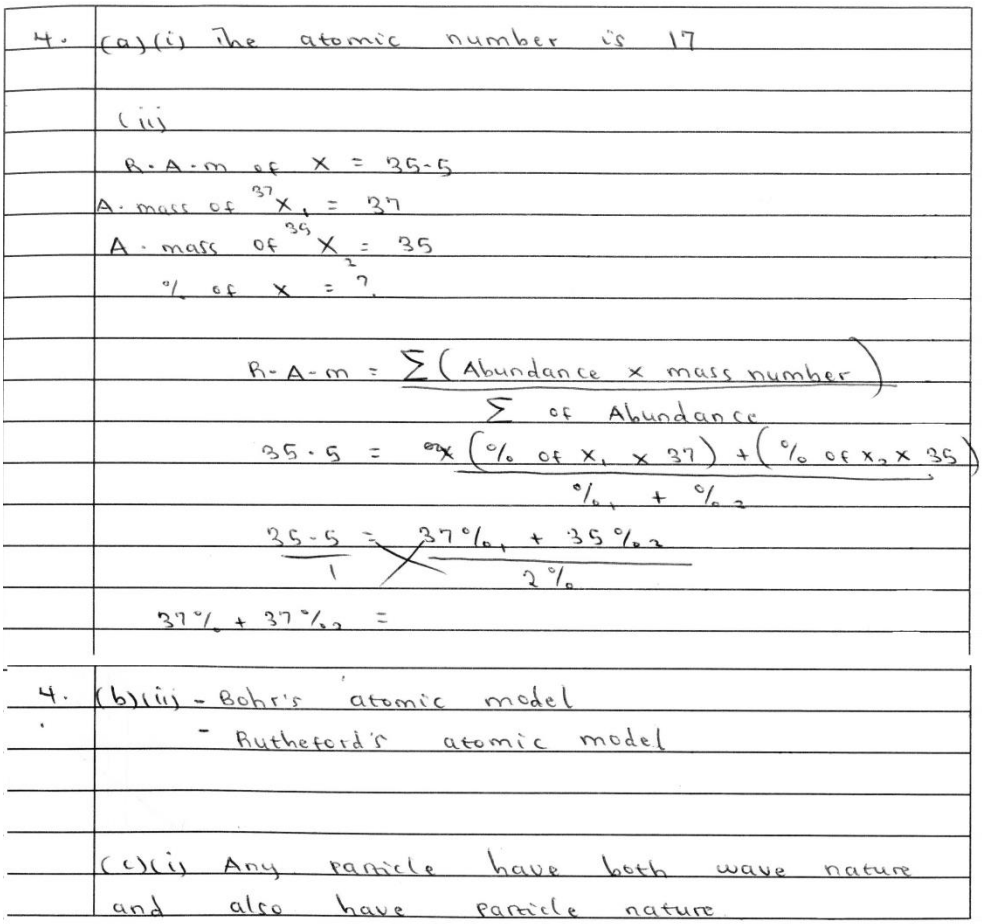
$v = 7.278 \times 10^{5}$ m/s

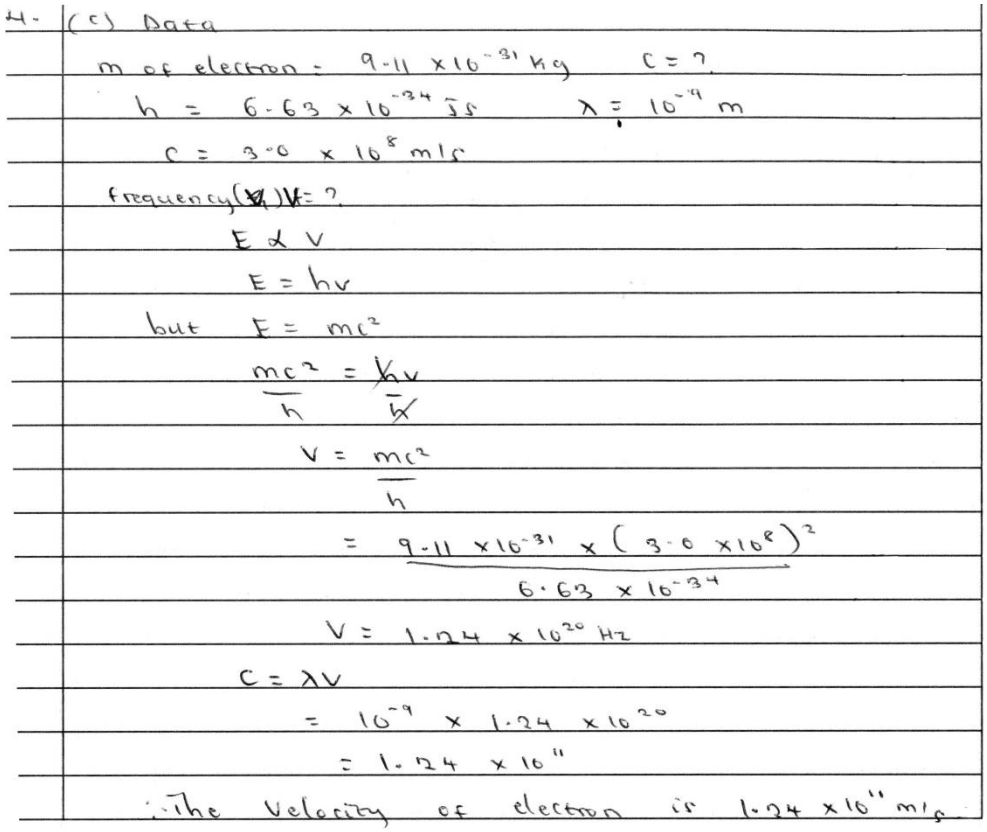
∴ Velocity is 7.278×10^{5} m/s.

Extract 4.1 shows a sample answer from one of the candidates who managed to perform well all parts of the question.

The candidates who scored low marks managed to write the atomic number by referring to electronic configuration given in 4 (a) (i) but encountered difficulties in determining the percentage of the given isotopes in 4 (a) (ii) due to application of incorrect formulae. Similarly, some were unable to calculate the velocity of an electron from the wavelength given in 4 (c) (i). This implies that candidates were not conversant with calculations of percentage abundance of isotopes and had insufficient knowledge about atomic models and electromagnetic radiation. Extract 4.2 is an example of a poor response given by one of the candidates.

Extract 4.2





Although the work of the candidate in extract 4.2 is systematically arranged, almost all the answers are not correct except parts a(i) and b(ii).

2.1.5 Question 5: Chemical Bonding

The question required the candidates to arrange green, blue, red, violet and yellow colours in the order of increasing wavelengths. The candidates were also asked to explain briefly the term frequency of a line with reference to a prism spectrometer. Moreover, they were required to write down the number of electrons at ground state with reference to krypton, given the set of quantum numbers having: n = 3; n = 3, l = 2; ml = 0 and n = 2, l = 1, ml = -1, s = ½. Finally, they were required to explain the bonding in silane (SiH_4) in molecular orbital terms.

A total of 5334 (33.0%) candidates opted for this question and only 5.5% of candidates managed to score above 5 out of 10 marks while 94.5% scored below 5 marks. Further analysis shows that, 59.6 percent of the candidates

scored 0 to 2.5 marks and there were no any candidate who managed to score all 10 marks. However, the performance in this question was average.

The candidates who scored low marks were not able to arrange the given colours in order of increasing wavelengths neither could they calculate the number of electrons in the given quantum numbers nor explain the bonding in silane in terms of molecular orbital. Such performance was attributed by failure of the candidates to understand exactly the demand of the question, analyse the facts related to frequency and the concept of quantum numbers. Extract 5.1 shows an example of a response from the candidate who performed poorly.

Extract 5.1

Qn 3 (a) (i) Increasing wavelength:

Green < Blue < red < violet < yellow.

(ii) Frequency of a wave is equal to the product of Wavelength and velocity.

$\therefore$ ~~from~~ $V = \frac{f}{\lambda}$

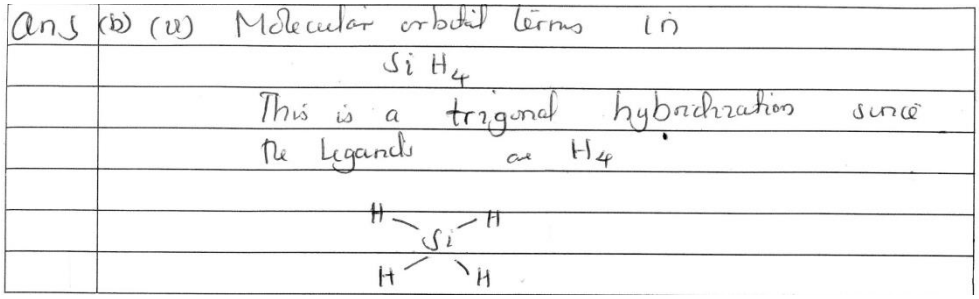
$\therefore f = V \times \lambda$

(b) (i) $n = 3$ $l = 2$

n	l	Orbital	m_s	m_l	number of orbitals
3	0	3s	$(+\frac{1}{2}, -\frac{1}{2})$	0	2
3	1	3P	$(+\frac{1}{2}, -\frac{1}{2})$	-1, 0, 1	6
3	2	3d	$(+\frac{1}{2}, -\frac{1}{2})$	-2, -1, 0, 1, 2	10

Total number of orbital = 16

= ~~16~~ + 16 electron.



In extract 5.1 the candidate could not arrange the given colours in order of increasing wave length. For example red colour which has highest wavelength is placed at the middle instead of being placed the last. In part (b) (i) the candidate performed unrelated calculations in finding the number of electrons in the given quantum numbers leading to incorrect answers. The candidate scored a zero mark.

The candidates who scored high marks were able to arrange the colours of the visible spectrum in order of increasing wavelength but failed to explain the term frequency of a line referring to prism spectrum hence could not score full mark in part 5 (a). Some candidates were able to calculate correctly the number of electrons in a given set of quantum numbers but had difficulties in explaining bonding in silane (SiH_4) in molecular orbital terms. Extract 5.2 shows an example of a good response from the candidates.

Extract 5.2

5@ (i) Violet < blue < green < yellow < red.

ii) Frequency -- is the number of cycles made by light wave per second.

(b) (i) n : 3

l :	0	1			2				
M_l	0	−1	0	1	−2	−1	0	1	2
M_s	$\pm\frac{1}{2}$	$\pm\frac{1}{2}$	$\pm\frac{1}{2}$	$\pm\frac{1}{2}$	$\pm\frac{1}{2}$	$\pm\frac{1}{2}$	$\pm\frac{1}{2}$	$\pm\frac{1}{2}$	$\pm\frac{1}{2}$

∴ There are 18 electrons in $n=3$.

b $n = 3$

$l = 2$

$M_l = -2, -1, 0, 1, 2.$

$M_s = \pm\frac{1}{2}\ \pm\frac{1}{2}\ \pm\frac{1}{2}\ \pm\frac{1}{2}\ \pm\frac{1}{2}$

∴ There are 10 electrons in $n=3, l=2$.

$M_l = 0$

$M_s = \pm\frac{1}{2}$

∴ There are two electrons in $M_l = 0$.

5(b)(i) $n = 2$

$l = 1$

$M_l = -1$

$s = \frac{1}{2}$

∴ There ~~are~~ is 1 electron in $n=2, l=1, M_l=-1$ $s=\frac{1}{2}$.

(ii) Structure of Si.

$_{14}Si$ = [Ne]

2S	2P		
↿⇂	1	1	

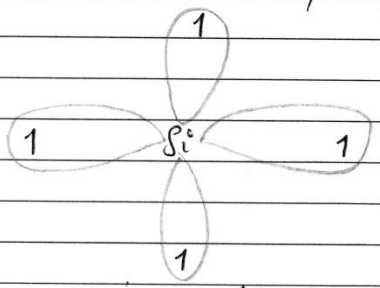
at excitation

$2SP^3$ - hybridized

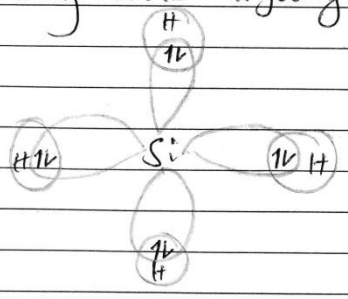
= [Ne]

1	1	1	1

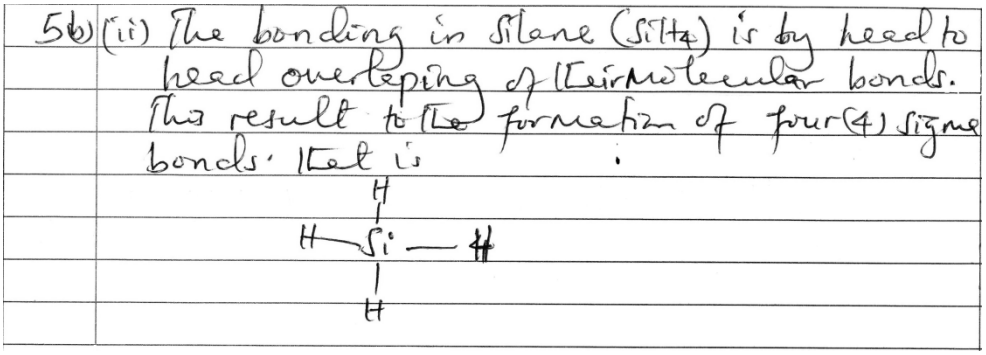
Molecular orbitals of Si.



bonding with ~~Hydrogen~~. Four hydrogens.



⟶ SiH_4.



In extract 5.2, the candidate arranged correctly the coloured light in order of increasing wavelength but he/she could not exactly explain the term frequency with reference to prism spectrometer. He/she managed to do the rest part of the question correctly. The candidate was awarded 9 marks.

2.1.6 Question 6: Two Liquids Components

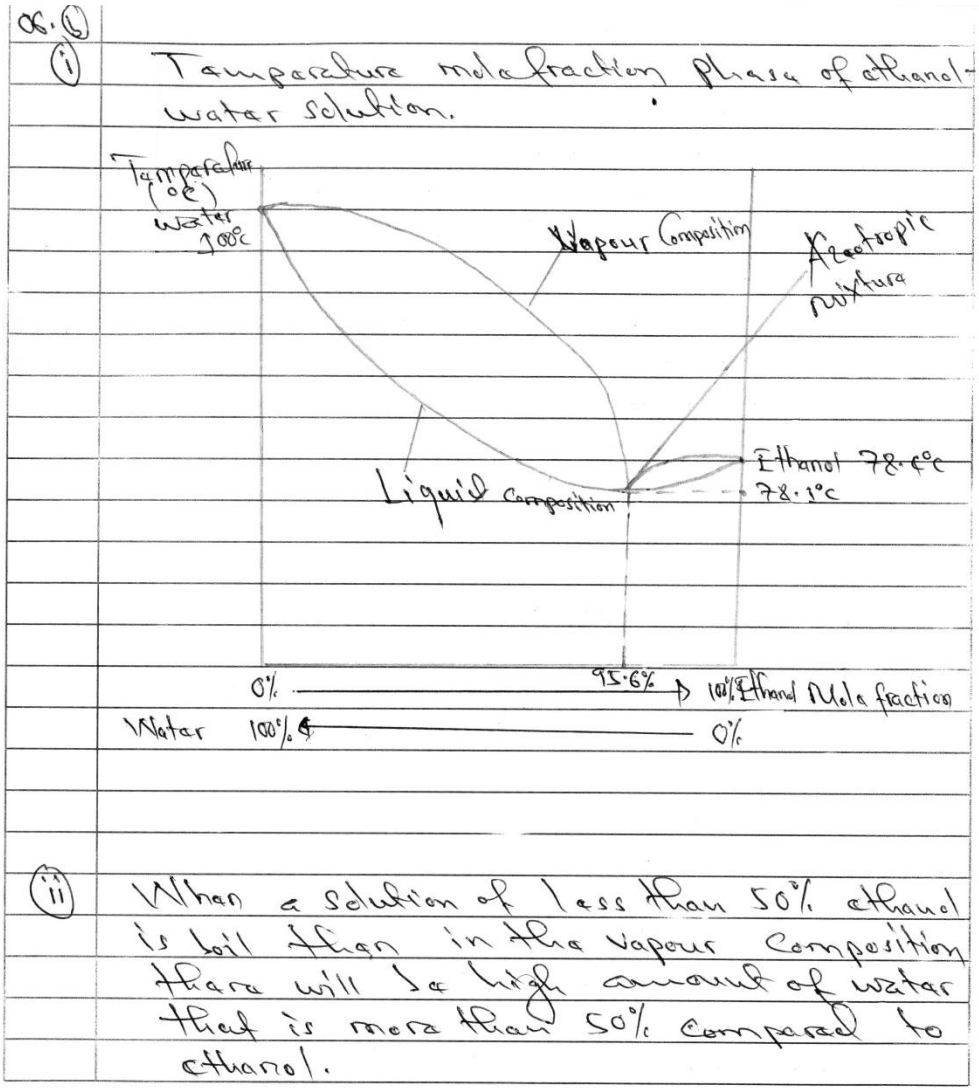
In part (a) of this question the candidates were required to calculate the approximate molecular mass of solute in a solution which is prepared from 90g of water and 10.6g of a non-volatile, non-dissociating solute given that the vapour pressure of the solution at 60 ºC is 18.91 x 10^3 Nm $^{-2}$ and that of water at the same temperature is 19.92 Nm^{-2}. In part (b), the candidates were required to draw a temperature-mole fraction phase diagram of ethanol – water solution and explain what would happen when a solution of less than 50% ethanol is boiled from the information that *Ethanol and water form an azeotropic mixture which boils at 78.1ºC with 95.6% ethanol given that the boiling points of pure ethanol and water are 78.4 ºC and 100 ºC respectively*.

The candidates who opted for this question were 9,583 (59.3%) out of which 43.3 percent scored 0 to 2.5 marks of which 8 percent scored a 0 mark. 42.4 percent scored 3 to 5 marks whereas 21 percent scored 5 to 10 marks with 0.1 percent scoring all 10 marks allocated for the question. This performance indicates an average performance for this question.

The candidates who scored high marks had sufficient knowledge on the stated items as shown in extract 6.1. The candidates managed to calculate molar mass of the solute from change of vapour pressure and masses of solute and solvents, drawing temperature – mole fraction phase diagram of

ethanol – water solution from the given parameters and explained what happens when a solution of less than 50% ethanol is boiled.

Extract 6.1

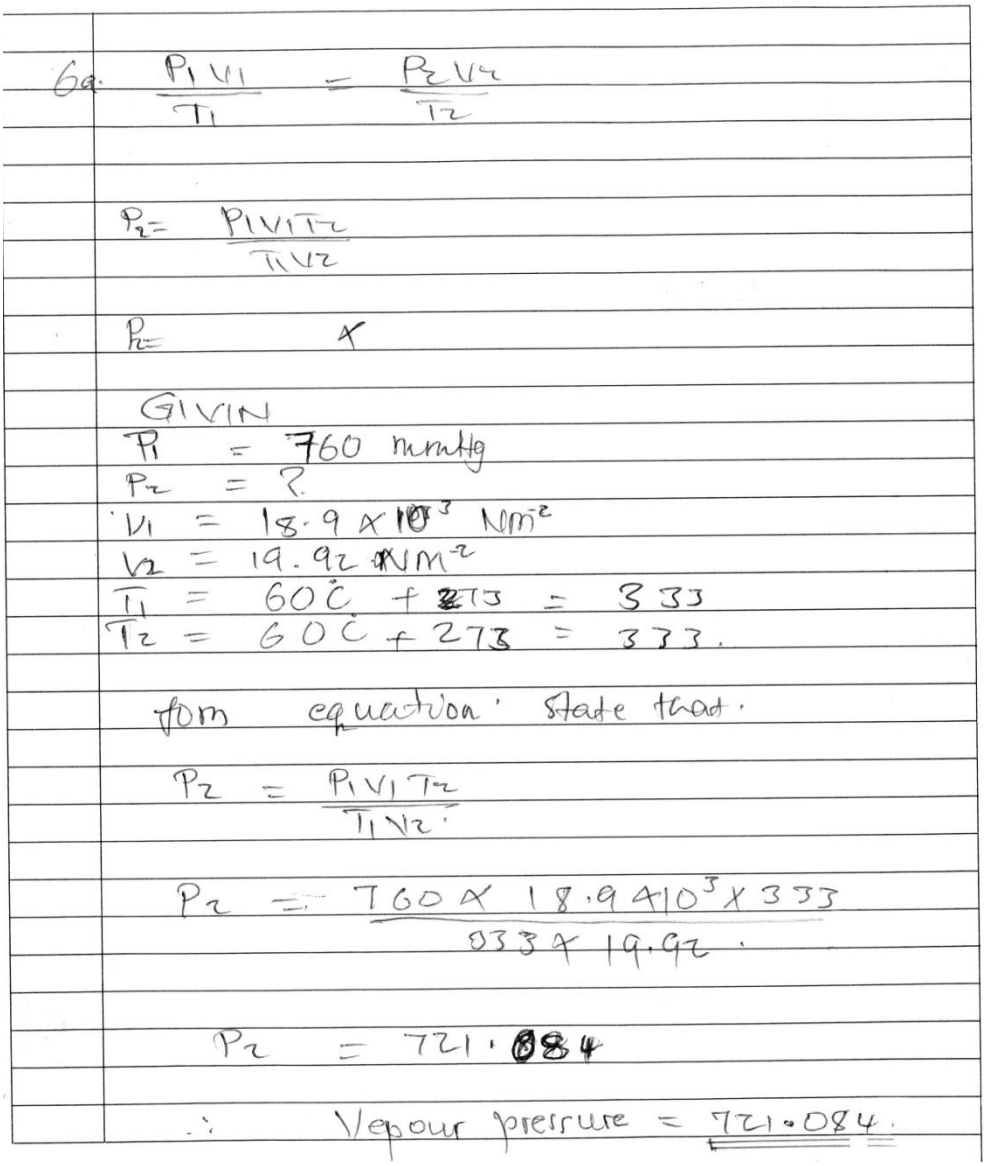


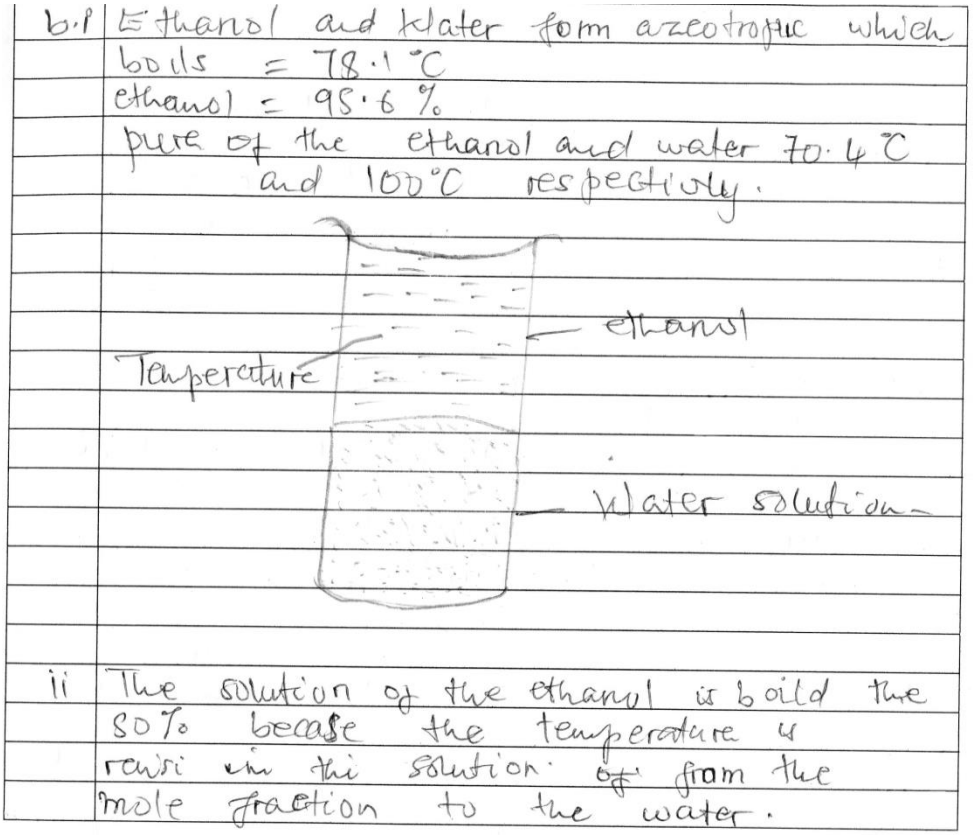
Extract 6.1, is a response to part 6 (b) from one of the candidate. The candidate managed to draw temperature – mole fraction phase diagram of ethanol – water solution and explained appropriately that the distillate will be rich in water and less rich in ethanol when a solution of less than 50% ethanol is boiled.

A few candidates with low marks had inadequate knowledge about vapour pressure -mole fraction relationship. They could not perform any calculation demanded by the question and could not draw the phase diagram required.

Furthermore, some candidates confused temperature composition phase diagram for the vapour pressure composition graph. Similarly, other candidates were not aware of the relationship on the increase of mole fraction towards purity of the substance as well as determination of distillate composition upon distillation of the mixture that deviate from ideal behaviour. This indicates lack of knowledge on different phase diagrams which differentiate ideal from non-ideal behaviour. Extract 6.2 illustrates an example of a poor response.

Extract 6.2





Extract 6.2 shows that, the candidate used the general gas equation to calculate the approximate molecular mass of the solute from the given vapour pressure of water instead of using vapour pressure formula. Similarly, he/she drew a diagram of immiscible liquids instead of temperature – mole fraction phase diagram.

2.1.7 Question 7: Energetics

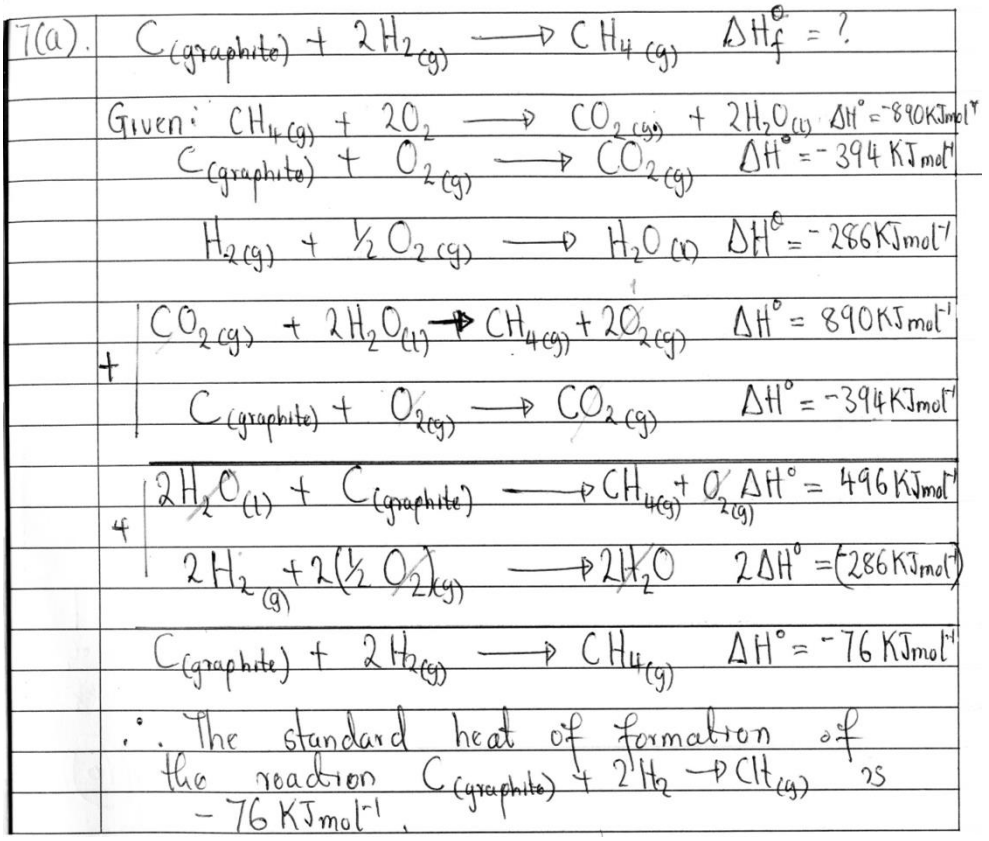
The question demanded the candidates to calculate the standard heat of formation of the reaction, $C_{(graphite)} + 2H_{2(g)} \rightarrow CH_{4(g)}$ having provided with heat of combustion of methane (-890 $kJmol^{-1}$), heat of combustion of carbon (-394 $kJmol^{-1}$) and heat of combustion of hydrogen (-286 $kJmol^{-1}$). They were also required to construct a well labeled Born–Haber Cycle for the formation of $NaCl_{(s)}$ having provided with the equation $Na^{+} + \frac{1}{2}Cl_{2(g)} \rightarrow NaCl_{(s)}$ $\Delta H^{o}f = -411 kJmol^{-1}$.

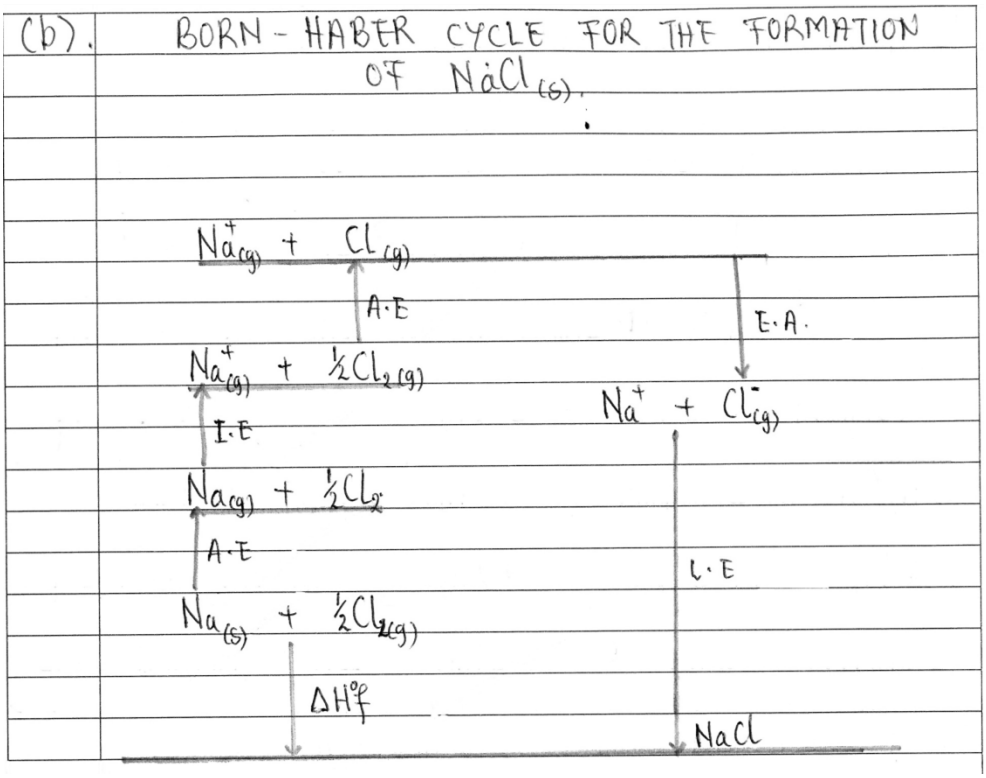
The question was attempted by majority of the candidates (92.4%) and out of which 4.3 percent scored 0 to 2.5 marks and 6.0 percent scored 3 to 4.5

marks. Many (89.7%) scored 5 to 10 marks of which 12.1 percent scored all the 10 marks signifying that the performance on this question was good.

The candidates who scored high marks seemed to master the question's subject matter as they calculated well the heat of formation of methane using Hess's law and constructed a well labelled Born-Haber Cycle for the formation of $NaCl_{(s)}$ from the given parameters. Extract 7.1 shows an example of good responses from the candidates.

Extract 7.1

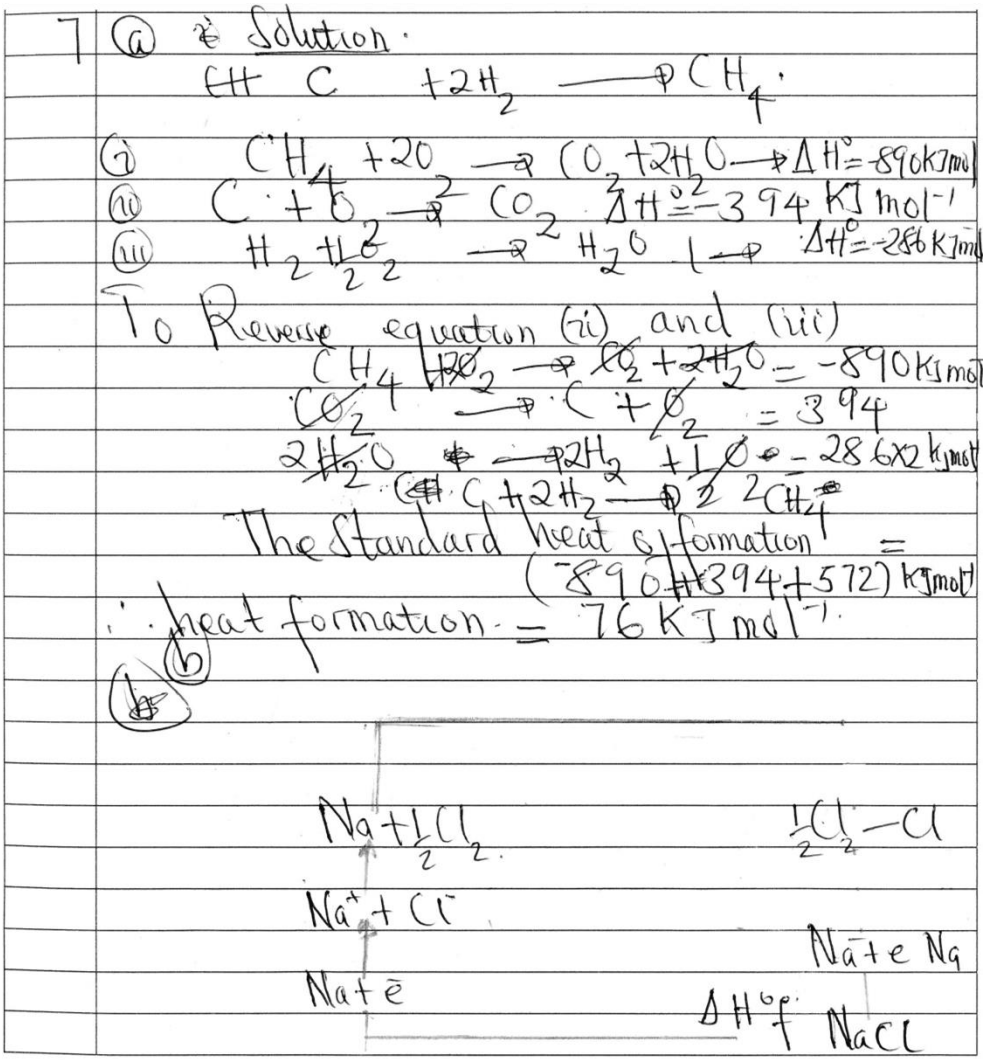




In extract 7.1 the candidate calculated correctly the standard heat of formation of methane from the given data and constructed a well labelled Born Haber Cycle for the formation of $NaCl_{(s)}$.

The candidates who scored low marks showed the evidences of lacking knowledge in the subject as they could not calculate the heat of formation of methane and could hardly draw a Born Haber Cycle. Other reasons that could be the cause were: lack of knowledge on calculations of enthalpy based on combustion data; wrong copying of the equation as realised from a candidate who wrote an unbalanced equation for the calculations of standard heat of formation of methane as $C_{(s)} + H_{2(g)} \rightarrow CH_{4(g)}$ instead of $C_{(s)} + 2H_{2(g)} \rightarrow CH_{4(g)}$ which causes wrong calculations on heat of formation of methane. This implies that they had little knowledge on calculations of enthalpy based on combustion data and thermochemical equations. Extract 7.2 illustrates a poor response to the question from one of the candidates.

Extract 7.2



In extract 7.2 the candidate showed incompetence in calculations using Hess's law as she/he failed to calculate the heat of formation of methane and did not even construct correctly the Born Haber Cycle.

2.1.8 Question 8: Chemical Equilibrium

In part (a), the candidates were required to observe the equilibrium reaction $2NO_{(g)} + O_{2(g)} \rightleftharpoons 2NO_{2(g)}$ ΔH^o = - 115kJ (left to right) established in a closed vessel at a fixed temperature given that the equilibrium constant has a value of 15 $mol^{-1}l$. They were then asked to write an expression for the equilibrium constant K, explain what does the magnitude of K indicate and the effect on the value of K if the temperature is increased giving reason for their answer. Furthermore, they were required to calculate the equilibrium

concentration of NO_2 when the equilibrium concentration of NO and O_2 are both 0.1 mol l^{-1}. In part (b), the candidates were provided the equilibrium equation; $\text{Acid} + \text{Alcohol} \rightleftharpoons \text{Ester} + \text{Water}$ with the value of K equal to 1. They were then required to: predict the maximum yield of ester under the given value of K and give reason as to why this yield might not be achieved in practice; explain with reasons whether or not the addition of a catalyst would increase the yield of ester and to comment on the statement that, *Increasing the concentration of alcohol in the reaction mixture would increase the yield of ester by altering the value of K*.

Many candidates (71.3%) opted for this question of which 17.9 percent scored 0 to 2.5 marks whereby 1.2 percent of them scored 0 marks. 54 percent of the candidates scored 3 to 5 marks and 28.1 scored above 5 marks. This trend shows that the performance of the candidates was good.

The candidates who performed well were able to write properly the expression for equilibrium constant K and supported with reasons, and calculated correctly the concentration of NO and O_2. They predicted correctly the maximum yield of ester under the given value of K and gave reasons as to why the yield can't be achieved in practice. Not only that, they stated with reasons whether or not the addition of catalyst will increase the yield of ester. They were also able to comment that K is a constant at a fixed temperature and altering the alcohol concentration will not change the value of K. It will, however, increase the yield of the ester as the forward reaction will increase. Extract 8.1 shows one of the good answers from one of the candidates.

Extract 8.1

8(a) Given the equation at equilibrium

$$2NO_{(g)} + O_{2(g)} \rightleftharpoons 2NO_{2(g)} \quad \Delta H^\circ = -115\ kJ$$

i/ An expression for an equilibrium constant, K

Rate $\propto [NO_2] \propto [NO][O_2]$

Rate $= K_1[NO_2] = K_2[NO][O_2]$ at equilibrium

$$\frac{K_1}{K_2} = \frac{[NO_2]}{[NO][O_2]}$$

$$K_c = \frac{[NO_2]}{[NO][O_2]}$$

For this Reaction

$$K_c = \frac{[NO_2]^2}{[NO]^2[O_2]}$$ Ans

8(a) ii/ The magnitude of K indicates the rate of the reaction at the equilibrium point. The higher value of K indicating that the reaction goes more forward than backward and the lower value of K indicating the reaction goes more backward than forward. But when the value of K is maintained as most constant that shows the rate of forward and backward reaction is equal.

iii/ If the temperature is increased the value of K will be reduced, the value of K will decrease.

The reaction is exothermic one as it ~~absorbs~~ radiates heat ~~from~~ the surroundings thus backward reaction will be favoured.

8(a) iii/ Given: $[O_2] = 0.1\ mol\ l^{-1}$

$[NO] = 0.1\ mol\ l^{-1}$

$K_c = 15\ mol^{-1}\ l$

$[NO_2] = ?$

from

$$K = \frac{[NO_2]^2}{[NO]^2[O_2]}$$

$$[NO_2]^2 = K[NO]^2[O_2]$$

$$[NO_2]^2 = (15\ mol^{-1}\ l) \times (0.1\ mol\ l^{-1})^2 \times (0.1\ mol\ l^{-1})$$

8(a) iv/ $[NO_2]^2 = 15 \times 0.1 \times 0.1 \times 0.1\ (mol\ l^{-1})^2$

$\sqrt{[NO_2]^2} = \sqrt{0.015}$

$[NO_2] = 0.123\ mol\ l^{-1}$

∴ The equilibrium concentration of NO_2 is $0.123\ mol\ l^{-1}$

8(b) ii/ Addition of catalyst will not increase the yield of ester.

The catalyst has the only purpose of accelerating the reaction, it only increase the rate of reaction but not concentration. The yield of ester depends upon the concentration of the reactants but not the ~~effect~~ rate of reaction which affected by the catalyst.

iii/ Increasing the concentration of alcohol in the reaction mixture would increase the yield of ester but not by affering the value of K. The value K is governed or depends on the concentration of ester but not true that yield of ester is depending up on the value of K.

The answers in extract 8.1 are an indication that the candidate had clear knowledge on Chemical Equilibrium as all parts of the question are systematically and correctly presented.

Candidates who performed poorly in this question wrote K expression with stoichiometric coefficients being considered as a part and parcel of concentration which was wrong concept. Some gave Kc expression as $K = \frac{[2NO_2]}{[2NO\ ]^2[O_2]}$ instead of $K = \frac{[NO_2]^2}{[NO]^2[O_2]}$ as provided in the question which is $2NO + O_2 \rightleftharpoons 2NO_2\ \Delta H\ -115 kJmol^{-1}$ left – right.

Lack of knowledge on simple arithmetical calculations and the subject matter of the topic were also the identified reasons for the poor performance of some candidates in this question. Extract 8.2 presents responses which did not meet the requirement of the question from one of the candidates.

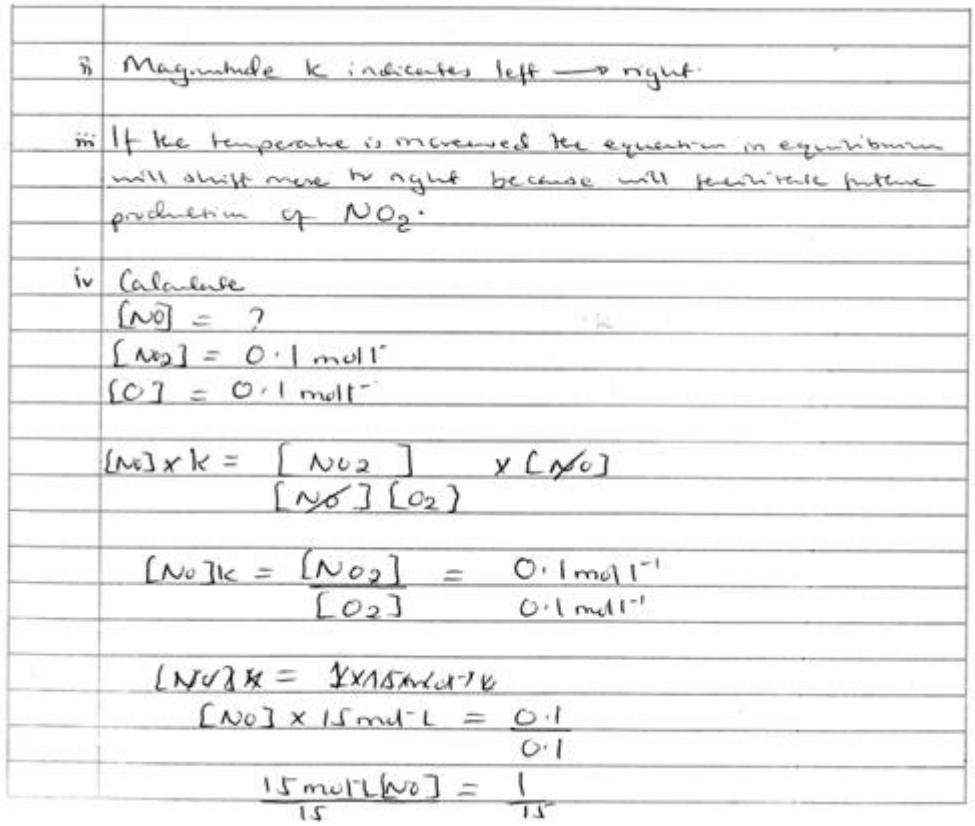
Extract 8:2

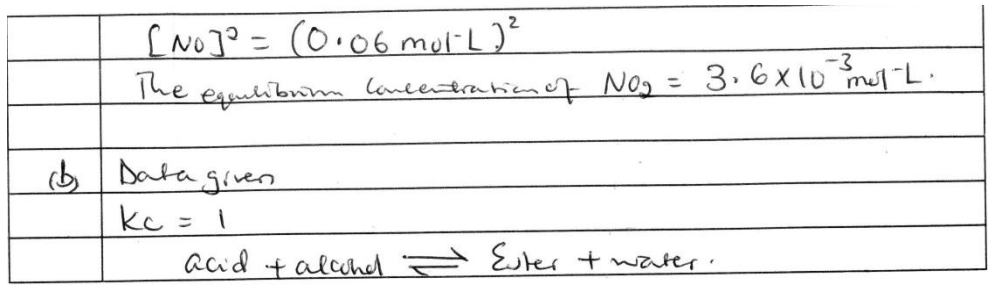
8(a) $2NO_{(g)} + O_{2(g)} \rightleftharpoons 2NO_{2(g)}$ $\Delta H = -115 kJ$ (left → Right)

Expression for equilibrium constant

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

$K = \frac{[2NO_2]}{[2NO][O_2]}$





In extract 8.2 the candidate failed to give correct responses. He/she merely wrote the equilibrium expression but could not use this expression to write correct responses in the preceded questions. She/he ended up copying data for 8 b and left this part unanswered.

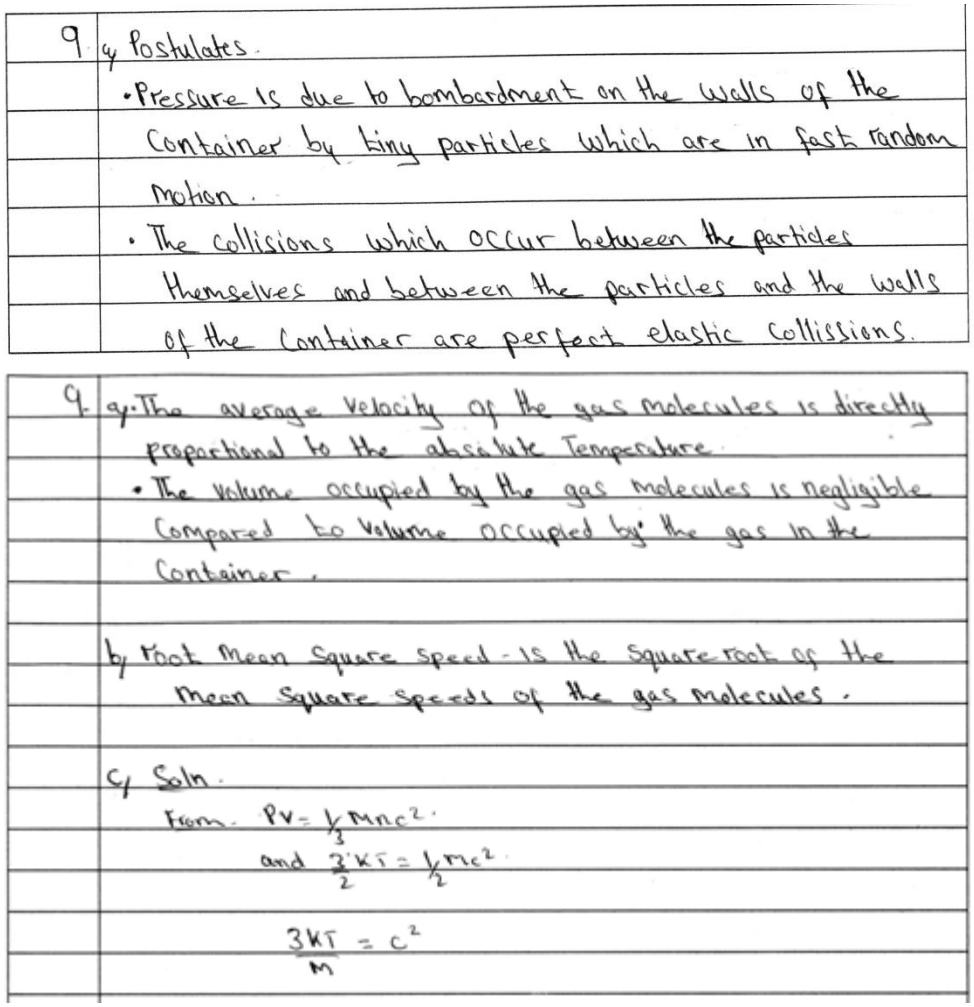
2.1.9 Question 9: Gases

Candidates were required to; state four postulates of the Kinetic theory of gases, define root mean square speed of gas molecules and calculate the root mean square speed of oxygen molecule at the same temperature when the root mean square speed of hydrogen is 1600 m/s.

The question was attempted by a good number of candidates (75.4%) and out of them 19.6 percent scored 0 to 2.5 marks and 47.0 percent scored 3 to 5 marks. The percentage of candidates who scored 5.5 to 10 marks was 33.4 with 2.9 percent scoring all 10 marks allocated for this question; a trend that shows a good performance for this question.

The candidates who scored high marks stated correctly the four postulates of the Kinetic theory of gases and defined correctly the root mean square speed of gas molecules. They applied proper formula for calculating root mean square speed and attained to the expected answers as extract 9.1 shows.

Extract 9.1

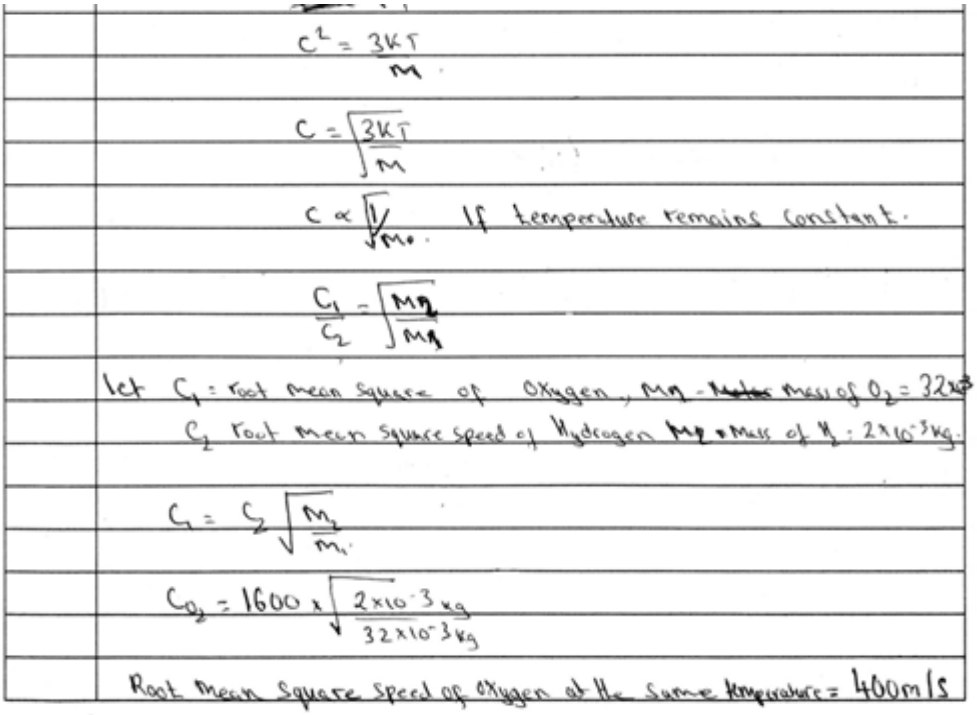

9 a) Postulates.
- Pressure is due to bombardment on the walls of the container by tiny particles which are in fast random motion.
- The collisions which occur between the particles themselves and between the particles and the walls of the container are perfect elastic collisions.

9. a) The average velocity of the gas molecules is directly proportional to the absolute Temperature.
- The volume occupied by the gas molecules is negligible compared to volume occupied by the gas in the container.

b) Root Mean Square speed - is the square root of the mean square speeds of the gas molecules.

c) Soln.
From $PV = \frac{1}{3}Mnc^2$.
and $\frac{3}{2}KT = \frac{1}{2}mc^2$.

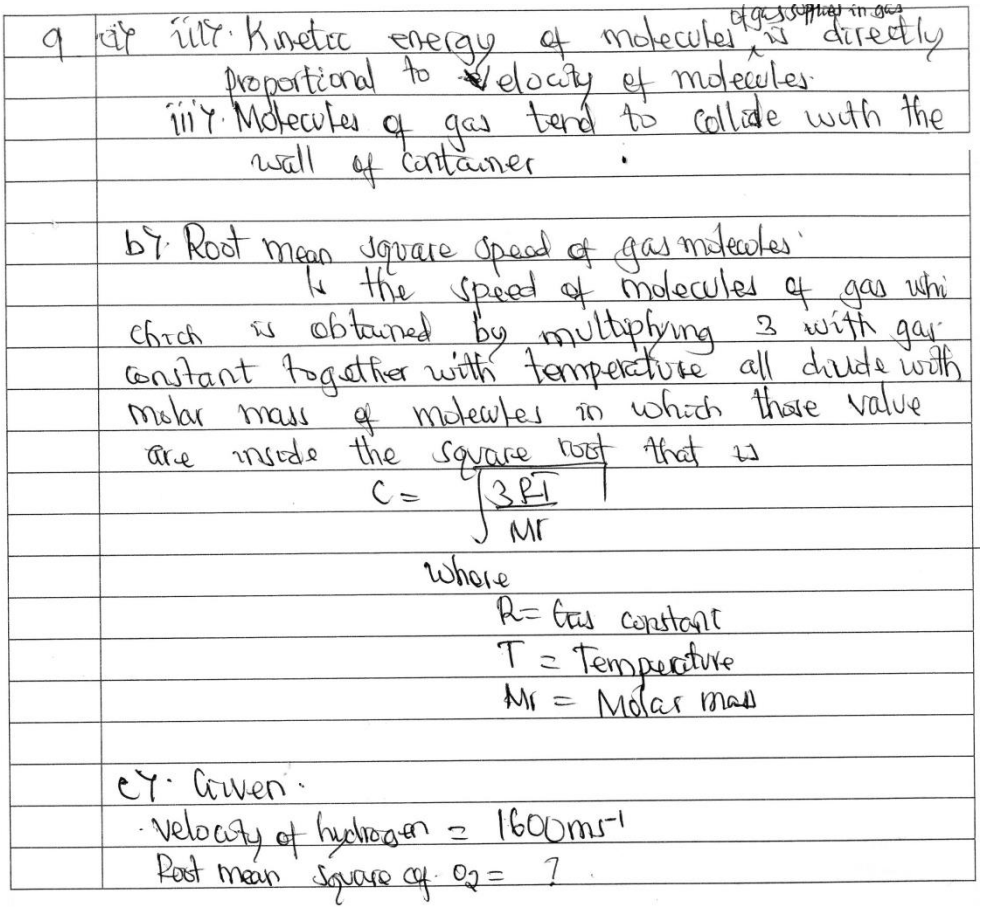
$\frac{3KT}{M} = c^2$



In extract 9.1 the candidate stated correctly the four postulates of the Kinetic theory of gases and defined correctly root mean square speed of gas molecules. Similarly, he/she applied appropriate formula and managed to calculate the root mean square speed of oxygen molecules at the given temperature.

On the other hand, candidates who performed poorly in this question failed to state the postulates of Kinetic theory of gases as well as to apply the correct formula for calculating root mean square speed for gas molecules. For example, some candidates applied the formula $C = \sqrt{\frac{3RT}{Mr}}$ instead of $\overline{C} = \sqrt{\frac{T}{M}}$ which led to the incorrect answer of root mean square speed of oxygen molecule. This indicates that, the candidates had insufficient knowledge on Kinetic theory of gases and the related calculations. Extract 9.2 displays a sample response of a candidate to some parts of the question which show that he/she had insufficient knowledge in this question.

Extract 9.2


9 (a) iii. Kinetic energy of molecules of gas supplied in gas is directly proportional to velocity of molecules.
iii. Molecules of gas tend to collide with the wall of container.

b. Root mean square speed of gas molecules is the speed of molecules of gas which is obtained by multiplying 3 with gas constant together with temperature all divide with molar mass of molecules in which those value are inside the square root that is

$$C = \sqrt{\frac{3RT}{Mr}}$$

Where
R = Gas constant
T = Temperature
Mr = Molar mass

c. Given:
Velocity of hydrogen = $1600ms^{-1}$
Root mean square of O_2 = ?

Extract 9.2, show responses to part of question 9 where the candidate failed to state the postulates of Kinetic theory of gases. She/he was also unable to define root mean square speed of molecules. He/she did not even try to answer part (c) of the question indicating poor mastery of the subject.

2.1.10 Question 10: Chemical Bonding

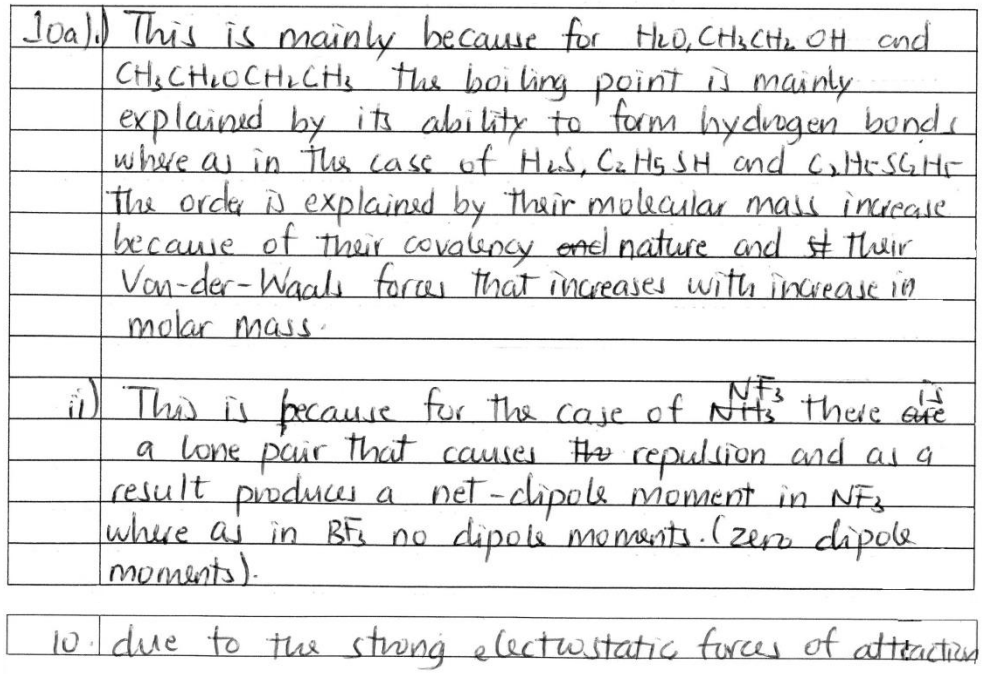
In part (a), the candidates were required to explain with reason the following observations: boiling points of water, ethanol and ethoxyethane are in the reverse order of their relative molecular masses unlike those of their analogous sulphur compounds H_2S, C_2H_5SH and $C_2H_5SC_2H_5$; BF_3 is non-polar but NF_3 is polar and aluminium fluoride has much higher melting point than aluminium chloride. Part (b) required them to; write the electronic configurations of elements X, Y and Z with atomic numbers 9, 19 and 34 respectively, to predict the type of bonding expected on reaction between X and Y; Y and Z and finally, to predict with reasons for relative volatility,

electrical conductance and solubility in water of the compound formed between X and Y compared to that formed between X and Z.

This question was attempted by 50.3 percent of the candidates and out of this 26.1 percent scored 0 to 2.5 marks of which 1.6 percent scored a 0 mark. 34.0 percent scored 3.0 to 4.5 marks whereas 33.7 percent scored 5.0 to 7.5 marks. A few (6.2%) candidate scored 8.0 to 10 marks. Thus, the performance on this question was good.

The candidates who had good performance managed to explain with reasons the listed observations in part (a). They were also able to write the electronic configurations of the given elements and recognised that X and Y form ionic bond whereas X and Z form covalent bond. They also predicted accurately with reasons for the volatility, electrical conductance and solubility in water for the compound formed between X and Y compared to that formed between X and Z. Extract 10.1 represents a sample of a good response from one of the candidates.

Extract 10.1



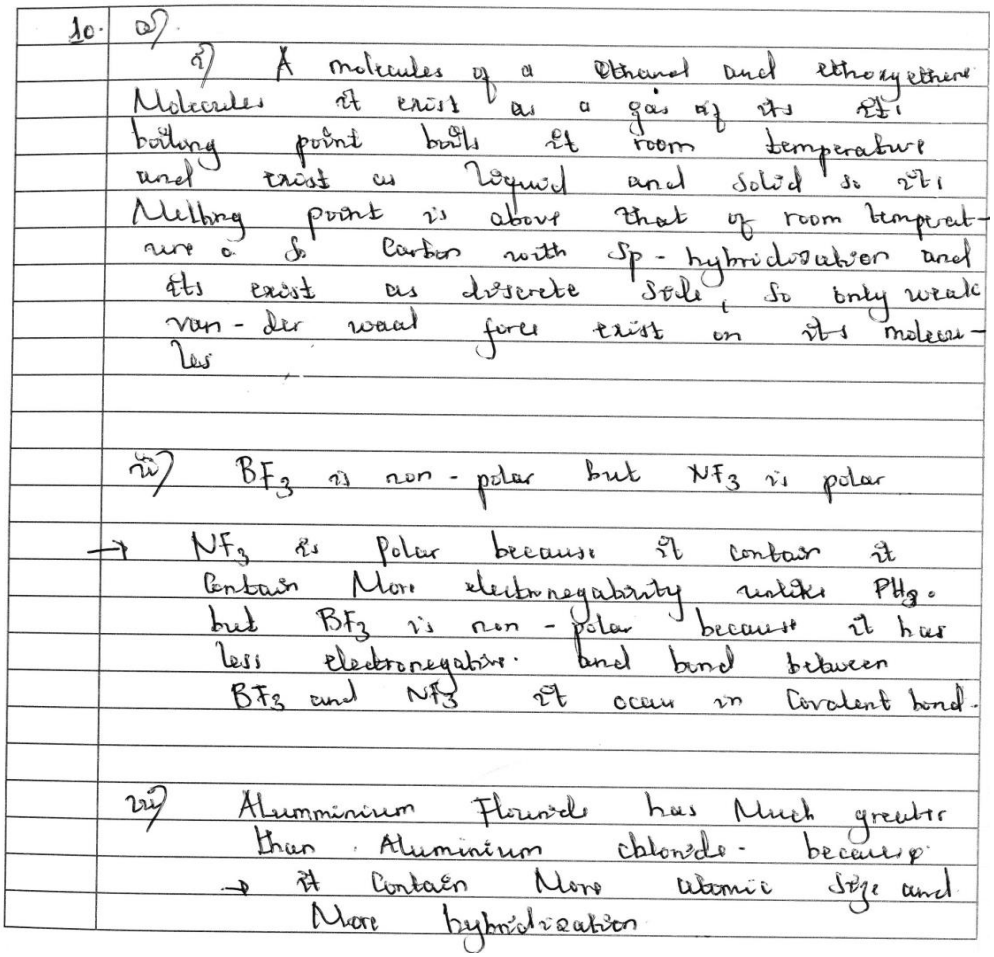
Extract 10.1 is an example of a well presented answer. The candidate managed to give reasons for the given observations, managed to write correct electronic configurations of Z, Y & Z, predicted the types of bonds

and subsequently predicted volatility, electrical conductance and solubility in water of compounds formed between X & Y and between X & Z.

On the contrary, candidates who scored poorly in this question seemed to have insufficient knowledge on bonding and its effects as well as the effect of lone pairs on polarity of a molecule. Also they showed little knowledge on electronic configuration as related to bonding which affects conductance, volatility and solubility of the compounds formed.

The candidates who performed poorly in this question ended up guessing the answers with no reasons. Some candidates completely failed to connect related concepts of bonding and ended with guess work which lead them to meaningless response in 10 (a). Extract 10.2 provides a sample answer to illustrate candidates' answers with a score of zero mark.

Extract 10.2


10. a)

i) A molecules of a Ethanol and ethoxyethane Molecules it exist as a gas of its it boiling point both it room temperature and exist as liquid and solid so its Melting point is above that of room temperature so Carbon with Sp - hybridization and its exist as discrete state, so only weak van - der waal force exist on its molecules

ii) BF_3 is non - polar but NF_3 is polar

→ NF_3 is Polar because it contain it Contain More electronegativity unlike PH_3. but BF_3 is non - polar because it has less electronegative. and bond between BF_3 and NF_3 it occur in Covalent bond.

iii) Aluminium Flouride has Much greater than Aluminium chloride - because

→ it Contain More atomic size and More hybridization

Extract 10.2 shows an example of the candidates' answers to part 10 (a) which completely did not meet the requirement of the question. The candidate failed to give reasons for the boiling point of the first set of oxygen compounds to be in reverse order as opposed to the given sulphur compounds in 10 (a) (i). Moreover, the candidate had problems with language as the sentences are not well constructed to extract the meaning.

2.1.11 Question 11: Aliphatic Hydrocarbons/Aromatic Hydrocarbons

Candidates were required to explain briefly chain reaction, chain initiating step, chain propagation step and chain terminating step in part (a). In part (b), they were required to explain why benzene molecule shows extra stability, the meaning of resonance and how it is applicable in benzene. Finally, they were asked to suggest suitable chemical tests to distinguish between hexane from 2-hexene; propyne from propene and 1-pentyne from 2-pentyne.

A total of 12,447 (77.0%) candidates opted for this question. The candidates who scored 0 to 2.5 marks were 44.5 percent out of which 9.5 scored a 0 mark. On the other hand, 42.8 percent scored 3.0 to 5.0 marks and 12.7 percent scored 5.5 to 10.0 marks. 11 (0.1%) candidates managed to score 9.5 to 10 marks.

The candidates who performed well explained clearly the meaning of chain reaction, chain initiating step, chain propagating step and chain terminating step. They explained correctly why benzene molecule shows extra stability, gave the meaning of resonance and how it is applicable in benzene and correctly distinguished between hexane and 2-hexene, propyne and propene, 1-pentyne and 2-pentyne. Extract 11.1 represents a good response.

Extract 11.1

11(a) i) Chain reaction is the reaction which involve the different steps the formation of the compound such as initiation propagation and termination.

(ii) Chain initiation step is the step in the chain reaction which is responsible for the formation of the chemical/reagent such as free radical, nucleophile or electrophile: $Cl_2 \rightarrow 2Cl^{\circ}$

(iii) Chain propagation is the step in the chain reaction in which the reagent formed from the chain initiation react with the other org compound. example

$CH_4 + Cl^{\circ} \rightarrow CH_3Cl + HCl$

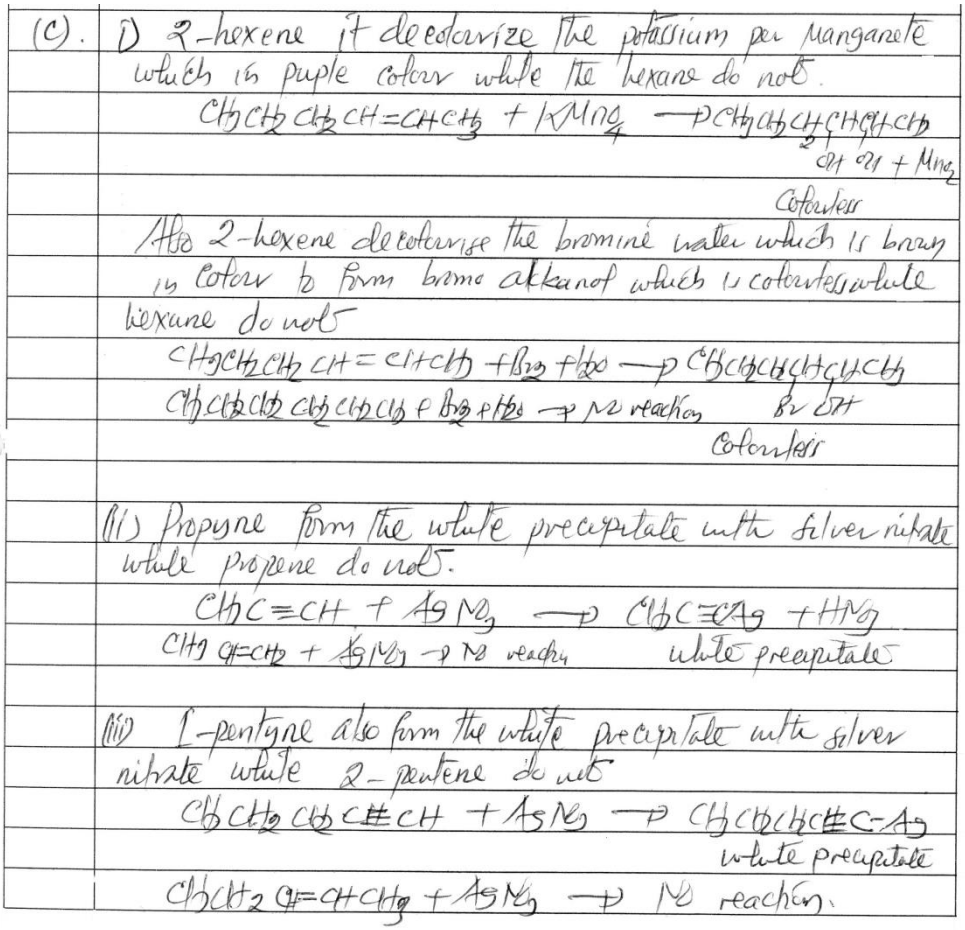
(iv) Chain termination is the chain reaction step at which the propagated molecules is terminated by it either the free radical, nucleophile or electrophile.

(b) (i) The benzene molecule shows extra stability this is due to the delocalization of π-bond which supply the electron and to stabilize the bonds by make the electron to delocalize.

(ii) Resonance is the theory which explain the structure

11(b) and bond of the benzene in which the benzene bond both sigma bond and π-bond have the equal energy and length.

These theory explain that ~~is why~~ the benzene is stable due to the delocalization ~~and~~ use of the π-bond electron that make it to be stable,. Hence Resonance become applicable to benzene due to investigation of its stability.

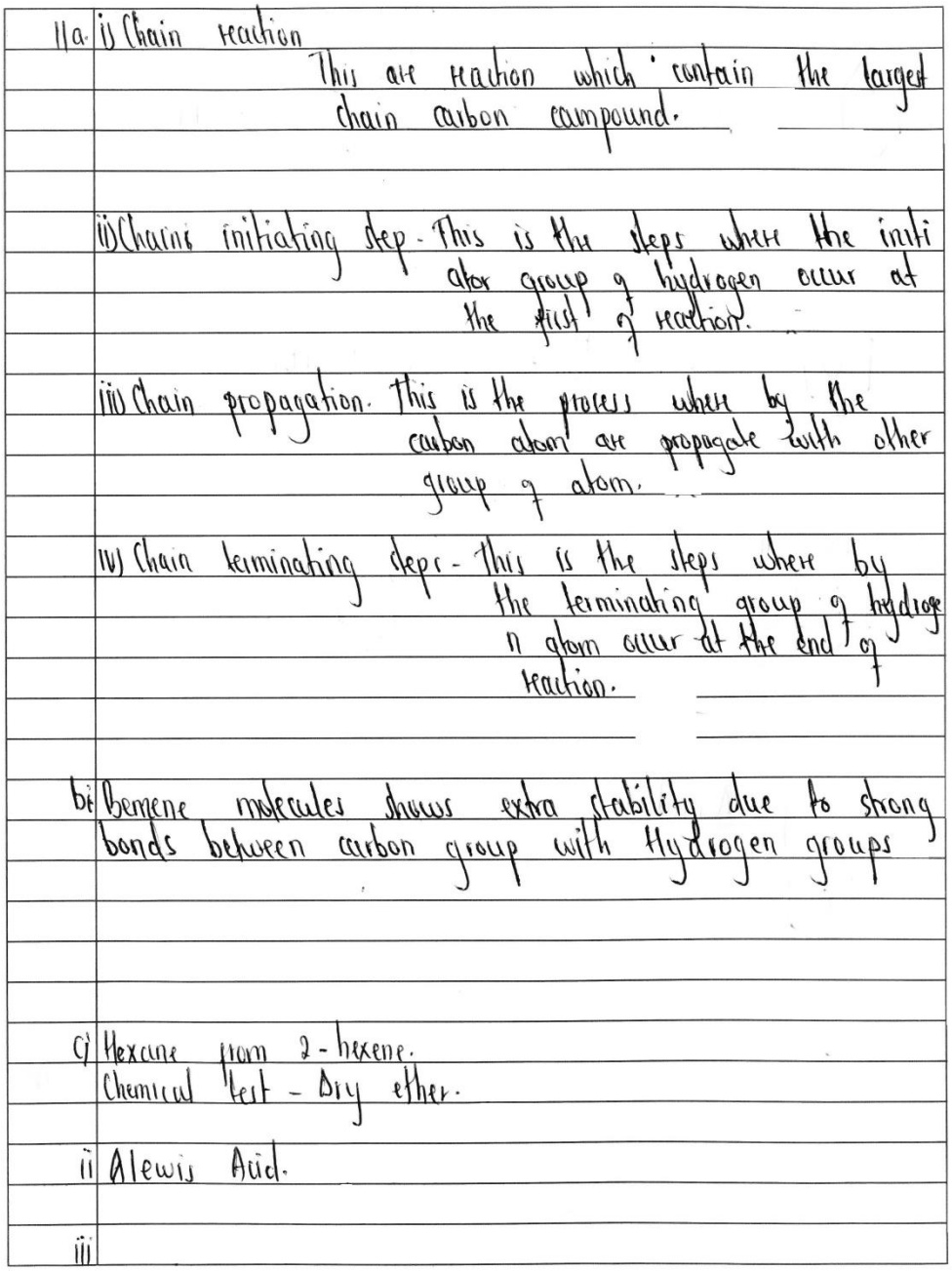


In extract 11.1, the candidate presented the answer precisely according to the requirement of the question. For example, she/he managed to explain the terms in 11(a) properly. In 11 (b), the candidate explained clearly why benzene molecule shows extra stability. However, he/she failed to give the meaning of resonance but managed to explain how resonance is applicable in benzene and in 11(c); she/he was able to suggest suitable chemical tests to distinguish pairs of organic compounds asked.

Few candidates who performed poorly in this question seemed to have insufficient knowledge on the correct definitions of the terms; chain reaction, chain propagation and chain termination steps. Some of them did not understand the meaning of the question, rather than relating the question with polymerization. Nevertheless, candidates failed to understand that distinguishing tests preferred are those which give easily observable results such as appearance or disappearance of colours, smell, formation of precipitates and effervescence. Candidates used ozonolysis reaction to

distinguish alkene from alkane of which has got no significant observable features. Extract 11.2 represents a poor response.

Extract11.2



In extract 11. 2 the candidate presented clearly the answers in each part of the question but all are not correct. For example, he/she gave the definitions which are irrelevant to the asked terms. She/he also

failed to explain the stability of benzene and how resonance is applicable in it. Similarly, he/she distinguished hexane from 2-hexene by dry ether whereas distinguished propene from propyne by Lewis acid which are completely inappropriate.

2.1.12 Question 12: Aromatic Hydrocarbons

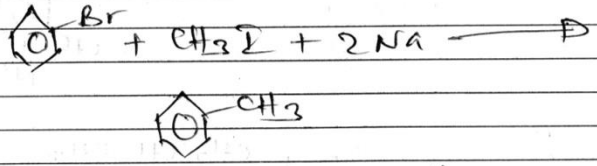
Part (a) required the candidates to give the organic products when: bromobenzene is reacted with iodomethane and sodium metal in dry ether; bromobenzene is reacted with hydrogen gas under platinum catalyst at 200^0C and chlorobenzene is heated in aqueous sodium hydroxide at 360 ºC and 150 atmospheres, then followed by addition of dil. HCl. In part (b) they were asked to show the mechanism for the nitration of benzene. Part (c) required them to show with the help of chemical equations how the following can be prepared: methylbenzene from benzene; butane from ethane; methylbenzene from ethyne and pentane from pent-3-yne.

This question was opted by majority of the candidates (81.5%). The percentage of the candidates who scored 0 to 2.5 was 35.2 out of which 8.2 percent scored 0 marks. 43.5 percent scored 3.0 to 5.0 marks while 19.8 percent scored 5.5 to 7.5 marks and 1.5 percent scored 8 to 10 marks. These data signify that the question was well performed.

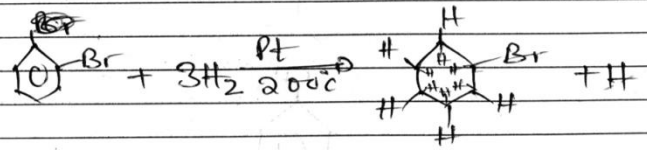
Candidates with high performance managed to give the products of each of the provided chemical reactions. They were also able to show the mechanism for the nitration of benzene. In addition, they managed to perform the conversions of benzene to methylbenzene; ethane to butane; ethyne to methylbenzene and pent-2-yne to pentane as illustrated in extract 12.1.

Extract 12.1

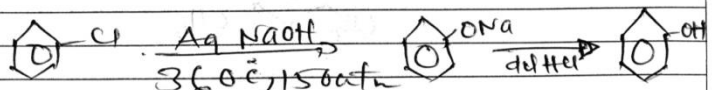
12 (a) (i)



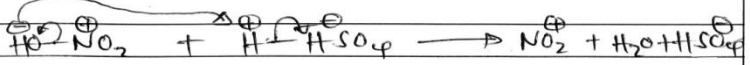
(ii)



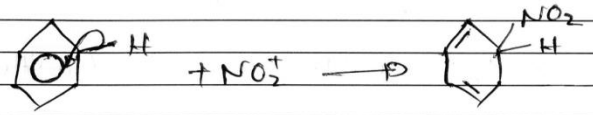
(iii)

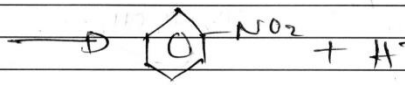


12 (b) (i) Formation of an electrophile that is then attacked.



(ii) Attack of electrophile (NO_2^+) in the ring

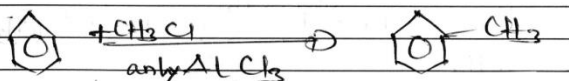




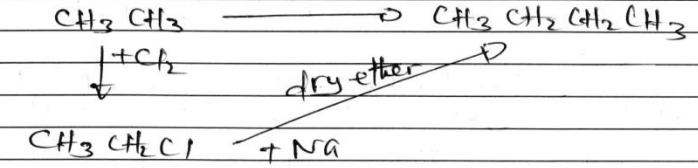
(iii) Regeneration of catalyst (H_2SO_4)

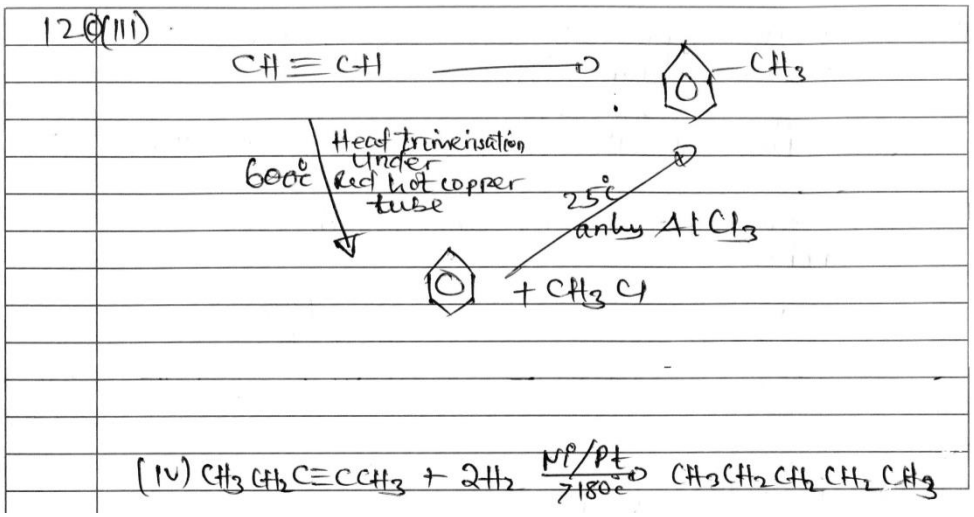
$$HSO_4^- + H^+ \longrightarrow H_2SO_4$$

(c) (i)



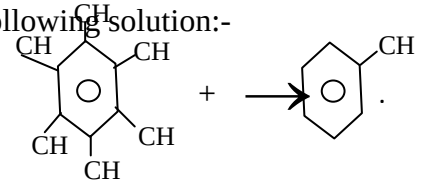
(ii)





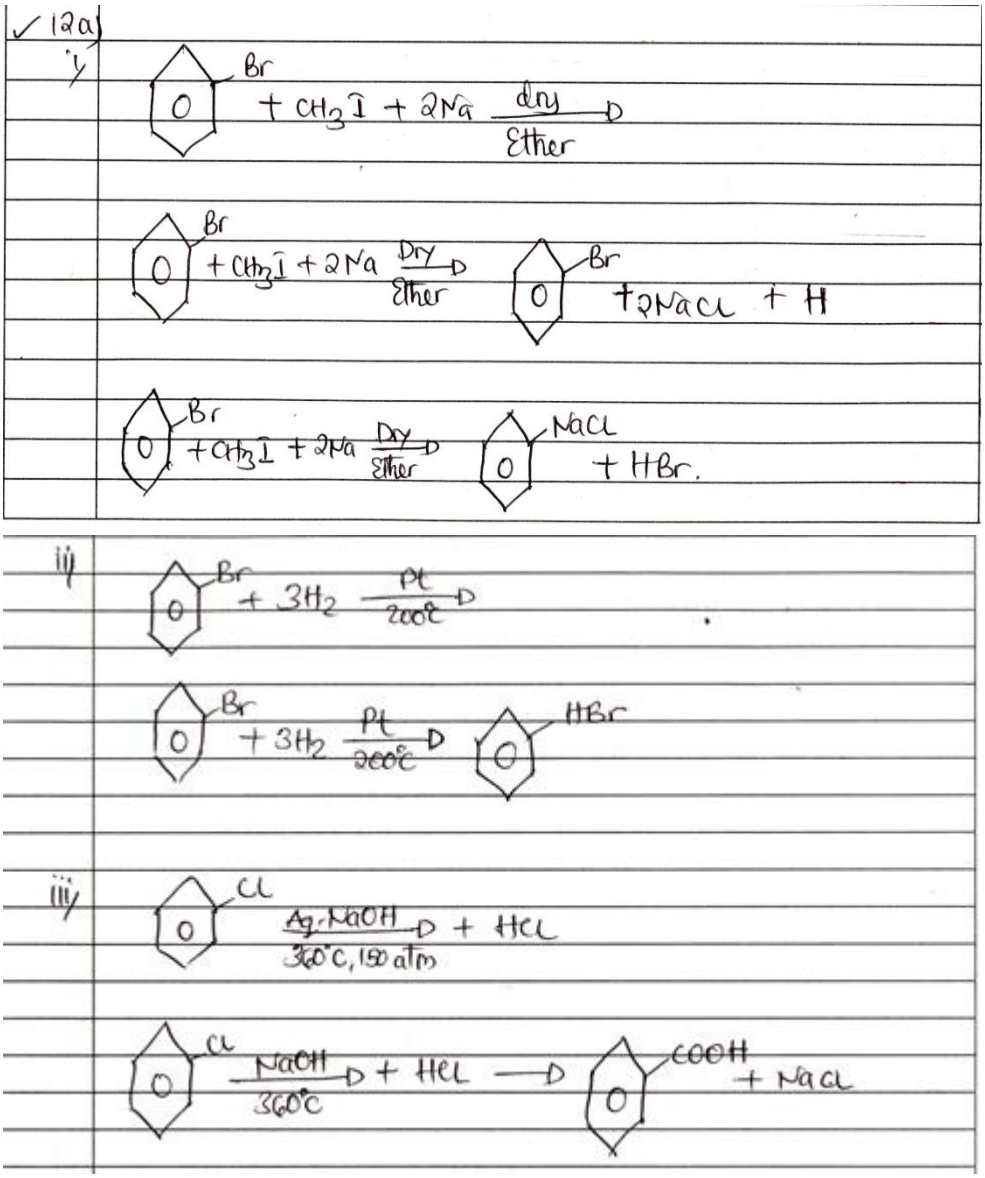
In Extract 12.1, the candidate managed to write the products in each chemical reaction. He/she was able to show the mechanism for the nitration of benzene, also conversant in performing given conversions. The candidate managed to score 9 marks out of 10.

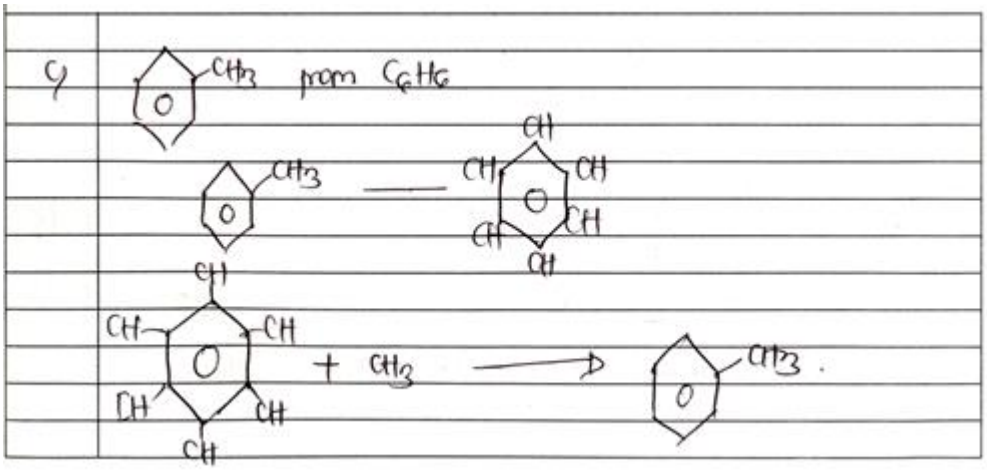
Candidates with low scores failed to give the organic products in the given organic reactions. Not only that, others had no idea about the mechanism of nitration of benzene. Moreover, conversion of benzene to methyl benzene; ethane to butane, ethyne to methyl benzene and pent-2-yne to pentyne was a problem to them. This is because they were unable to understand basic reactions of different functional groups as per advanced level syllabus. Nonetheless, the concept of reaction mechanism was not easy for them to comprehend leading to the observed low score. Apart from the general knowledge of aromatic hydrocarbons some candidates provided responses which seemed to be non-existing. Example, in 12 (c), where they were asked to convert C_6H_6 to methylbenzene, some students came up with the following solution:-

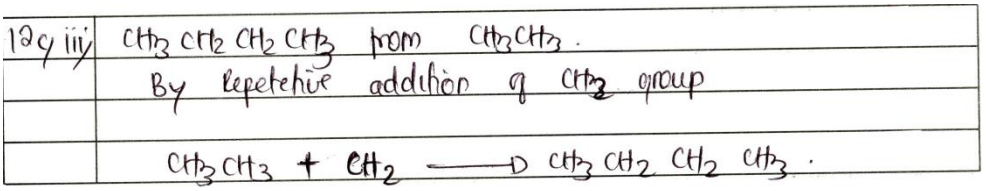


Poor performance in this question was caused by insufficient knowledge of candidates on the items in question. Extract 12.2 shows an example of a response which did not meet the requirement of the question.

Extract 12.2


12a)
i)
Br
+ CH3I + 2Na
dry
Ether
Br
+ CH3I + 2Na
Dry
Ether
Br
+ 2NaCl + H
Br
+ CH3I + 2Na
Dry
Ether
NaCl
+ HBr.
ii)
Br
+ 3H2
Pt
200°C
Br
+ 3H2
Pt
200°C
HBr
iii)
Cl
Ag.NaOH
360°C, 150 atm
+ HCl
Cl
NaOH
360°C
+ HCl
COOH
+ NaCl





In extract 12.2, the candidate did not give the correct products for the given organic reactions. She/he did not attempt part (b) of the question and also failed to show with the help of chemical equation how the given products result from the given substances.

2.1.13 Question 13: Halogen Derivatives of Hydrocarbons

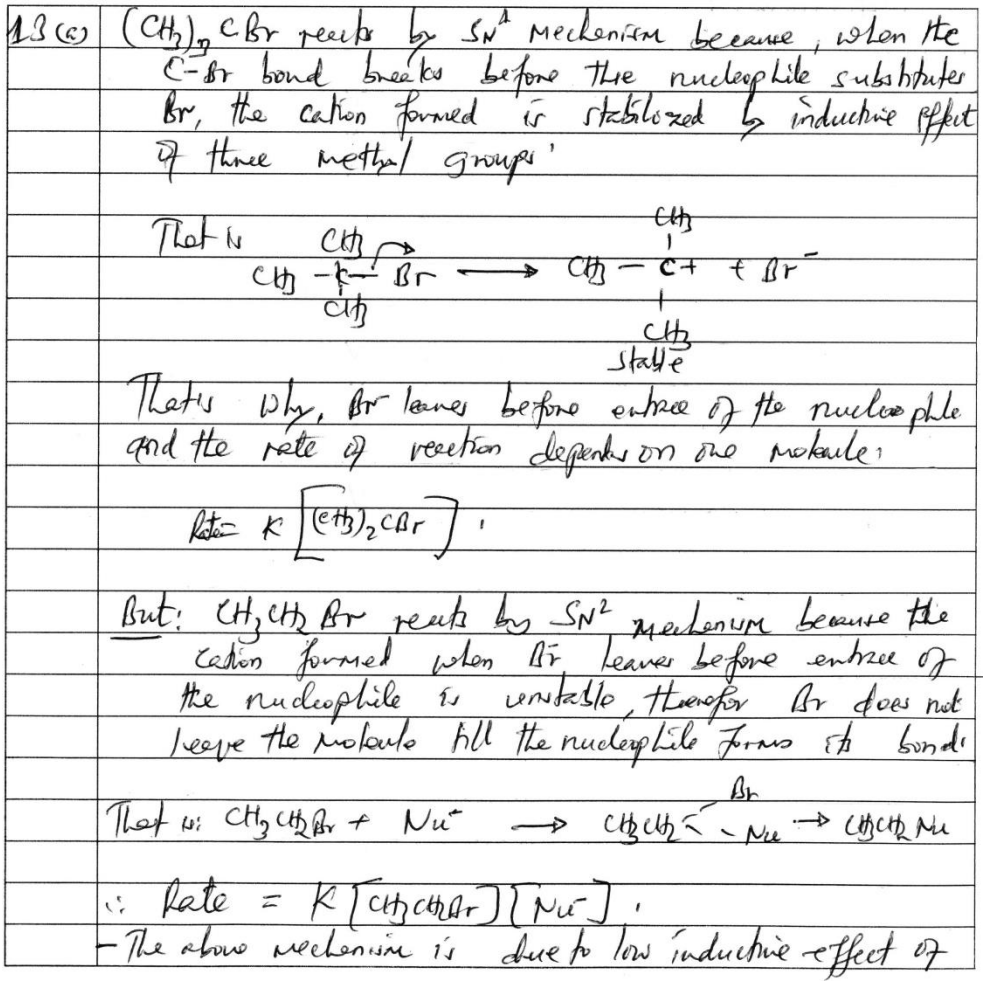
Candidates were asked to explain briefly why $(CH_3)_3CBr$ reacts by SN^1 mechanism while CH_3CH_2Br reacts by SN^2 mechanism. They were also required to explain why nucleophilic substitution reaction of alkyl halide R–X with OH is of the order C – I > C – Br > C – Cl > C – F, and lastly they were required to give all possible isomers of compound $C_5H_{10}Br_2$ and their corresponding IUPAC names.

The question was opted by few (43.6%) candidates out of which 32.6 percent scored 0 to 2.5 marks and of which 10.7 percent scored a 0 mark. Majority (63.9%) scored 3.0 to 6.0 marks whereas a few (3.5%) scored 6.5 to 10 marks with only 0.1 percent scoring all 10 marks for this question. Thus, the performance in this question was good.

Candidates with good performance managed to explain that $(CH_3)_3CBr$ forms tertiary carbonium ion and hence react by SN^1 mechanism while CH_3CH_2Br forms primary carbonium and therefore reacts by SN^2

mechanism. They were also able to explain the ease for the nucleophilic substitution reaction of alkyl halide R–X with OH to follow the trend C–I; C–Br; C–Cl; C–F; and they were able to write enough isomers for the compound $C_5H_{10}Br_2$ and their corresponding IUPAC names. An example of a good response is illustrated by extract 13.1.

Extract 13.1



1.3(a) single ethyl group (CH_3CH_2-).

1.3(b) Given the trend of nucleophilic substitution with OH^-:

$C-I > C-Br > C-Cl > C-F$.

In C–I, Iodide (I^-) ion is easily substituted due to its larger structure and low electronegativity which makes the C–I bond to be weaker than the rest

$\therefore C-I + OH^- \rightarrow C-OH + I^-$ occurs easily

Where, In C–F bond, the substitution reaction with OH^- is difficult due to the smallest structure (size) of Fluorine and high electronegativity which makes the C–F bond to be strong.

1.3(c) Given the compound: $C_5H_{10}Br_{12}$.

(i) first isomer is $CH_3CH_2CH_2\underset{Br}{CH}-\underset{Br}{CH_2}$

1,2-dibromopentane.

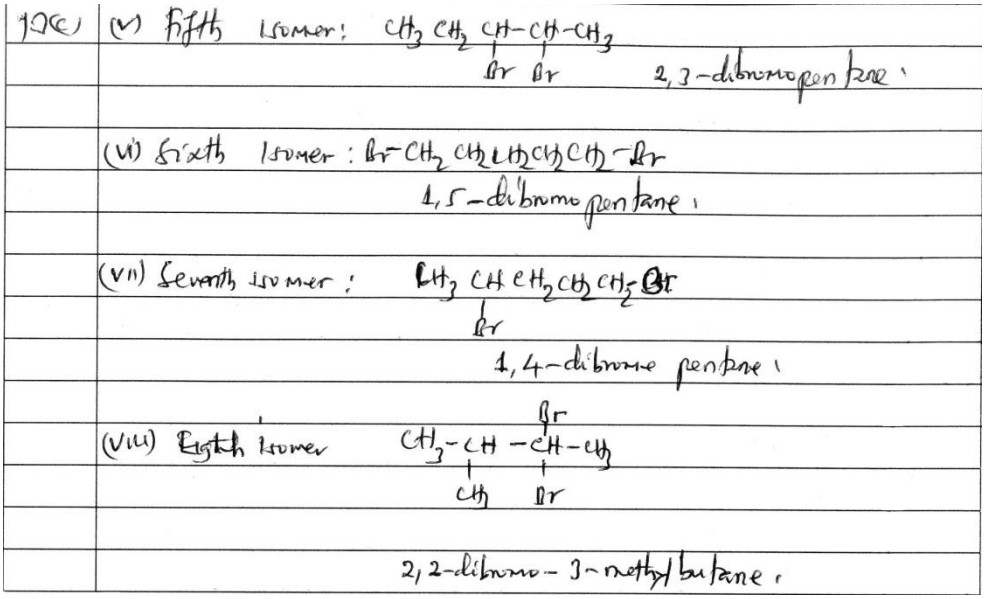
(ii) Second isomer: $CH_3CH_2\underset{Br}{CH}CH_2\underset{Br}{CH_2}$

4,3-dibromopentane.

(iii) Third isomer: $CH_3CH_2CH_2-\underset{Br}{\overset{Br}{C}}-CH_3$

2,2-dibromopentane.

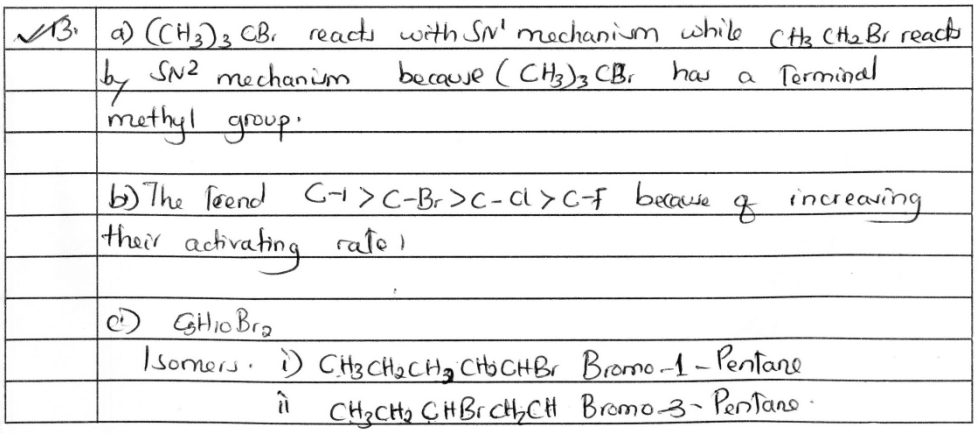
(iv) ~~Third~~ Fourth isomer $CH_3CH_2-\underset{Br}{\overset{Br}{C}}-CH_2CH_3$ 3,3-dibromopentane.



Extract 13.1 shows a well presented answer, the candidate gave correct answers to all parts of the question.

Candidates with poor performance seemed to have no idea about SN^1 and SN^2 mechanisms; as no one approached the right response which was mainly because of stabilization of tertiary carbonium ion whose reaction is unimolecular as opposed to primary carbonium ion whose reaction is bimolecular. These candidates had no clear understanding about electronegativity differences in halogen, that, it follows the order F > Cl > Br > I and also failed to relate electronegativity with bond strength, thus, they could not explain why nucleophilic substitution reaction of alkyl halide R – X with OH is in the given order. For example, one candidate responded to part (b) of the question that the trend follow their activating rate which was wrong response. Most of such candidates were unable to write the isomers of the compound $C_5H_{10}Br_2$ and those who tried had very few responses. This implies that these candidates had poor understanding of the concepts related to the question. Extract 13.2 shows a poor response from one of the candidates.

Extract 13.2



Extract 13.2 shows an example of a response in which the candidate failed to give reasons for $(CH_3)_3CBr$ to react by SN^1 mechanism while CH_3CH_2Br reacts by SN^2 mechanism. He/she was not able to explain the trend of ease for nucleophilic substitution of alkyl halide with OH for the given order. He/she also failed to give a single isomer among 15 possible isomers of $C_5H_{10}Br_2$ and their IUPAC names.

2.1.14 Question 14: Aromatic Hydrocarbons

Part (a) of this question required candidates to state what is ozonolysis. In part (b) they were required to determine the structure of a hydrocarbon having a molar mass of 96 $gmol^{-1}$ and molecular formula C_7H_{12} whose after ozonolysis followed by hydrolysis in the presence of zinc produces ethanol, propanone and glyoxal (H–C(=O)–C(=O)–H).

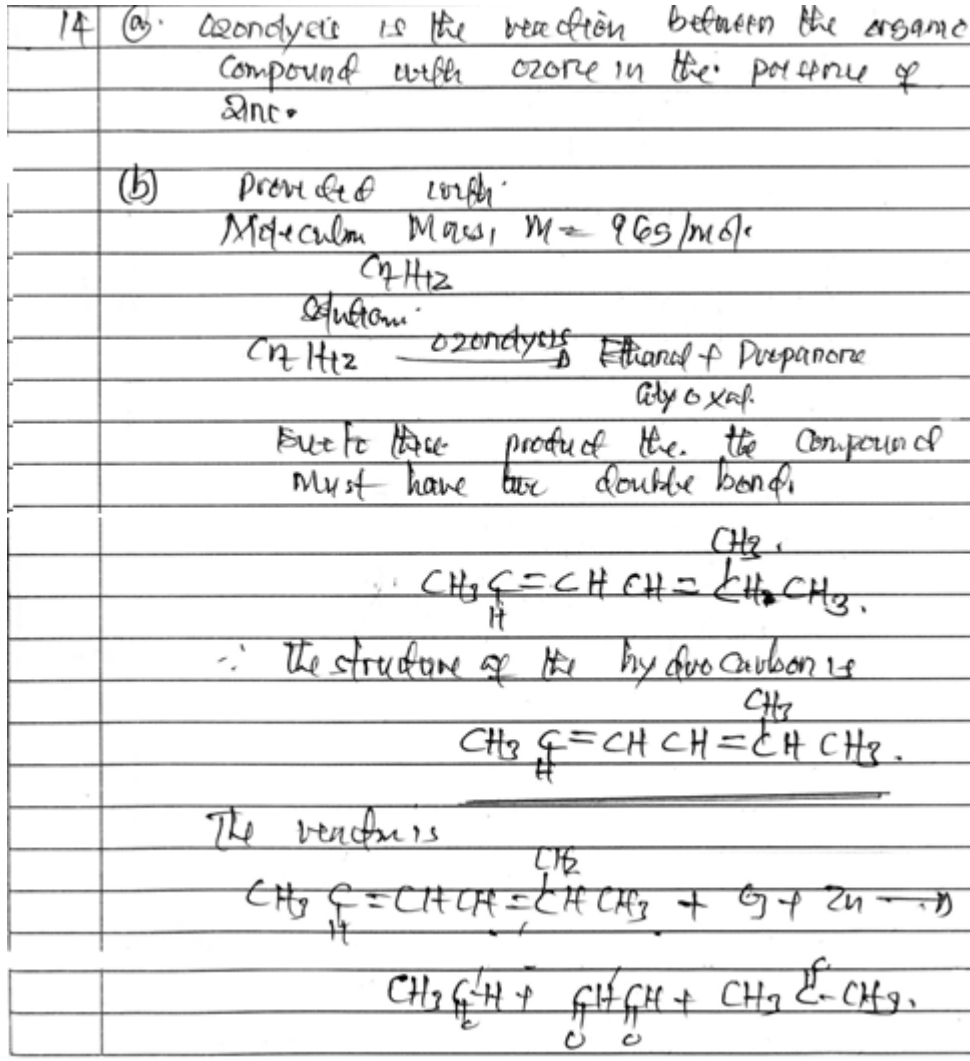
In part (c) they were provided with two isomeric hydrocarbons P and Q which have molecular formula C_9H_{12} where on oxidation of P gives monocarboxylic acid and when treated with soda lime yields benzene. Q oxidized to give tri carboxylic acid and can undergo nitration to give two mono nitro derivatives. They were then required to; write down the structural formula of P and Q, write an equation to show how Q is oxidized to give tricarboxylic acid and to name the compound formed when P undergoes oxidation.

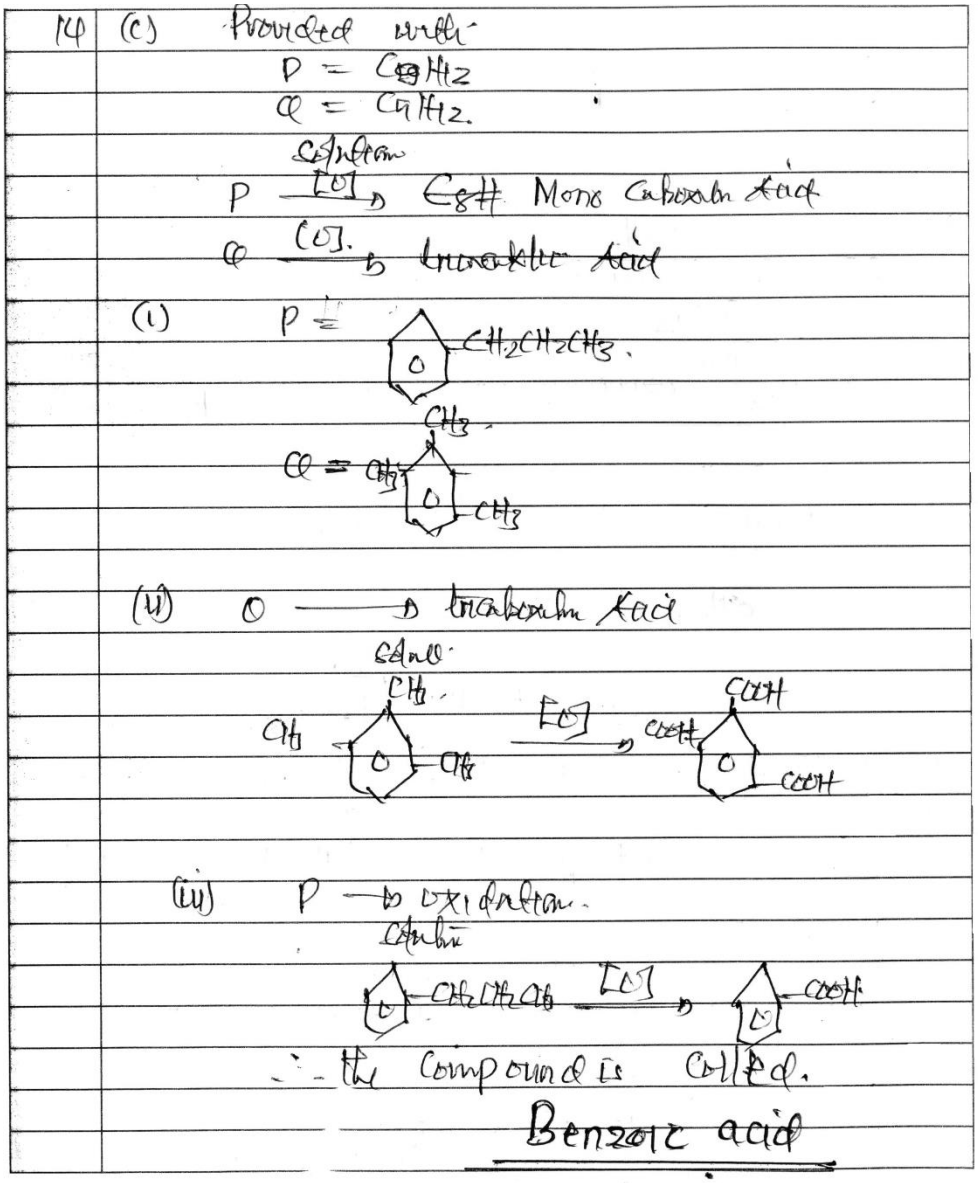
This question was opted by almost half of the candidates (48.3%) and 48.9 percent scored below 3 marks out of which 14.3 percent scored 0 marks. 30.1 percent scored 3.0 to 6.0 percent while 21.0 percent scored above 6.0

marks. The percentage of candidates who managed to score all 10 marks was3.1, indicating a good performance on this question.

Candidates with higher marks were able to define ozonolysis and they were able to determine the required structure of hydrocarbon in part (b). They were also able to write down the structural formula of two isomeric compounds, equation to show the oxidation of Q to carboxylic acid and finally named the compound which is formed when P undergoes oxidation. Extract 14.1 shows a sample of the candidate's good response.

Extract 14.1



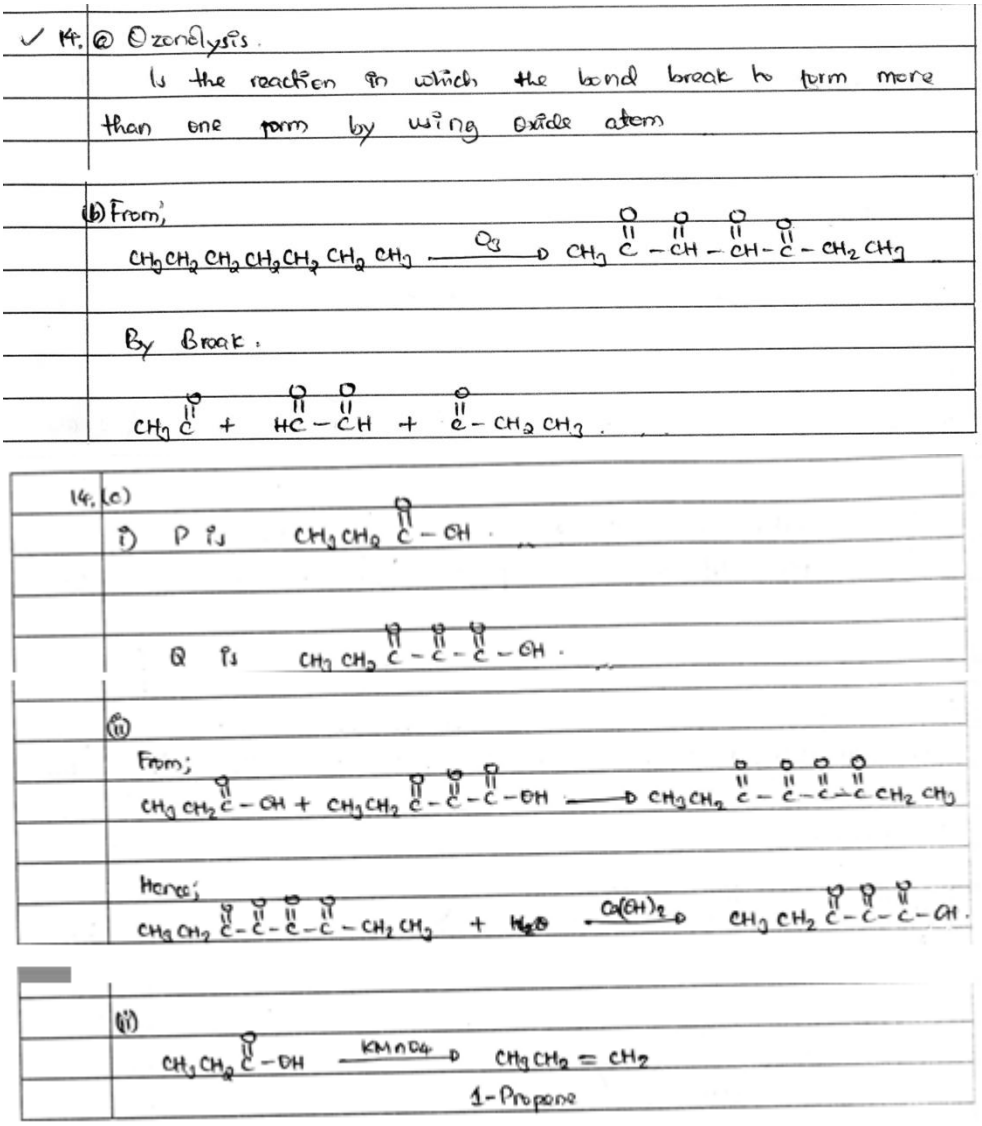


In extract 14. 1 the candidate presented accurate answers clearly and according to the requirement of the question. The candidate defined ozonolysis correctly, determined the structure of the hydrocarbon and showed the ozonolysis as required. He/she was also able to write the structural formula of P and Q and the equation of oxidation of Q to tricarboxylic acid and correctly named the compound which is formed after oxidation of P.

The candidates with lower marks could not define correctly ozonolysis. For example, one candidate regarded ozone as an atom instead of a molecule hence gave a wrong definition. They failed to determine the structure of

hydrocarbon which was ozonolysed to give the products in part (b). In part 14 (c), they could not comprehend from the given information that, P and Q were alkylbenzenes which when oxidized yield acids; therefore, they failed to write the structural formulae of P and Q and the required oxidation equations. Poor performance in this question might have been caused by lack of knowledge on the concepts of ozonolysis, isomerism and oxidation of organic compounds. Extract 14.2 is given as a sample of a poor response.

Extract 14.2



In extract 14.2 the candidate considered the ozone as an oxide atom instead of molecule hence gave incorrect definition of ozonolysis. He/she identified the structures of P and Q to be alcohol and acid respectively instead of alkylbenzenes and hence could not write equation to show oxidation of Q to carboxylic acid.

2.2 132/2-CHEMISTRY 2

2.2.1 Question 1: Electrochemistry

In part (a) of this question, the candidates were required to give a brief explanation of electrochemical series, electrochemical equivalent, redox series and redox reaction. In part (b), the candidates were required to study the given two equations,

$Ni^{2+}_{(aq)} + 2e^- \rightleftharpoons Ni_{(s)}$ $E^O\ Ni^{2+}/Ni_{(s)} = -0.25\,V$

$Zn^{++}_{(aq)} + 2e^- \rightleftharpoons Zn_{(s)}$ $E^O\ Zn^{++}//Zn_{(s)} = -0.76\ V.$

From the equations, they were required to identify by giving reasons the feasible reaction between the reduction of Ni^{2+} by zinc or the reduction of Zn^{2+} by nickel. In addition the candidates were required to draw a cell diagram and finally to calculate the e.m.f of the cell. In part (c), the candidates were required to use oxidation numbers to show the particles which undergone oxidation or reduction in the equation,

$NaOCl \xrightarrow{\Delta} NaClO_3 + 2\,NaCl.$

The question was opted by 58.6 percent of the candidates, out of which 19.7 percent scored below 6 out of 20 marks of which 0.9 percent scored a zero mark. The candidates who scored 6 to 10 marks were 42 percent while 32 percent scored 10.5 to 15 marks. A few (6.3%) candidates scored 15.5 to 20 marks of which 0.1 percent scored all the allocated marks. This trend indicates that, the performance of the candidates in this question was good.

The candidates who performed well in this question were able to give a brief explanation of the terms asked in part 1 (a). They were also able to select with reasons the feasible reaction and wrote a well-balanced redox equation for the selected feasible reaction. Not only that, they managed to draw the cell diagram and calculated the e.m.f of the cell. They were also able to use oxidation numbers to show the particles which had undergone oxidation and those undergone reduction from the given equation. Extract 1.1 illustrate the case.

Extract 1.1

1 (a) i/ Electrochemical series is the arrangement of elements (metals and non-metals) in order of increasing their electrode reduction potential

ii/ Electrochemical equivalent is the mass of the substance produced during electrolysis when a quantity of charge is passed through an electrolyte. Electrochemical equivalent = mass / Quantity of charge

iii/ Redox series is the arrangement of elements in order of their easiness of being reduced or oxidized.

iv/ Redox reaction is the reaction which involve transfer of electrons such that oxidation and reduction occurs simultaneously.

For example

$$MnO_4^- + 5Fe^{2+} + 8H^+ \longrightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$$

(b) i/ The feasible reaction is the reduction of Ni^{2+} by zinc because zinc has lower electrode potential than Nickel, hence zinc is a strong reducing agent reducing $Ni^{2+}_{(aq)}$ to $Ni_{(s)}$.

- Because zinc is a stronger reducing agent it will act as an anode electrode and Nickel as a Cathode electrode, ~~Electrode~~ then $E^{\ominus}_{Ni} - E^{\ominus}_{Zn}$ give a positive value of e.m.f making this form to be feasible reaction.

ii/ At anode

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

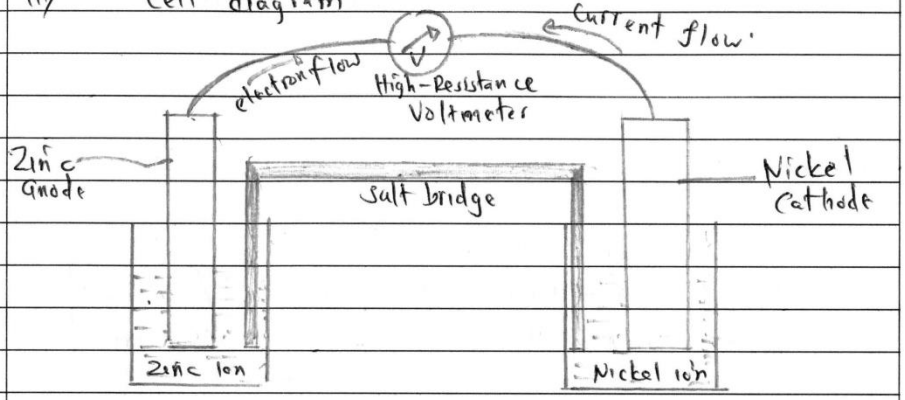
At cathode

$$Ni^{2+}_{(aq)} + 2e^- \longrightarrow Ni_{(s)}.$$

1 (b) ii/ Feasible reaction

$Ni^{2+}_{(aq)} + Zn_{(s)} \longrightarrow Zn^{2+}_{(aq)} + Ni_{(s)}$.

iii/ Cell diagram



iv/ $E.m.f = E^{\theta}_{cathode} - E^{\theta}_{anode}$

$= E^{\theta}_{Nickel} - E^{\theta}_{Zinc}$

$= -0.25V - (-0.76V)$

$= 0.51V$

∴ E.m.f of cell = 0.51V

(c) i/ Oxidation number of Cl in NaOCl

$+1 + (-2) + Cl = 0$

$Cl = +1$

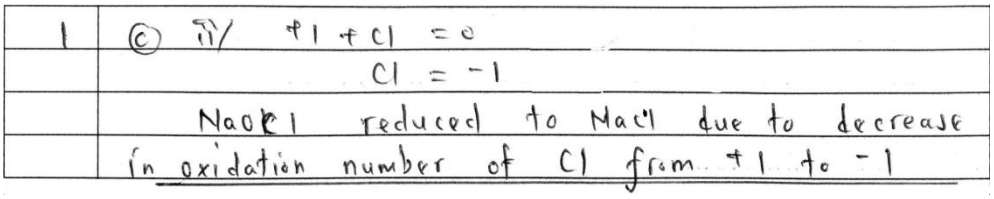
Oxidation number of Cl in $NaClO_3$

$+1 + (-6) + Cl = 0$

$Cl = +5$

∴ NaOCl is oxidized to $NaClO_3$ since the oxidation number of Cl increased from +1 to +5

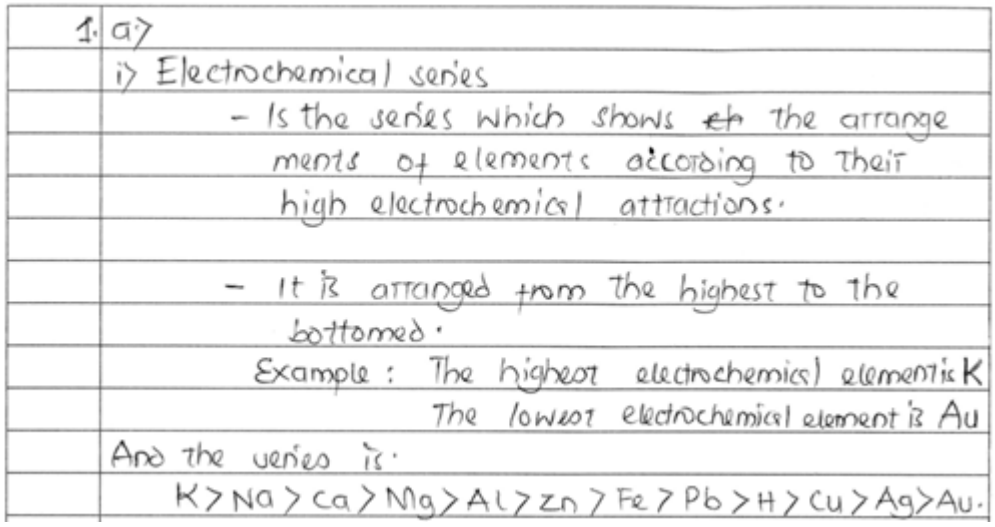
ii/ Oxidation number of Cl in NaCl



Extract 1.1 is an example of a well presented answer. The candidate gave explanation of the terms as required. The candidate also managed to select the feasible reaction and wrote a balanced redox equation. Not only that, she/he was able to draw the cell diagram and calculated the e.m.f of the cell. Finally, she/he managed to use oxidation numbers to show the particle which had undergone oxidation and reduction.

The candidates who performed poorly in this question failed to give a brief explanation of the terms: electrochemical series, electrochemical equivalent, redox series and redox reactions as they were demanded by the question. They also failed to write a balanced redox equation for the selected feasible reaction and they were not able to draw the cell diagram. The candidates also could not even calculate the e.m.f of the cell from the given information. They failed to understand that, feasibility of a cell reaction depends on the e.m.f of the cell constructed or proposed. Not only that, others drew electrolytic cell instead of galvanic cell. This shows that, the candidates did not understand the requirement of the question. Extract 1.2 represents sample answers from one of the candidates which did not meet the requirement of the question.

Extract 1.2



ii) Electrochemical equivalent

- Is the ratio of the effective electrochemical summation of the respective elements to their effective electromotive forces.

iii) Redox series

- Is the arrangement or the trend of chemical reactions which shows the ascending and descending order of elements in a given chemical trends of acidic or basic nature properties

iv) Redox reaction

- Is the reaction in which both basic and acidic reactions take place at the same time and at the same chemical equation

1. b) Soln.

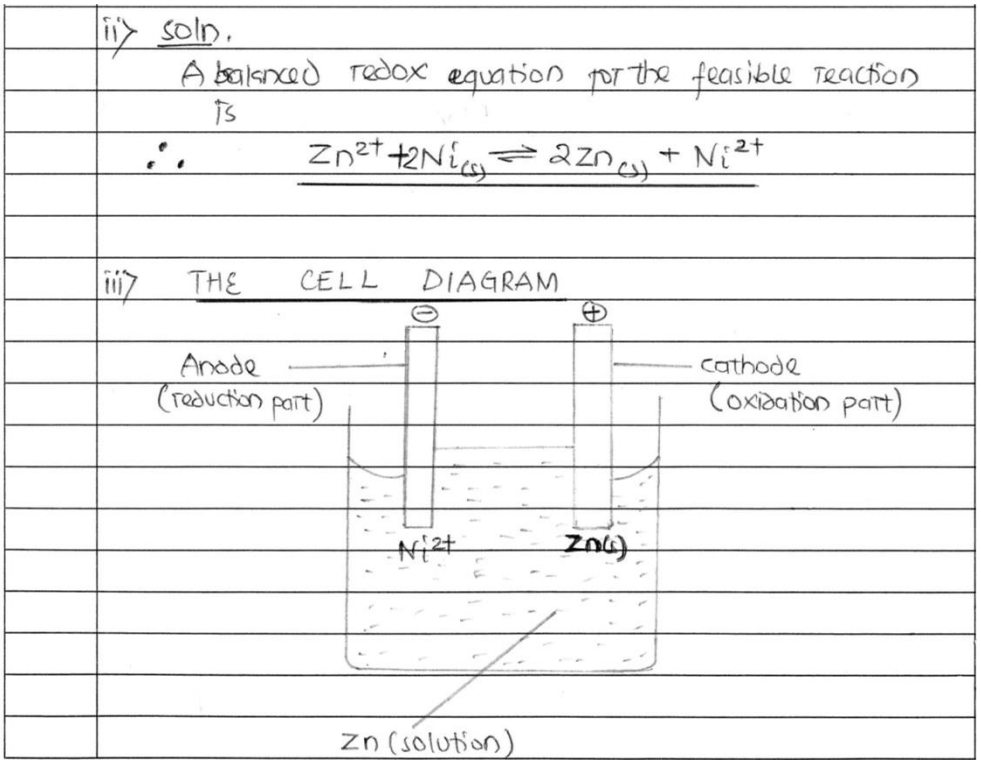
Given data

$Zn^{2+}_{(aq)} + 2e^- \rightleftharpoons Zn_{(s)}$ $\quad E^\theta Zn^{2+}/Zn = 0.76V$

$Ni^{2+}_{(aq)} + 2e^- \rightleftharpoons Ni_{(s)}$ $\quad E^\theta Ni^{2+}/Ni = 0.25V$

i) The feasible reaction is the reduction of Zn^{2+} by Nickel, due to the fact that Nickel it is a stronger oxidising agent and so it reduces Zn^{2+}.

- Also Nickel act as a catalyst to reduce Zn^{2+}



Although the answers in extract 1.2 are presented clearly, they are all wrong. The candidate did not manage to explain correctly even a single term in part 1 (a). In part (b) (iii) the candidate drew the electrolytic cell without external circuit connection. This indicates insufficient knowledge on electrode potentials, electrochemical cells as well as redox reactions.

2.2.2 Question 2: Chemical Kinetics

In part (a), the candidates were required to describe the term homogeneous catalyst supported with an example. They were also required to show how the rate of change of concentration of N_2O_5 is related to the rates of change of concentration of NO_2 and O_2 in the equation, $2N_2O_5 \rightarrow 4NO_2 + O_2$. Furthermore, they were required to write a balanced equation for the rate equation $\frac{-d[CH_4]}{dt} = \frac{1}{2}d\frac{[O]}{dt} = \frac{1}{2}\frac{d[H_2O]}{dt} = \frac{d[CO_2]}{dt}$. In part (b), they were required to determine the order of reaction and the rate constant of the reaction at 75°C, given that, at 25°C the rate constant of the reaction is $4.7 \times 10^{-3} s^{-1}$ and the activation energy is 33.6 kJmol^{-1}. In part (c), they were provided with the data shown in table 1 for the reaction, $4H_{2(g)} + 2NO_{2(g)} \rightarrow 4H_2O_{(l)} + N_{2(g)}$ and from these, they were required to

write the rate expression and calculate the order of a reaction with respect to each reactant in the equation given the data in the following Table1 collected at 298K.

Table 1

$[H_2]$	$[NO_2]$	Rate ($mols^{-1}$)
0.6	0.37	0.18
0.6	0.74	0.72
1.2	0.74	0.72

The question was opted by 51.3 percent of the candidates, out of which 32.3 percent scored below 6 out of 20 marks of which 0.6 percent scored a zero mark. A large number (53.6%) of candidates scored 6 to 10 marks while 14 percent scored 10.5 to 15.5 marks. A few (0.1 %) candidates scored 16 to 17 marks, but there were no any candidates who scored all the allocated marks. Generally the performance of the candidates in this question was good.

The candidates who scored high marks were able to describe the term homogeneous catalyst and wrote the relevant equation showing how the rate of concentration of N_2O_5 is related to the rate of concentration of NO_2 and O_2 in part 2(a) (i) & (ii); but they encountered difficulties in part 2(a) (iii), as they failed to interpret the relationship given in order to obtain a balanced equation; hence failed to score full marks. However, they were able to determine the order of reaction and the rate constant in part 2 (b). Not only that, they were able to write the rate expression and calculated the order of the reaction in part 2(c). Extract 2.1 is a part of the candidate's response who scored well in this question.

Extract 2.1

2(a) (i) Homogeneous catalyst is the type of catalyst which have the same physical state as the (states of) reacting species as well as products involved in a chemical reaction. ie Is the type of catalyst which have got the same phase as that of different species involved in a given chemical reaction.
eg Dilute Sulphuric Acid ($H_2SO_{4(aq)}$) in esterification reaction is a homogenous catalyst.

$\therefore$ $CH_3CH_2COOH_{(l)} + CH_3CH_2OH_{(l)} \underset{\text{a catalyst}}{\overset{\text{dil. } H_2SO_{4(l)} \text{ as}}{\rightleftharpoons}} CH_3CH_2\overset{O}{\overset{\|}{C}}-O-CH_2CH_{3(l)} + H_2O_{(l)}$
(Carboxylic acid) (Alcohol) (Ester)

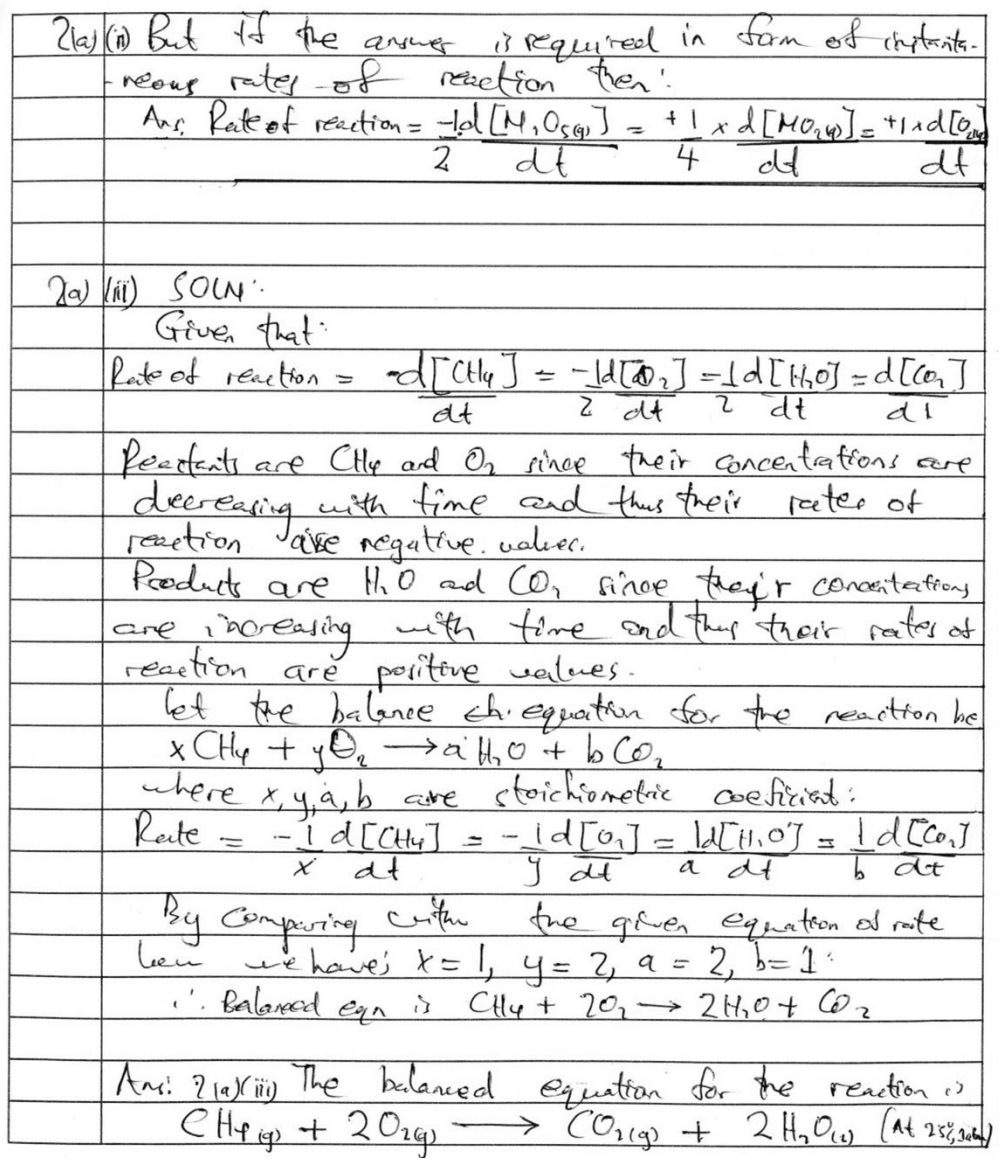
(ii) Given that:
$2N_2O_{5(g)} \longrightarrow 4NO_{2(g)} + O_{2(g)}$
From which:
Rate of reaction: (w.r.t time)
(i) w.r.t $N_2O_{5(g)}$ (R) $= -\frac{1}{2}\frac{d[N_2O_{5(g)}]}{dt}$ OR $-\frac{1}{2}\frac{\Delta[N_2O_{5(g)}]}{\Delta t}$

(ii) w.r.t NO_2 (R) $= \frac{1}{4}\frac{d[NO_{2(g)}]}{dt}$ OR $\frac{1}{4}\frac{\Delta[NO_{2(g)}]}{\Delta t}$

(iii) w.r.t O_2 (R) $= \frac{d[O_{2(g)}]}{dt}$ OR $\frac{\Delta[O_{2(g)}]}{\Delta t}$

$\therefore$ In combining (i), (ii) and (iii) we have
$R = -\frac{1}{2}\frac{\Delta[N_2O_{5(g)}]}{\Delta t} = \frac{1}{4}\frac{\Delta[NO_{2(g)}]}{\Delta t} = \frac{\Delta[O_{2(g)}]}{\Delta t}$

Ans: $-\frac{1}{2}\frac{\Delta[N_2O_{5(g)}]}{\Delta t} = \frac{1}{4}\frac{\Delta[NO_{2(g)}]}{\Delta t} = \frac{\Delta[O_{2(g)}]}{\Delta t}$
$\therefore$ negative means the $[N_2O_{5(g)}]$ is decreasing with time.



Extract 2.1 shows that, the candidate was able to give answers which were expected. The candidate gave clear and correct explanations as well as chemical equation and an example to illustrate the answers given. However, the candidate encountered problems in part 2 (ii) as she/he failed to write the relevant equation showing how the rate of concentration of N_2O_5 is related to the rate of concentration of NO_2 and O_2, hence failed to score full marks.

The candidates who scored low marks in this question failed to describe the term homogeneous catalyst. Furthermore, others determined the order of reaction through incorrect calculations. For example one candidate wrote:-

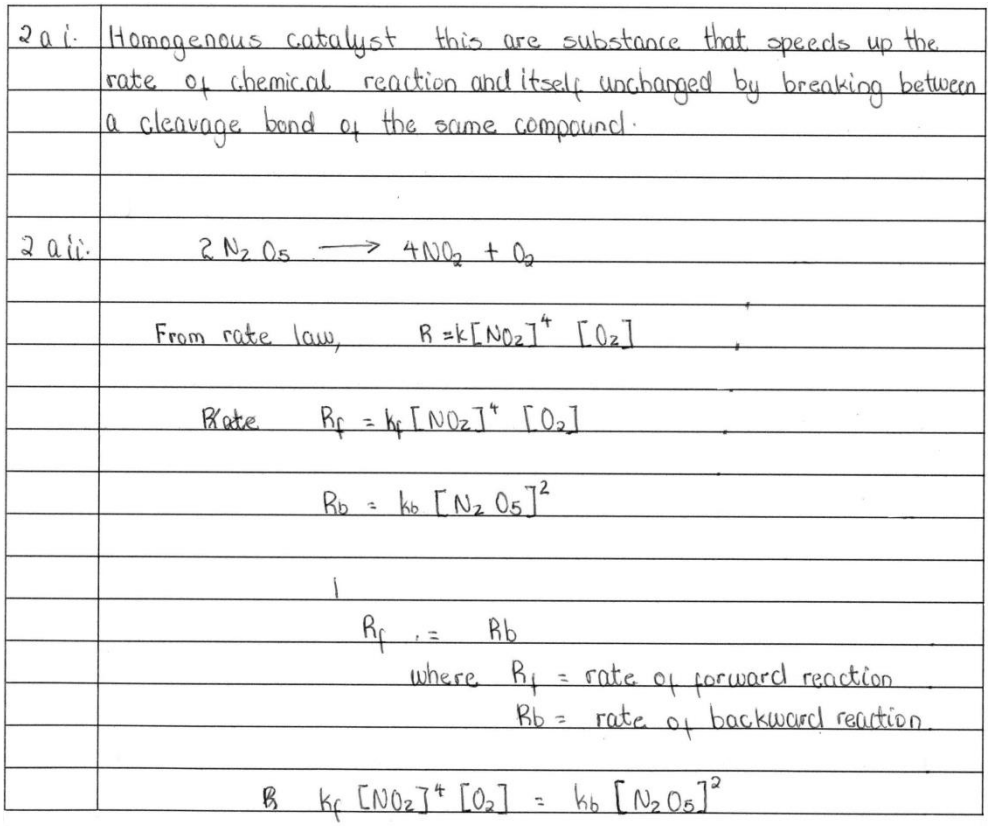
$0.18 = (0.6)^{a} + (0.37)^{b}$

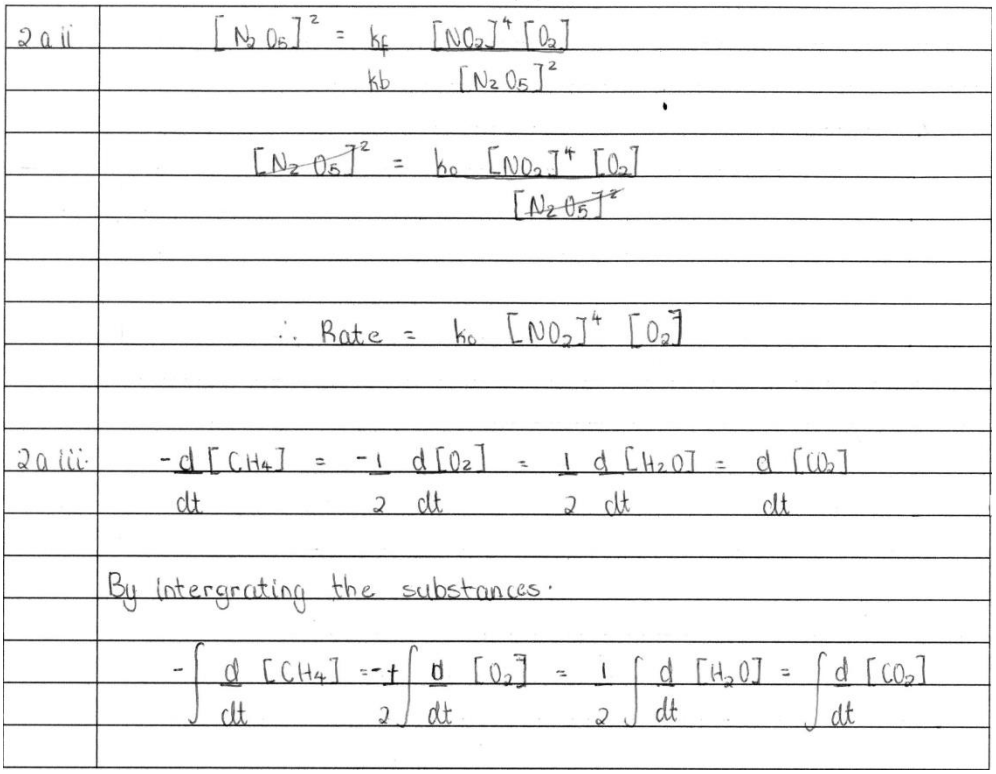
$0.72 = (0.6)^{a} + (0.74)^{b}$ instead of

$0.18 = (0.6)^{a} (0.37)^{b}$

$0.72 = (0.6)^{a}(0.74)^{b}$ and concluded by providing the value of b=2, of which is impossible according to the calculation used. Also she/he failed to determine the order of reaction with respect to H_2 from simple exponential equation, $1 = (0.5)^{a}$ and he/she came up with a = 1 instead of a = 0. This indicates insufficient knowledge on the concept of order of reaction and also had poor basic skills on mathematical computation. Extract 2.2 is an example of such a case.

Extract 2.2





Although the answers in extract 2.2 are presented clearly they are all wrong. The candidate failed to define the term homogenous catalyst and did not give the supporting example. He/she also failed to apply dimensional analysis in order to write a balanced equation in part 2(a) (iii).

2.2.3 Question 3: Acids, Bases and Salts

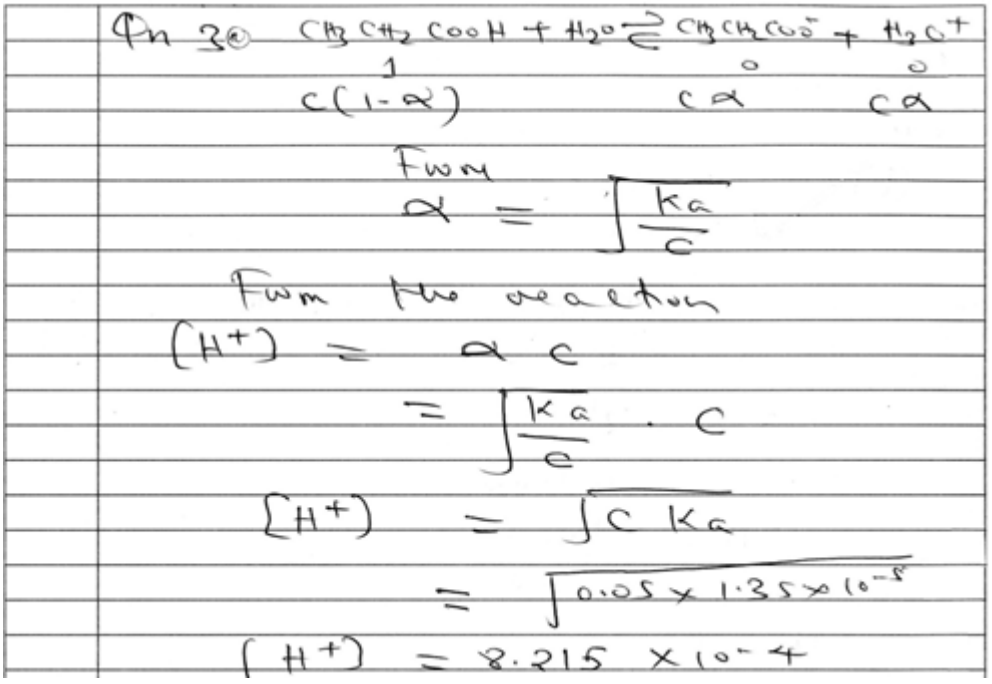
In part (a) of the question, the candidates were given K_a of propanoic acid as 1.35×10^{-5} mol/dm^3, then they were required to calculate the pH of propanoic acid solution of molarity 0.05 mol/dm^3 and of a solution containing 0.05 mol/dm^3 propanoic and 0.05 mol/dm^3 sodium propanoate. In part (b), they were required to write the formulae of the acids and their conjugate bases in the provided equations. In part (c), they were required to calculate the amount of ammonium sulphate in grams which has to be added to 500cm^3 of 0.2M NH_3 to yield a solution of pH 9.35 where by K_b for NH_3 was 1.78×10^{-5} mol dm^{-3}. Lastly, in part (d) they were required to predict and explain whether the solution of NH_4Br, $CaCl_2$, and KCN will be acidic, basic or nearly neutral.

Statistics indicate that, this question was among the most opted question as many candidates (63.6 %) attempted it. It was noted that, nearly half

(46.5%) of the candidates scored 6 to 10 out of 20 marks while 29.7 percent scored 10.5 to 15 marks. The candidates who scored below 6 were 22.1 percent of which 0.6 percent scored a zero mark. A few (1.7%) candidates scored between 15.5 and 18.5 marks. On the other hand, there was no any candidate who scored all the 20 allocated marks. These data conclude that, the general performance for this question was good.

The candidates who performed well in this question calculated correctly the pH of 0.05M propanoic acid and 0.05M sodium propanoate. They wrote correctly the acid base conjugate pairs for the reactions provided; but encountered problems in part 3(c), as they failed to recall Henderson equation as a result they failed to get the correct amount of ammonium sulphate. However, they were able to predict with explanation that NH_4Br is acidic; $CaCl_2$ neutral; and KCN basic. Extract 3.1 shows sample of answers of candidates who scored well in this question.

Extract 3.1



$pH = -\log(H^+) = -\log(8.215 \times 10^{-4})$

$pH = 3.085$

(ii) For Propanoic acid and Sodium propanoate

It is a buffer solution

For acidic Buffer solution

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

$K_a = 1.35 \times 10^{-5}$

$[Salt] = 0.05 \text{ mol dm}^{-3}$

$[Acid] = 0.05 \text{ mol dm}^{-3}$

$pH = -\log(1.35 \times 10^{-5}) + \log\left(\frac{0.05}{0.05}\right)$

$pH = 4.869$

(b) (i) HCl Acid, Cl^- Conjugate base

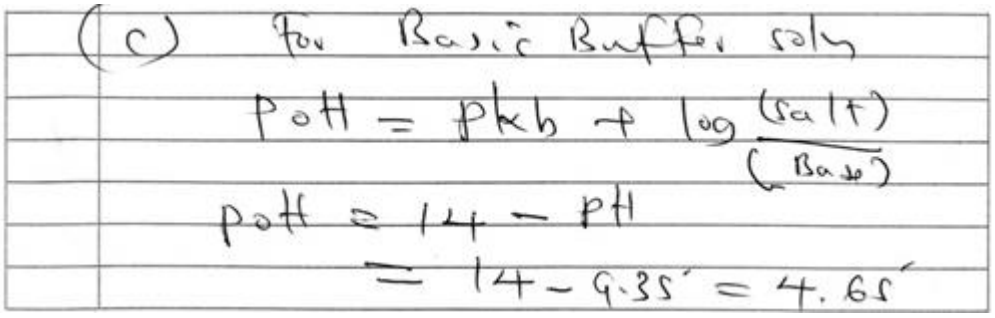
NH_4^+ Acid, NH_3 Conjugate base

(ii) H_2SO_4 Acid, HSO_4^- Conjugate base

$H_2NO_3^+$ Acid HNO_3 Conjugate base

(iii) NH_4Cl Acid NH_3 Conjugate base

NaCl Acid $NaNH_2$ Conjugate base



Extract 3.1 shows a sample of a response of a candidate who performed well in this question. The candidate gave a correct calculation of pH for the solutions given and wrote correctly the acid/base conjugate pairs.

However, the candidates who performed poorly failed to identify the acids and their respective conjugate bases. They also failed to write structural formula for propanoic acid as well as that of sodium propanoate. For example one candidate wrote $CH_3CH_2CH_2COOH$ as propanoic acid instead of CH_3CH_2COOH. Others used wrong formula in the calculation of amount of ammonium sulphate, as a result they failed to manipulate the degree of dissociation which led to wrong pH value of the given solution. Not only that, others failed to recall the correct Henderson equation, for example one candidates wrote $\mathrm{pH}=\mathrm{pKa}+\log\left[\frac{\text{Salts}}{\text{Acids}}\right]$ for basic buffer solution instead of $\mathrm{pOH}=\mathrm{pKb}+\log\left[\frac{\text{Salts}}{\text{Base}}\right]$. This indicates lack of knowledge on Acids, Bases and Salts concepts, extract 3.2 illustrates the case.

Extract 3.2

03. (a)

Data,

$ka = 1.35 \times 10^{-5}$

$pH = 7$

(i) $M = 0.05 \text{ mol/dm}^3$

Since

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

propanoic Acid = CH_3CH_2COOH

Molarity = $\frac{C}{M.M}$.

Concentration = Molarity $\times$ M.M.

$M = 0.05$

$M.M = 12 + 1 \times 3 + 12 + 1 \times 2 + 12 + 16 \times 2 + 1$

$= 74$.

Concentration $= 0.05 \times 74$

Concentration $= 3.7$

$\alpha = \frac{2\sqrt{ka}}{C}$

$\alpha = \frac{\sqrt{1.35 \times 10^{-5}}}{3.7}$

$\alpha = 9.9 \times 10^{-4}$

$[H^+] = \alpha C$.

$= 9.9 \times 10^{-4} \times 3.7$

$[H^+] = 3.67 \times 10^{-3}$.

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

$= -\log [3.67 \times 10^{-3}]$.

$pOH = 2.4$

∴ The pOH of propanoic acid is 2.4

(11) Data given.

Molarity = 0.05mol/dm³ of propanoic Acid

Molarity = 0.05mol/dm³ of sodium propanoate

pH = 7

Soln.

$K_a = 1.35 \times 10^{-5}$

From M.M = $[CH_3CH_2COONa] = 96$.

$\text{Molarity} = \frac{C}{M.M}$.

Concentration = Molarity × M.M.

= 0.05 × 96.

Concentration = 4.8

$\alpha = \frac{\sqrt{K_b}}{C} = \frac{\sqrt{1.35 \times 10^{-5}}}{4.8}$

$\alpha = 7.6547 \times 10^{-4}$.

$[OH^-] = \alpha C$

$= 7.7 \times 10^{-4} \times 4.8$

$= 3.67 \times 10^{-3}$.

$pH = -\log [OH^-]$.

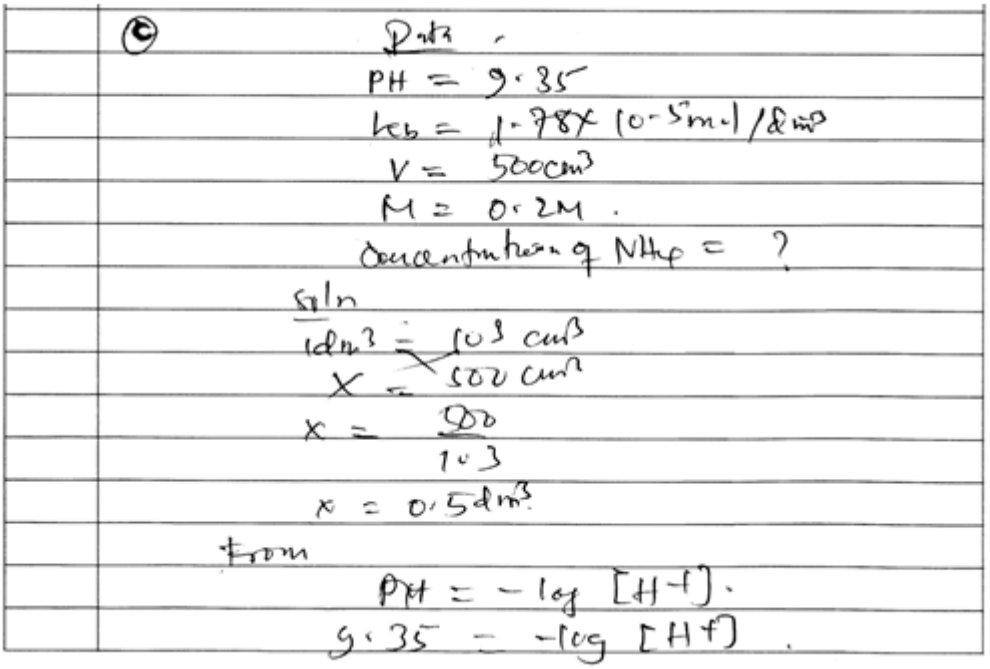
$= -\log [3.67 \times 10^{-3}]$.

pH = 2.4 X

∴ pH of Propanoic Acid × pH of propanoic Acid

= 2.4 × 2.4 = 5.76.

∴ The pH of the solution containing 0.05mol/dm³ of propanoic and 0.05mol/dm³ of propanoate is 5.76 or 6 X



Extract 3.2 indicates an example of the candidate's poor response. The candidate failed to recall the correct formula which as a result she/he obtained wrong answers in each part of the question.

2.2.4 Question 4: Periodic Classification

In part (a) the candidates were required to explain briefly five factors that affect ionization energy of elements, four causes of anomalous behaviour of the first elements in a group of the periodic table and the cause of the diagonal relationship. In part (b) they were asked to give four reactions which show how beryllium of group IIA is related to aluminium in group IIIA. In part (c), they were required to discuss briefly the trends of oxides of elements of period three (3) in the periodic table.

The question was opted by 36.4 percent of the candidates, out of which 25.5 percent scored below 6 out of 20 marks of which 1.0 percent scored a zero mark. The candidates who scored 6 to 10 marks were 36.3 percent while 33.5 percent scored 10.5 to 15 marks. A few (3.7%) candidates scored between 15.5 and 20 marks. Besides, only one candidate scored all the allocated marks. In brief, these data indicates that the performance of the candidates in this question was good.

The candidates who performed well had sufficient knowledge on Periodic Classification as they were able to explain all the factors that affect

ionization energy of the elements. They were also able to explain four causes of anomalous behaviour of the first elements in a group of periodic table and the causes of diagonal relationship. Moreover, they presented correctly the diagonal relationship between beryllium and aluminium and explained the trend of oxides of elements found in period three (3) in the periodic table. Extract 4.1 illustrates the case.

Extract 4.1

4. (a)
(i)

• Stability of Electronic Configuration, an element with its electron fully paired or half paired is stable hence its ionization energy is ~~highly~~ high while the element with unstable, has low ionization energy.

• Size of Nuclear charge.
- An Element with high Nuclear charge has high ionization Energy than the element with low nuclear charge.

• Distance from the Nucleus
- The Electrons which are far away from the Nucleus have low ionization energy while that which are found near the nucleus have high ionization energy since are strongly held by Nuclear attractive force compare to those which are far away

• Size of the Element atom
- If the size of the atom of an element is small then its electrons are strongly held by nuclear attractive fore hence high ionization energy and if large size then its electron are weakly held hence low ionization energy.

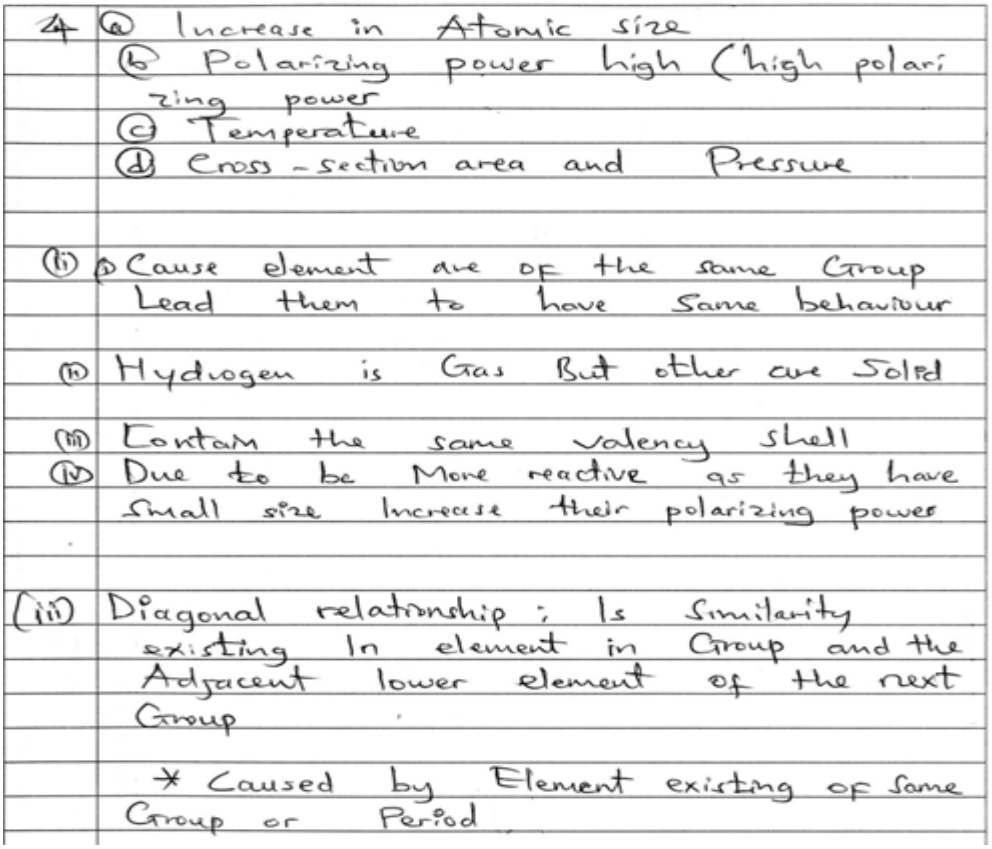
	• Repulsion between Inner and Outer Electrons
	- An atom with large repulsion between Inner Electrons
	and ~~water~~ outer has low ionization energy since
	the nuclear attractive force is screened while that with
	little or no repulsion has high ionization energy since
	the nuclear attractive is not screened hence valence electrons
	are strongly held.

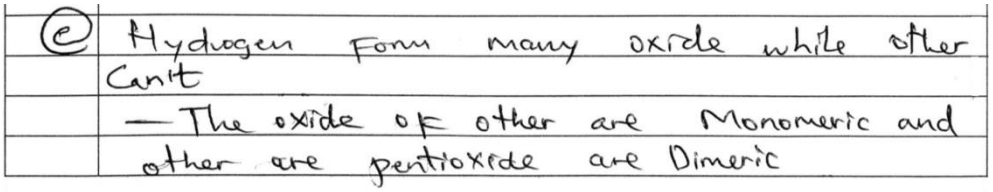
4	(b) Reaction ~~with~~ of Hydroxides of Be and Al. when
	$Be(OH)_3 + 3HCl \longrightarrow BeCl_3 + 3H_2O_{(l)}$ react with acid.
	$Al(OH)_3 + 3Hcl \longrightarrow AlCl_3 + 3H_2O_{(l)}$
	Reaction of $Be(OH)_3$ & $Al(OH)_3$ with Bases.
	$Be(OH)_3 + 3NaOH \longrightarrow Na_3BeO_3 + 3H_2O_{(l)}$
	$Al(OH)_3 + 3NaOH \longrightarrow ~~Al_3~~ Na_3AlO_3 + 3H_2O_{(l)}$
	This shows that the hydroxides of Be and Al are
	amphoteric in nature reacting with acid & bases
4	(c)
	The period 3 elements are.
	Na, Mg, Al, Si, P, S, Cl.
	The oxides of period 3 elements are.
	NaO, MgO, Al_2O_3; SiO_2; P_4O_6 or P_4O_{10}, SO_2, Cl_2O_7.
	The ~~first~~ two oxides NaO and MgO are Basic, they
	dissolve in water to give a Basic Solution.
	$NaO_{(s)} + H_2O \longrightarrow NaOH$
	$MgO_{(s)} + H_2O \longrightarrow Mg(OH)_2$.
	The Al_2O_3 is amphoteric oxide, it dissolves in
	water to give amphoteric solution that reacts with
	both acids and bases.
	$Al_2O_3 + 3H_2O \longrightarrow 2Al(OH)_3$
	- P_4O_6, P_4O_{10}, SO_2 and Cl_2O_7 are acidic oxides
	$Cl_2O_7 + H_2O \longrightarrow HClO_4$
	$P_4O_{10} + 6H_2O \longrightarrow ~~4H_4PO_3~~ 4H_3PO_4$
	$SO_2 + H_2O \longrightarrow H_2SO_3$

In extract 4.1, the candidate explained all the five factors affecting ionization energy as stated in part 4 (a) (i); but in (ii), the candidates was able to explain only three instead of four causes of anomalous behavior of the first element hence failed to score full marks. However, in part 4(b) & (c) the candidate presented correctly the answers according to the requirement of the question.

The candidates who performed poorly in this question failed to explain the factors which affect ionization energy of elements; the anomalous behavior of the 1st elements in a group of the periodic table and the causes of diagonal relationship. Others did not give reactions showing diagonal relationship between beryllium and aluminium. In addition, there were some candidates who did not understand the demand of the question as they discussed hydrogen instead of the trends of oxides of elements of period three (3) in the periodic table contrary to the requirement of the question. Extract 4.2 represents a poor response.

Extract 4.2





Extract 4.2 shows an example of the poor responses. The candidate failed to explain factors affecting ionization energy. In part 4 (a) (ii), the candidate wrote causes which are contrary to the requirement of the question. The same applies for part 4 (a) (iii) she/he gave incorrect causes of diagonal relationship. In part 4 (c), the candidate discussed hydrogen instead of the trends of oxides of elements of period three (3) in the periodic table.

2.2.5 Question 5: Solubility, Solubility Product and Ionic Product

In part (a), the candidates were required to differentiate between electrolytic cell and electrochemical cell, molarity and molality, anode and cathode, positive pole and negative pole. In part (b), they were required to find out whether precipitate will be formed when $200cm^3$ of 0.0040M $BaCl_2$ are added to $600cm^3$ of 0.008M K_2SO_4 given that Ksp of $BaSO_4$ is 1.6×10^{-10} $mol^2\ m^{-6}$. In part (c), they were required to calculate the number of moles of silver chloride which will saturate 250 cm^3 of 0.0001 M sodium chloride solution, given the $Ksp_{(AgCl)} = 1.6 \times 10^{-10}\ mol^2m^{-6}$.

A total of 9,407 (58.2%) candidates opted for this question and their performance was good as 37 percent scored 6 to 10 marks, 22.9 percent scored between 10 and 15 marks. However, 37.5 percent scored below 6 out of 20 marks of which 4.1 percent scored a zero mark. The candidates who scored 15 to 20 marks were 4.3 percent of which only four candidates scored all the allocated marks.

The candidates who performed well in this question were able to differentiate the terms given in 5(a) and they calculated well the ionic product of $BaSO_4$ which led to the conclusion that precipitate will form since Q > Ksp. They also calculated correctly the number of moles of silver chloride. Extract 5 illustrates good responses to parts (b) and (c).

Extract 5

5 (b) Soln:

$BaCl_2 + K_2SO_4 \longrightarrow BaSO_4 + KCl$

Recall: Precipitates forms when $Q_{ksp} > ksp$.

Number of moles of $BaCl_2$, n_B = $[BaCl_2] \times$ Volume

$= 0.2 \times 0.004$

Number of moles of $BaCl_2$, $n_B = 0.0008$ moles.

Number of moles of K_2SO_4, n_a = $[K_2SO_4] \times$ Volume

$= 0.6 \times 0.008$

$n_a = 0.0048$ moles.

Concentration of $BaCl_2$ in the reaction mixture, $[BaCl_2]_B = \frac{0.0008 \text{ mol}}{\text{Total volume}}$

Total volume $= (600 + 200) \times 10^{-3}$

$= 0.8 dm^3$

$[BaCl_2]_B = \frac{0.0008 \text{ mol}}{0.8 dm^3}$

$[BaCl_2]_B = 0.001 \text{ mol}/dm^3$

(b) Concentration of K_2SO_4 in the reaction mixture, $[K_2SO_4]_A$

$[K_2SO_4]_A = \frac{0.0048}{0.8}$

$[K_2SO_4]_A = 0.006 \text{ mol}/dm^3$.

From:

$K_2SO_4 + BaCl_2 \longrightarrow BaSO_4 + 2KCl$

Initially	0.006	0.001	0	0	t=0
Finally	0.006 − 0.001	0	0.001	0.001	

Final $[K_2SO_4] = 0.005 \text{ mol}/dm^3$

$[BaSO_4] = 0.001 \text{ mol}/dm^3$.

$[Ba^{2+}] = 0.001 \text{ mol}/dm^3$.

and $[SO_4^{2-}] = [BaSO_4] + [K_2SO_4]$

$= 0.005 + 0.001$

$[SO_4^{2-}] = 0.006 \text{ mol}/dm^3$.

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

$Q_{ksp} = (0.001 mol/dm^3)(0.006 mol/dm^3)$

$Q_{ksp} = 6 \times 10^{-6} (mol/dm^3)^2$.

since $Q_{ksp} > K_{sp}$

then the precipitate will occur.

(c) Soln:

$K_{sp} = 1.6 \times 10^{-10} mol^2 dm^{-6}$

volume $V = 250 \times 10^{-2}$ $0.25 dm^3$.

$[NaCl] = 0.0001 M$

since: $NaCl \longrightarrow Na^+ + Cl^-$

$[NaCl] = [Cl^-]$

$[Cl^-] = 0.0001 M$

(c) For saturation to occur $Q_{ksp} \geq K_{sp}$.

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

$AgCl \rightleftharpoons Ag^+ + Cl^-$ ---(i)

$\quad\quad X \quad\quad X$

The total concentration of $[Cl^-] = X + 0.0001 M$ but since $X \approx 0$

$[Cl^-] = 0.0001$

and $[Ag^+] = X$

$K_{sp} = (X)(0.0001)$

$1.6 \times 10^{-10} = 0.0001X$.

$\frac{1.6 \times 10^{-10}}{10^{-4}} = X$

$X = 1.6 \times 10^{-6} mol/dm^3$.

The number of moles Ag^+ in $250 cm^3$ $n = 1.6 \times 10^{-6} \times 0.25$

$n = 4 \times 10^{-7}$ moles.

From eqn (i) above mole ratio of AgCl and Ag^+ is 1 : 1

∴ The number of moles of silver chloride is 4×10^{-7} moles.

Extract 5 shows one of the candidates' responses who provided good response in parts (b) and (c). The candidate calculated the ionic product of $BaSO_4$ which led to the conclusion of the formation of precipitate. Furthermore, he/she calculated correctly the number of moles of silver chloride.

However, the candidates who performed poorly in this question failed to differentiate the terms in part 5 (a). They also had problems in finding whether precipitate will be formed when the solutions provided in the question are mixed together. Furthermore, they could not calculate the number of moles of AgCl required to saturate the provided solution. The failure to differentiate terms like molality and molarity, electrolytic cell and electrochemical cell as well as anode and cathode is the indication of lack of knowledge on solubility product and ionic product.

2.2.6 Question 6: Transition Elements

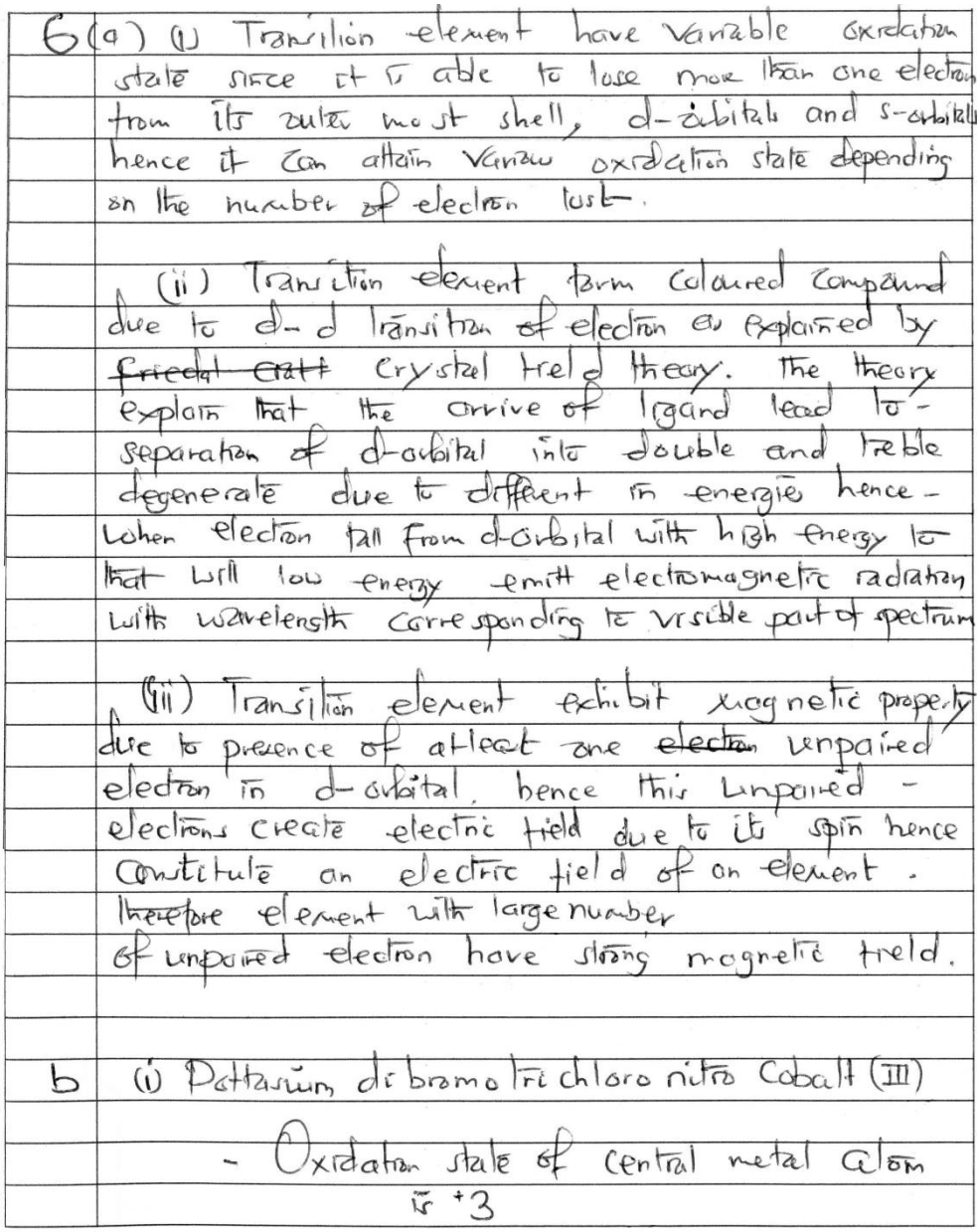
In part (a), the candidates were required to explain briefly why transition elements have variable oxidation states, form coloured compounds and exhibit magnetic properties. In part (b), they were required to give IUPAC names for the given complex compounds and to state the oxidation state of the central metal atom in the complexes. In part (c), they were required to name the two ligands in the complex structure on the right side of the equation, $[Fe(H_2O)_6]^{3+} + 3Cl^-_{(aq)} + H_2O_{(l)} \rightleftharpoons [Fe(H_2O)_5\,OH]^{2+} + H^+_{(aq)} + 3Cl^-_{(aq)}$; to draw a diagram showing shape of the complex ion on the right side of the equation and name its shape. Finally, they were required to explain why it is more difficult to remove a proton from $[Fe(H_2O)_5\,OH]^{2+}$ than from $[Fe(H_2O)_6]^{3+}$.

The question was opted by 63.6 percent of the candidates, out of which 24.5 percent scored below 6 out of 20 marks of which 2.4 percent scored a zero mark. The candidates who scored between 6 and 10 marks were 33.7 percent. Besides, 31.1 percent scored 10 to 15 marks. It is only 4.1 percent of the candidates who managed to score 15.5 to 19 marks. Besides, there was no any candidate who scored all the allocated marks.

The candidates who performed well in this question were able to explain clearly as to why transition elements have variable oxidation states; form coloured compounds and exhibit magnetic properties. They also wrote correct IUPAC names and stated the oxidation states of the central metal

atoms of the complex species. They were also able to name the two ligands to the right side of the equation and explained how they act as ligands. They drew a correct structure of the complex ion to the right side of the equation and named correctly its shape; but encountered problem in part 6 (c) (iii), as they failed to apply the concept of polarization of O–H bonds when a water molecule acts as a ligand. Extract 6.1 shows a sample of a good response.

Extract 6.1



6b (ii) diammine Silver (I) ion

oxidation state of central metal is +1

(iii) Tetra chloro aurate (III) ion

The oxidation state of Centra metal is +3

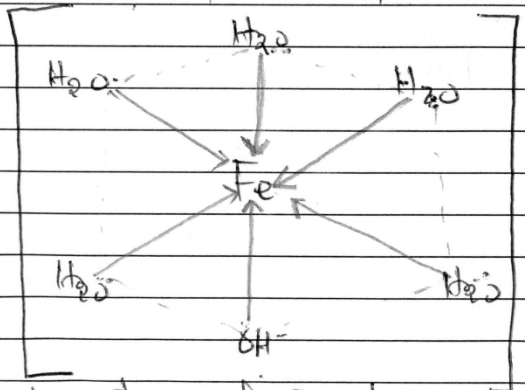
(iv) hexa cyno Palladate (IV) ion

oxidation state of central metal is +4

6C. (i) - water (aqua) and hydroxo

They act as a ligand by making dative - bond to the central atom through donating the lone pair of an electron to the empty orbital of the Central metal atom or ion.

(ii) Shape of the Complex

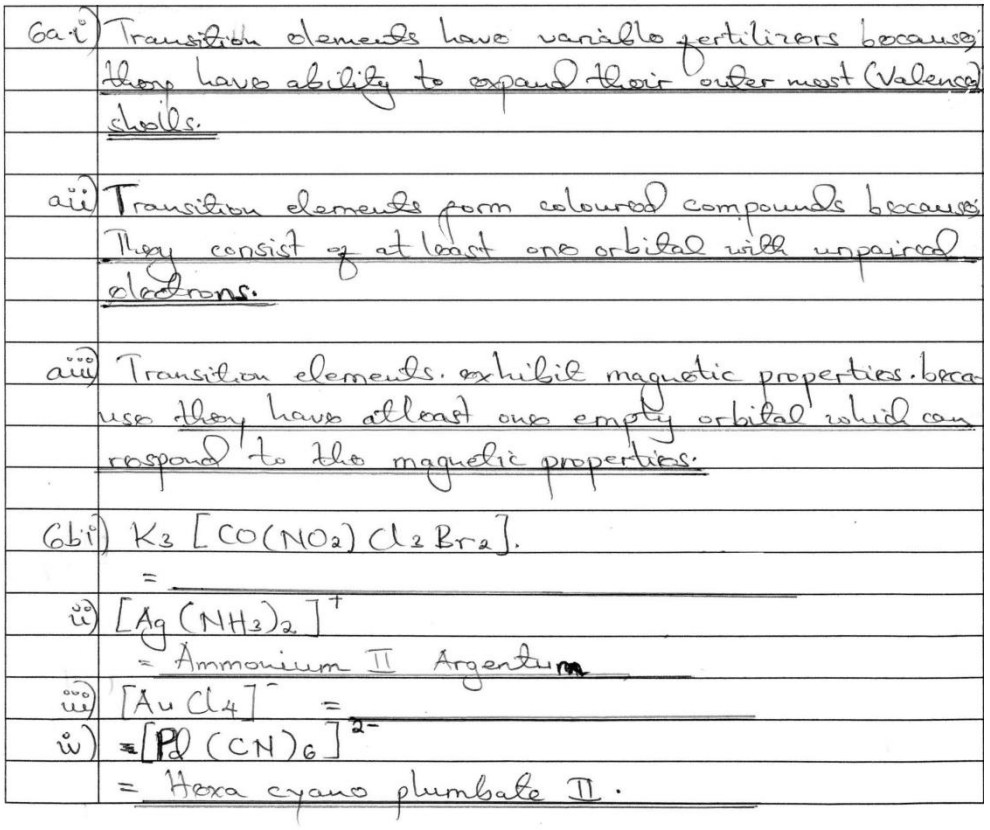


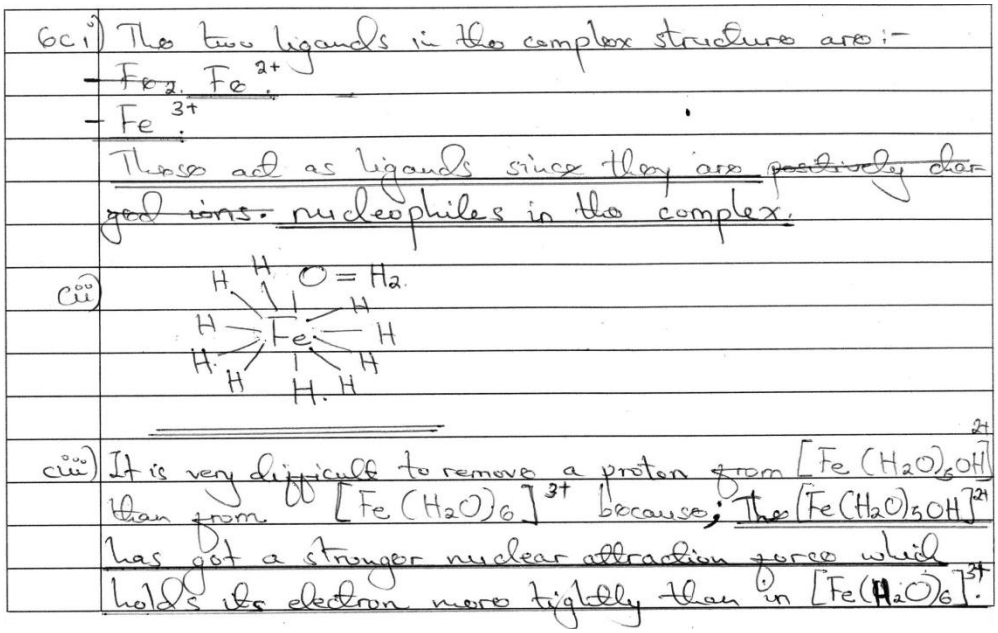
The shape of Complex is octahedral

Extract 6.1 shows a sample of a response of a candidate who provided good answers in this question. The candidate explained clearly why transition elements have variable oxidation states. He/she wrote correctly the IUPAC names and stated correctly the oxidation states of the central metal atom of the complex species. He/she drew a well structure of the complex ion and named correctly its shape.

The candidates who scored low marks in this question failed to explain why transition elements possess the named properties given in 6(a). They gave incorrect IUPAC names and oxidation states of central metal atoms of the complex species. Not only that, they also failed to link the concept of polarization to the difficultness of removing a proton from $[Fe(H_2O)_5 OH]^{2+}$ than from $[Fe(H_2O)_6]^{3+}$. This indicates lack of knowledge on unique properties of transition elements and general knowledge on complex species. Extract 6.2 illustrates the case.

Extract 6.2





Extract 6.2 shows a sample of response of the candidate who scored poor in this question. The candidate failed to explain why transition elements possess the named properties in part (a). She /he also failed to give proper IUPAC names and oxidation numbers of the central metal atom of the complex species in part (b). Not only that, she/he failed completely to write correct response to part (c). This is an indication of lack of knowledge on behavior on transition elements.

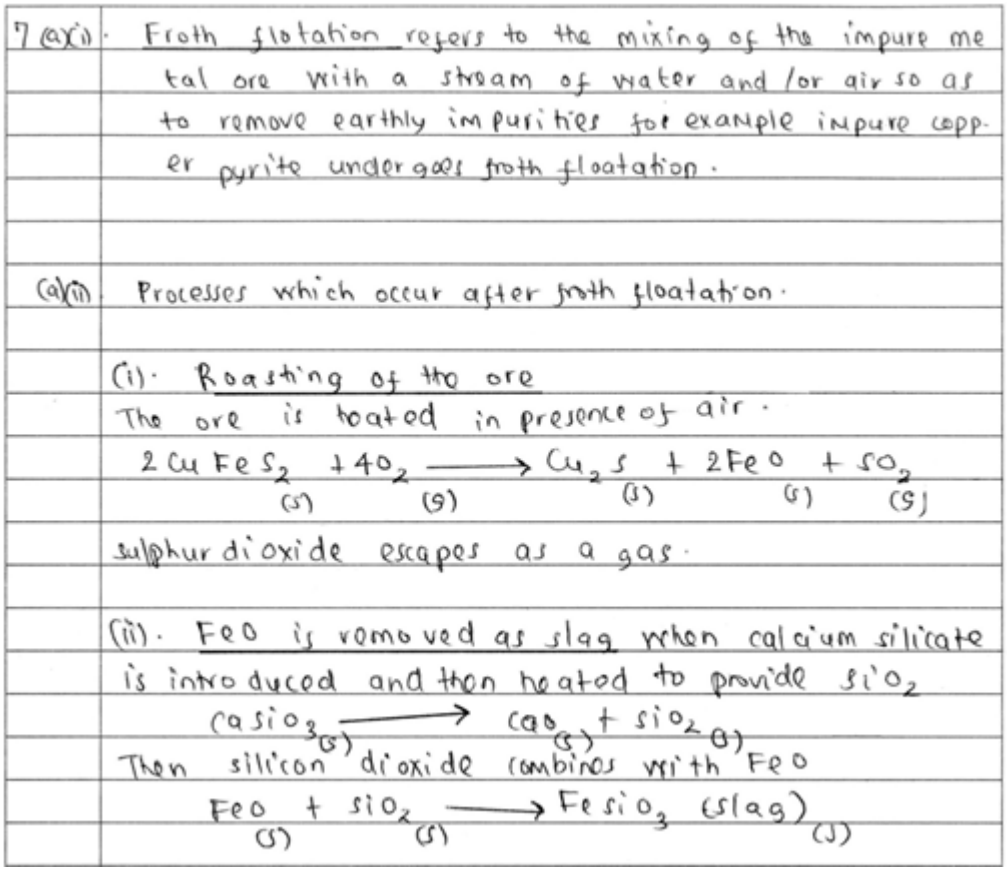
2.2.7 Question 7: Extraction of Metals

In part (a), the candidates were required to write the meaning of froth floatation as used in extraction of metals. They were also required to write the processes which occur after froth flotation of copper pyrites ($CuFeS_2$) to form impure copper with supporting equations where necessary. In part (b), they were required to analyse the stages involved in the purification of bauxite ore and explain why it is necessary to purify before electrolysis.

The question was opted by 32.6 percent of the candidates, out of which 3.6 percent scored a zero mark. The candidate who scored from 0.5 to 6 out of 20 marks was 38 percent. Moreover, the candidates who scored 6 to 10 marks were 33.2 percent while 23.8 percent scored between 10.5 and 15 marks. A few (1.4 %) candidates scored 15.5 to 18.5 marks. On the other hand, there was no any candidate who scored all the allocated marks.

The candidates who performed well in this question were able to explain clearly the meaning of froth flotation; but encountered difficulties in writing the processes which occur after froth floatation hence failed to score full marks. They also analysed correctly the stages involved in the purification of bauxite ore and explained why it is necessary to purify it before electrolysis. Extract 7.1 illustrates the case of candidate's good response.

Extract 7.1



(iii). Oxidation of Cu_2S.

The sulphide is then reacted with oxygen gas in presence of heat.

$$Cu_2S_{(s)} + O_{2(g)} \longrightarrow 2Cu_{(s)} + SO_{2(s)}$$

The copper obtained is bluster (impure) copper. To purify it the electrolytic process follow after oxidation of the sulphide.

(b). stages involved in purification of Bauxite ore:

(i). Bayer's process (Removal of water)

This is the process with which water is removed from the hydrated bauxite ore that is;-

$$Al_2O_3{\cdot}2H_2O \xrightarrow{\Delta} Al_2O_{3(s)} + 2H_2O_{(L)}$$

(bauxite) (corundum)

corrundum (Al_2O_3) is obtained.

(ii). Al_2O_3 then is reacted with concentrated alkali (NaOH) KOH may also be used.

$$Al_2O_{3(s)} + NaOH_{(aq)} + H_2O_{(L)} \longrightarrow Na[Al(OH_6)_6]_{(s)} + H_2O_{(L)}$$

sodium aluminate is obtained $Na[Al(OH)_6]$ which is then combined/passed through a stream of carbondioxide gas.

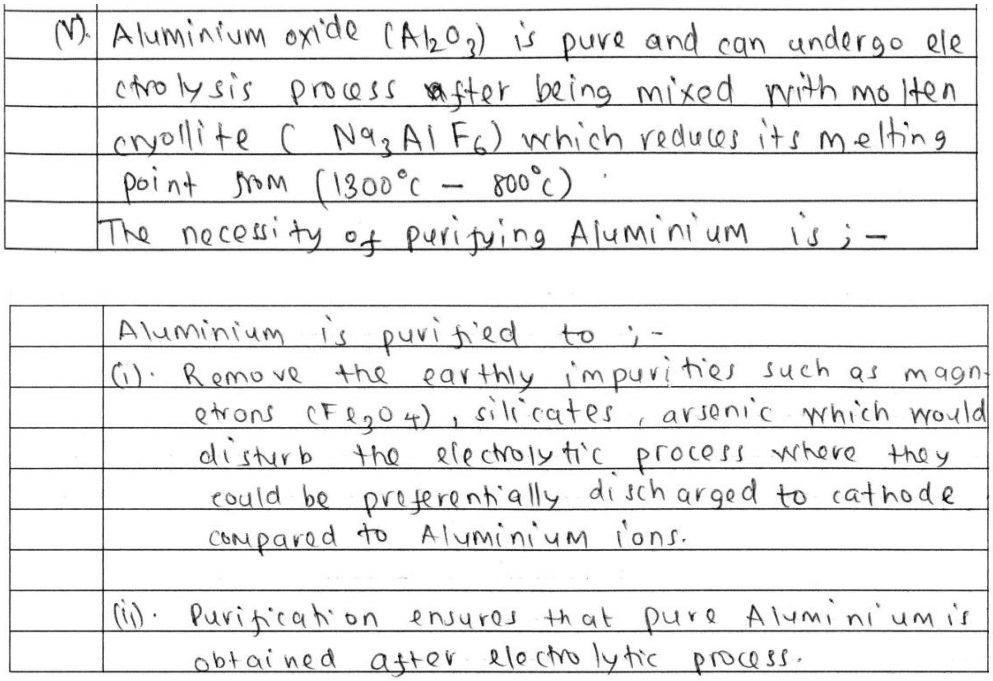
(iii). When passed through $CO_{2(g)}$, aluminium hydroxide is then formed with carbonate of sodium.

$$Na[Al(OH)_6] + CO_{2(g)} \longrightarrow Na_2CO_{3(s)} + Al(OH)_{3(aq)}$$

(iv). carbonate of sodium is filtered off and the hydroxide of alumina is heated;

$$Al(OH)_{3(aq)} \longrightarrow Al_2O_3 + H_2O$$

(aluminium hydroxide).



Extract 7.1 shows a response from the candidate who performed well in this question. The candidate presented correctly the meaning of froth floatation in 7 (a) (i). In 7(a) (ii), the candidate could not mention some of the processes which occur after froth flotation hence he/she could not score full marks. However, she/he analysed all stages involved in the purification of bauxite ore and gave a good reason as to why purification before electrolysis is necessary.

The candidates who scored low marks failed to explain the meaning of froth floatation. Others failed to write the processes which occur after froth floatation of copper pyrites ($CuFeS_2$) ore from which bluster copper (impure) is obtained. They also did not analyse the stages involved in the purification of bauxite ore. Not only that, others could not produce correct answers to any part of the question (see extract 7.2). This is an indication of insufficient knowledge on extraction of metals. The case is illustrated by Extract 7.2.

Extract 7.2

7 (a) (i) Froth Flotation in metal extraction is the separation of the gangue from the metal ore by means of oils like crude oils

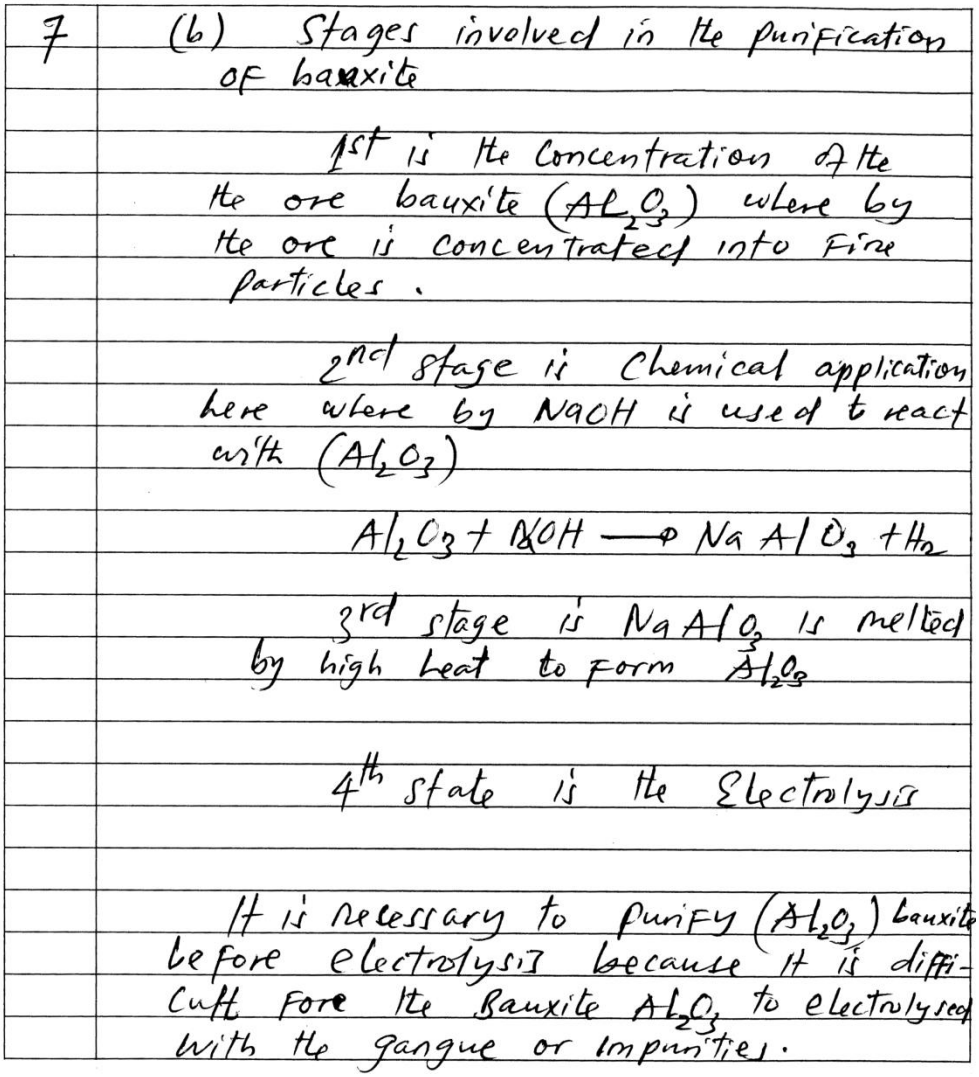
(ii) Processes which occur after froth Flotation of copper pyrites ($CuFeS_2$) which bluster copper (impure)

1st process is purification of the Ore by means of electrolysis in this stage molten copper pyrites is dissolved in the electrolytes and pass electricity through the s/n of electrolytes and molten copper.

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

and Electrolysis of the purified copper

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



Extract 7.2 shows a response from the candidate who scored low marks. The candidates could not produce correct answer to any part of the question. This is an indication of insufficient knowledge on extraction of metals.

2.2.8 Question 8: Soil Chemistry

In part (a), the candidates were required to explain briefly six advantages and four disadvantages of using manures. In part (b), they were required to differentiate immobilization from ammonification and to describe how farm manure should be handled and stored. In part (c), they were required to calculate in Kg, the quantity of ammonium sulphate required to fulfill plant requirement of 80kg of nitrogen per hectare.

The question was opted by 48.3 percent of the candidates, out of which 49.2 percent scored below 6 out of 20 marks of which 2.7 percent scored a zero mark. The candidates who scored from 6 to 10 marks were 37 percent. Besides, 12.2 percent scored 10.5 to 15 marks. It is only 1.2 percent of the candidates who managed to score 15.5 to 19.5 marks, but there was no any candidate who scored all the allocated marks.

The candidates who scored high marks were able to explain properly six advantages and four disadvantages of using manures. They also differentiated immobilization from ammonification, but encountered problem in part 8 (b). For example one candidate wrote application of farm yard manures instead of handling and storage processes which implies that, he/she did not understand the requirement of this question. However, they were able to calculate the quantity of ammonium sulphate required to fulfill plant's requirement as demanded by the question. Extract 8.1 gives an example of a good response.

Extract 8.1

8 (a) Advantages of Using Manure.

(i) Increases soil fertility.

- Manures supply nutrients to the soil which are required by Plants to their growth such as Nitrogen, sulphur and carbon.

(ii) Very easy and simple to use

- Manures are very easy to use since do not require much knowledge to use them to the soil

(iii) Increases microbial activities in the soil

- Farm manures which are natural organic source tends to increase microbial activities such as decomposition which results into soil fertility.

(iv) Do not increase soil acidity

- Manures provides a medium to the soil which is approximately neutral. This is a good medium for growth of Plants.

(v) Modifys the soil structure

- Green and farm yard manures tends to modify the soil structure by either modifying aggregates of soil particles or through increasing soil composition.

(vi) Prevents loss of soil nutrients

- Manure supply organic matters which modify the soil structure and acts as a glue which prevents loss of nutrients through erosion.

8 (a) Advantages of Using Manure.

(i) Increases soil fertility.

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(iv) Do not increase soil acidity

- Manures provides a medium to the soil which is approximately neutral. This is a good medium for growth of Plants.

(v) Modify the soil structure

- Green and farm yard manures tends to modify the soil structure by either modifying aggregates of soil particles or through increasing soil composition.

(vi) Prevents loss of soil nutrients

- Manure supply organic matters which modify the soil structure and acts as a glue which prevents loss of nutrients through erosion.

8 (a) Disadvantages of manures.

(i) Nutrients Imbalance
- Manures brings nutrient imbalance in the soil which in turn effect growth of plants since its not in any proportion.

(ii) Provides a long term effect.
- The effect of manure results from its decomposition which may take place for a long time hence can't supply immediate nutrients.

(iii) Its supply of nutrients depends much on environmental factors such as temperature, microorganism, water and air.

(iv) Very difficult to handle.

8 (b) (ii) (i) Under moderate temperature conditions
- Farm manure have to be stored under moderate temperature condition.

(ii) Under moist conditions.
- Farm yard manure have to be stored under moist condition to activate microbial activities.

(iii) Farm yard manure should be used in a moderate proportion and regulated means so as to balance nutrients.

(iv) Farm manure should be used under a regulated means to allow decomposition of organic matters

Extract 8.1 is an example of a well presented answer. The candidate explained properly advantages and disadvantages of using manures. He/she differentiated immobilization from ammonification, but in part 8 (b) (iii), the candidate wrote application of farm yard manures instead of handling and storage processes, hence failed to score full marks. However, she/he was able

to calculate correctly the quantity of $(NH_4)_2SO_4$ fertilizer as demanded by the question.

The candidates who scored low marks failed to give correct answers as demanded by the question. Specifically those who scored a zero mark could not explain even a single advantage or disadvantage of using manures. Others had an idea of how to handle and store farm yard manures but they could not present it well due to poor mastery of English Language (see extract 8.2). Not only that, others interchanged the concepts for the terminologies immobilization and ammonification. For example one candidate wrote:

> "*Ammonification is the conservation of an element from the inorganic to organic form in microbial or plant tissues, thus rendering the elements not readily available to other organisms or plants,while Immobilization is the conversion of an element from an organic to inorganic or plant available forms as a result of microbial decomposition".*

In other cases, the candidates completely failed to calculate the quantity of ammonium sulphate as required by part 8 (c). Poor responses of most of the candidates might have been caused by lack of knowledge on the properties of manures as well as application of mole concept that could enable them to carry out the calculation. Extract 8.2 illustrates the case of a candidate with poor response.

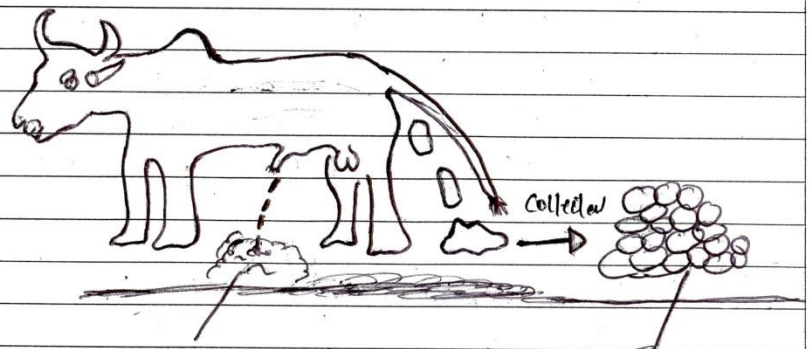
Extract 8.2

8 b.) (ii) formation of farm manure.

The ways of handled and stored of farm manure are:-

(i.) Through Composite or collected:- Farm manure are manure which produced from animals so when the animals it produce the manure it should be to collect them and store at the dry areas where there is no ~~or~~ interconnection of the urine and humidity it help to handle the manure

(ii.) Through supply to the farms after wet seasons to pass:- Farm ~~yard~~ manure it stored or handled through supply to the farms because wet season after passed it became dry season and this season supply the manure to handle the farm manure up to another seasons it became activated through stored.

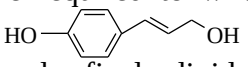


Urine it ~~remain~~ remain on surface of soil at long time levels farm manure

Faeces are Collected and store at the Centain are to stored.

Extract 8.2 shows a sample of a response of the candidate who scored low marks in this question. The candidate failed to present well his/her points due to poor mastery of English language. For example, in part 8 b (ii) the candidate decided to represent his/her ideas by drawing a cow excreting to show the process of handling and storing farm yard manures.

2.2.9 Question 9: Carbonyl Compounds, Hydroxyl Compounds and Carboxylic Acid

In part (a), the candidates were required to give the structural formulae of methyl-phenyl ether, methanol, propanone, methylethanoate and 3-phenyl-1-pentene. In part (b), they were required to give the structure and the name of the products formed in the reaction between benzene carbaldehyde and concentrated nitric acid in the presence of concentrated sulphuric acid, and between 2-nitro phenol and nitric acid in the presence of concentrated sulphuric acid. In part (c), they were required to identify the stronger acid with reasons among the pairs 2-chlorocarboxylic acid and 3-chlorocarboxylic acid; phenol and 2-bromophenol; and 2-fluoroethanoic acid and 2-chloroethanoic acid. In part (d), they were required to write balanced chemical equations for the reactions between 

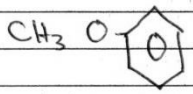
and sodium, dilute $KMnO_4$, acetic acid, and hydrogen under finely divided nickel.

The question was opted by 59.0 percent of the candidates, out of which 9.4 percent scored below 6 out of 20 marks of which 0.5 percent scored a zero mark. The candidates who scored 6 to 10 marks were 20 percent. A large number (51.7%) of candidates scored from 10 to 15 marks. Moreover, 22.2 percent of the candidates scored 15.5 to 20 marks of which only two candidates scored all the allocated marks. In brief, these data indicates that the performance of the candidates in this question was good.

The candidates who performed well in this question gave correct answers. For example, they were able to give the structural formula of the named compounds in part 9 (a); they wrote accurately the structures and names of the products formed in part 9 (b); identified properly with reasons a stronger acid among the given pairs in part 9 (c). Finally, they wrote correct balanced chemical equations for the given compounds with the provided reagents in part 9 (d). Extract 9:1 shows an example of a good response.

Extract 9.1

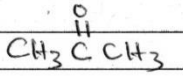
9 (a)(i) Methyl phenyl ether



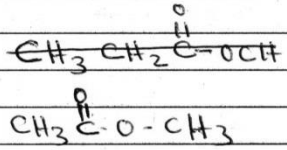
(ii) Methanol

CH_3OH

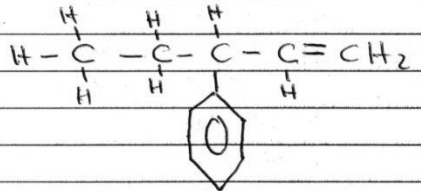
(iii) Propanone



(iv) Methyl ethanoate

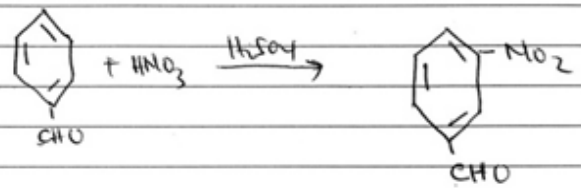


(v) 3-phenyl-1-pentene

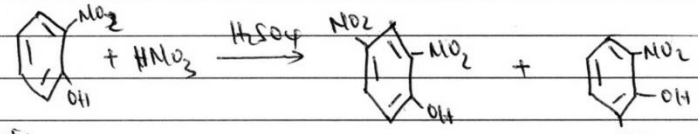


b)

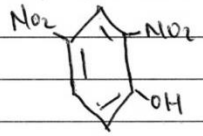
(i)



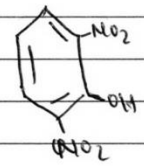
Name of product is 3-nitrobenzaldehyde

(ii) 

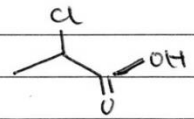
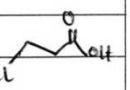
Their names are

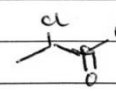
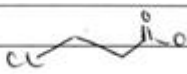


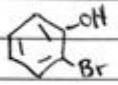
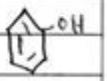
2,4-dinitrophenol



2,6-dinitrophenol

c)  is stronger acid than 

Because negative inductive effect is greater when chlorine is near to the functional group hence for  is more pronounced which weaken more the O-H bond make H^+ to easly be released hence it is more acidic than 

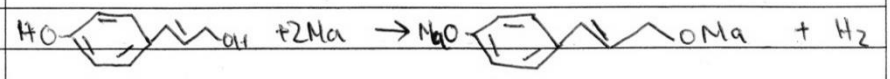
(ii)  is ~~more~~ stronger acid than 

Because Br being deactivating group reduce electron density in benzene ring and in O-H bond hence makes the bond OH more weak compared ~~in~~ to that in phenol hence H^+ can easly be released in

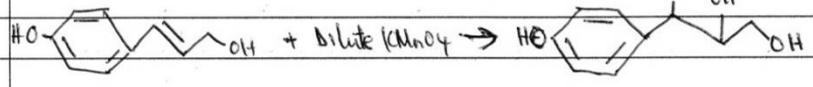
(iii) $CH_2F-\overset{O}{\overset{\|}{C}}-OH$ is stronger acid than $CH_2Cl-\overset{O}{\overset{\|}{C}}-OH$

Because Fluorine (F) being ~~stro~~ more electronegative than Chlorine (Cl) makes F to exert strong negative inductive effect which reduce more electron density in functional group at O–H bond and make the bond more weak to release easly H^+ hence $CH_2F\overset{O}{\overset{\|}{C}}-OH$ is stronger acid than $CH_2Cl\overset{O}{\overset{\|}{C}}OH$

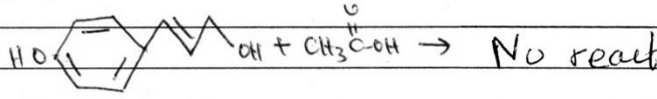
d) i)



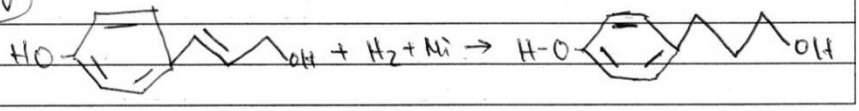
ii)



(iii)



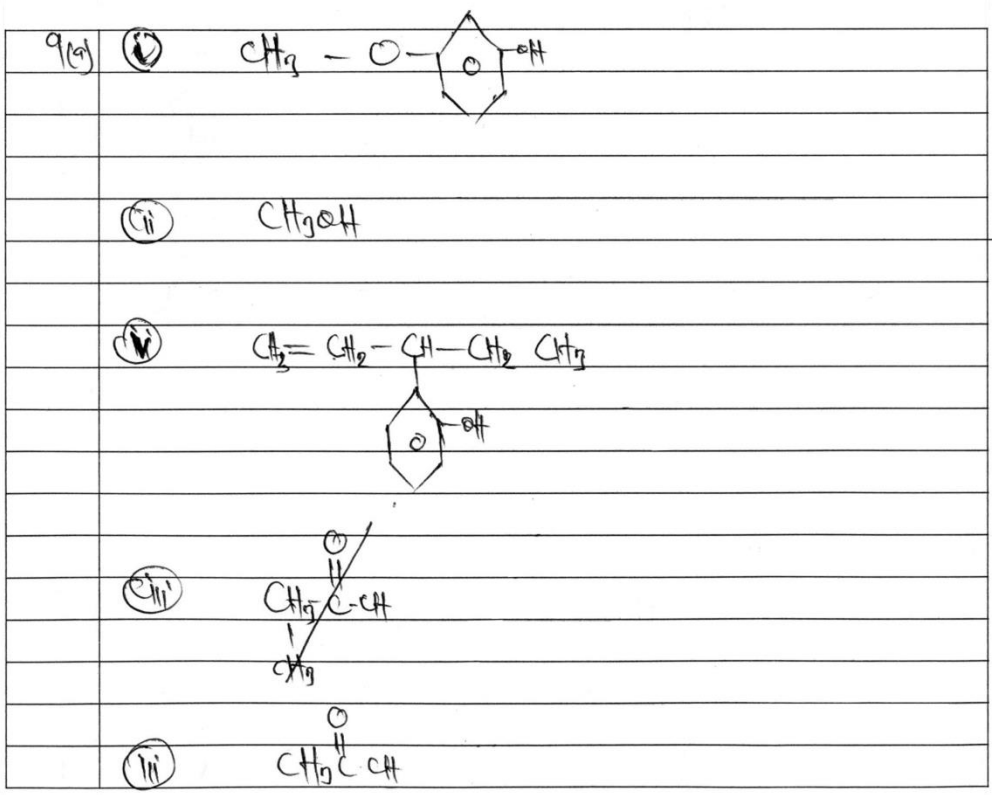
(iv)

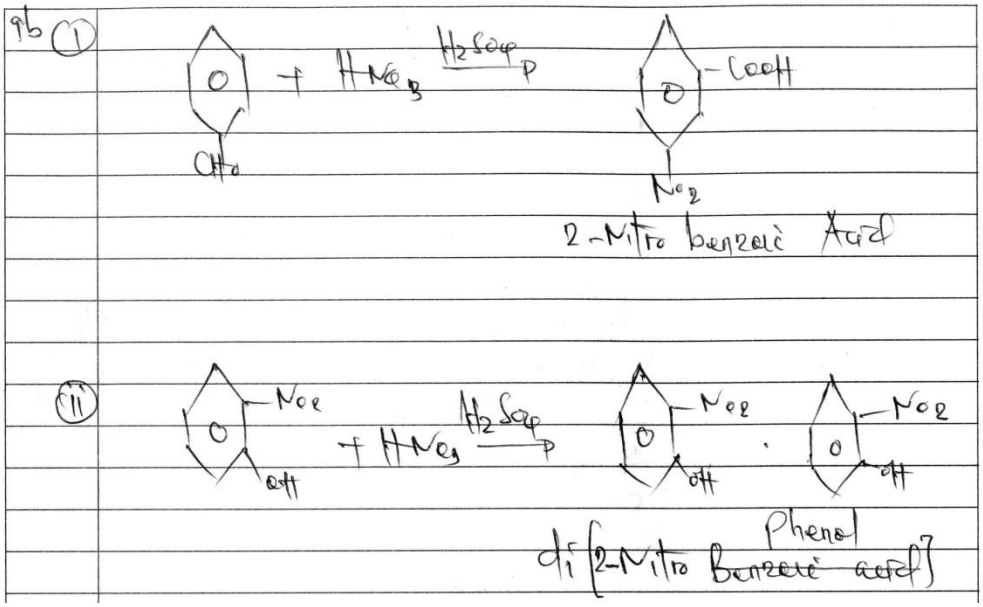


Extract 9.1 shows that, the candidate was able to give the structural formula of the named compounds in part 9 (a). The candidate also gave correct structures and names of the products formed in reactions in part (b). She/he identified properly the stronger acid among the given pairs in part (c). Not only that, she/he wrote a correct balanced chemical equations of the given compound with the provided reagents in part (d) of the question.

The candidates who scored low marks in this question were unable to draw the structure of the compounds asked in part 9 (a). Others had insufficient knowledge about electrophilic substitution reactions of benzene, as they failed to give the structure and name of the products required in part 9 (b). Not only that, others were unable to recall the factors affecting organic reactions such as inductive effects which is exerted by electronegative atoms like fluorine and chlorine. These factors play a greater role in acidic strength of the compounds. Extract 9.2 illustrates the case.

Extract 9.2





Extract 9.2 shows an example of the poor responses. The candidate wrote only a single correct structure [9 (a) (ii)] out of the required five structures in 9 (a). She/he also failed to name the products formed from the given reactions in part (b). This indicates that the candidate had insufficient knowledge of Organic Chemistry.

2.2.10 Question 10: Carbonyl Compounds and Amines

In part (a), the candidates were required to describe aldol condensation and explain why acetone and ethanol can undergo aldol condensation whereas $(CH_3)_3C\text{-}CHO$ and $(CH_3)_3C\text{-}CHO$ cannot. In part (b), they were required to distinguish ethanoyl chloride and 2 – chloro ethanal; phenol and cyclo hexanol; methanoic acid and ethanoic acid. In part (c), they were required to carry out conversions in not more than three steps from butanamide to butanonitrile, benzene to 1-methyl-ethylbenzene, benzene to phenyl ethanone, phenyl amine to 4-nitrophenyl amine & 2-nitrophenyl amine,

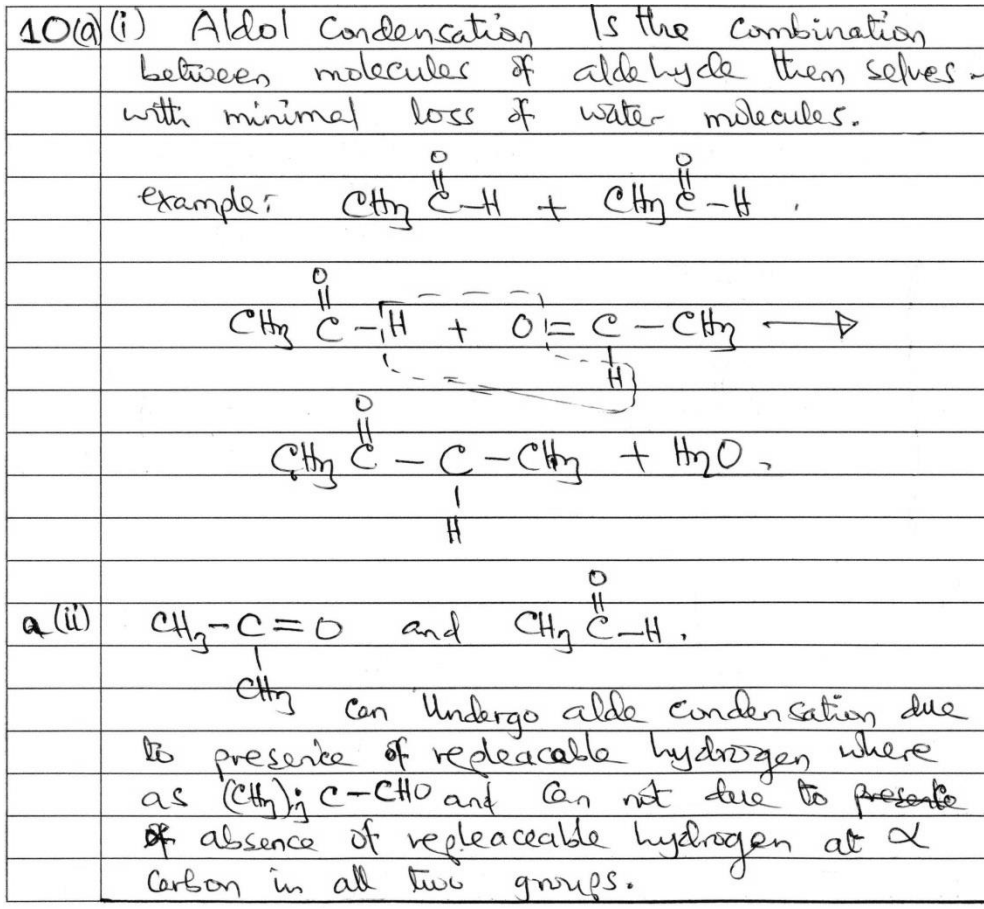
$$NH_2\text{–}\overset{\overset{O}{\|}}{C}\,CH_2 - COO^-NH_4^+ \text{ to } \quad \overset{\overset{O}{\|}}{\underset{\underset{NH_2}{|}}{C}}\text{-}CH_2\text{-}\,COOH.$$

It was observed that this question was skipped by most of the candidates as only 3,307 (20.5%) opted for the question. Among the candidates who attempted the question, 18.6 percent scored below 6 out of 20 marks of which 2.8 percent scored a zero mark. The candidates who scored from 6 to 10 marks were 40.7 percent. Besides, 37.3 percent scored 10.5 to 15 marks.

It is only 3.4 percent of the candidates who managed to score 15.5 to 19 marks, but there was no any candidate who scored all the allocated marks. However, the performance in this question was good.

The candidates who performed well were able to describe correctly aldol condensation and explained why acetone and ethanol can undergo aldol condensation whereas two, 2,2-dimethyl propanal cannot. They also distinguished well the given pairs of compounds in 10 (b); but encountered difficulties in part (c) (v), as they failed to understand that, amino group is first protected by acetylation then the acetylated product is nitrated. Not only that, others had problems in part 10 (c) (iv), as they failed to understand that the compound is treated with dilute mineral acid in the cold hence they could not score full mark. Extract 10.1 illustrate the case.

Extract 10.1



10(b) (i) $CH_3\overset{O}{\overset{\|}{C}}-Cl$ and $H-\overset{O}{\overset{\|}{C}}-CH_2-Cl$.

This can be distinguished by chloro form test.

$CH_3\overset{O}{\overset{\|}{C}}-Cl$ can react with excess chlorine in basic medium to produce white precipitate of chloroform.

$$CH_3\overset{O}{\overset{\|}{C}}-Cl + 3Cl_2 + 4NaOH \longrightarrow \underset{\text{white (ppt)}}{CHCl_3} + HCOONa + 3NaCl + 3H_2O$$

- while $H\overset{O}{\overset{\|}{C}}-CH_2-Cl$ does not react with chloro form.

that is $H\overset{O}{\overset{\|}{C}}-CH_2-Cl + 3Cl_2 + 4NaOH \longrightarrow$ no white (ppt.

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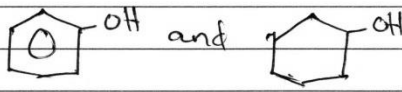
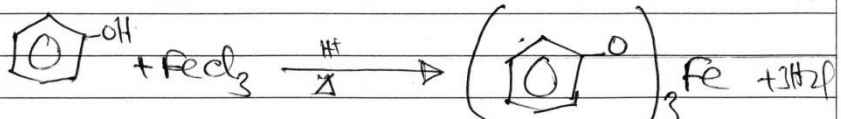
b(ii)  and

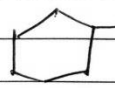
This can be distinguished by Ferric chloride

- phenol react with Iron(III) chloride to produce violet ppt of complex compound.



violet ppt formed

10(b) (ii) While does not produce violet colour with iron(III) chloride



$+ FeCl_3 \xrightarrow{\Delta}$ No violet Precipitate formed.

(iii) HCOOH and CH_3COOH.

Methanoic acid (HCOOH) decolourizes purple ~~potassium~~ potassium permanganate due to its oxidation property it is oxidized into carbondioxide:

ie. $HCOOH + KMnO_4 \longrightarrow CO_2 + KMnO_2 + H_2O$

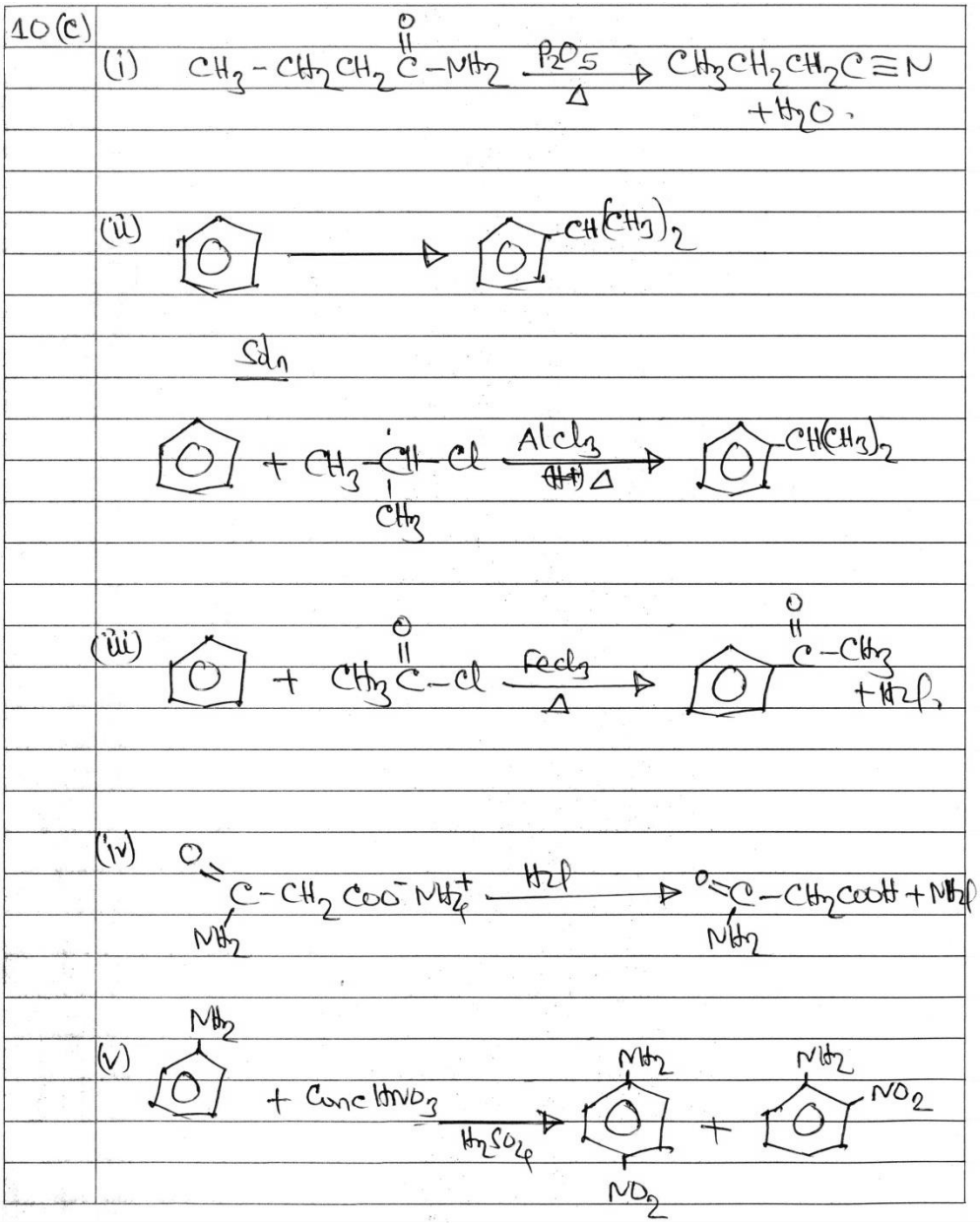
(Purple) colourless

While,

Ethanoic acid does not decolourize purple potassium permanganate because does not undergo oxidation reaction.

ie. $CH_3\overset{O}{\overset{\|}{C}}-OH + KMnO_4 \longrightarrow$ No reaction.

(Purple) (Purple).

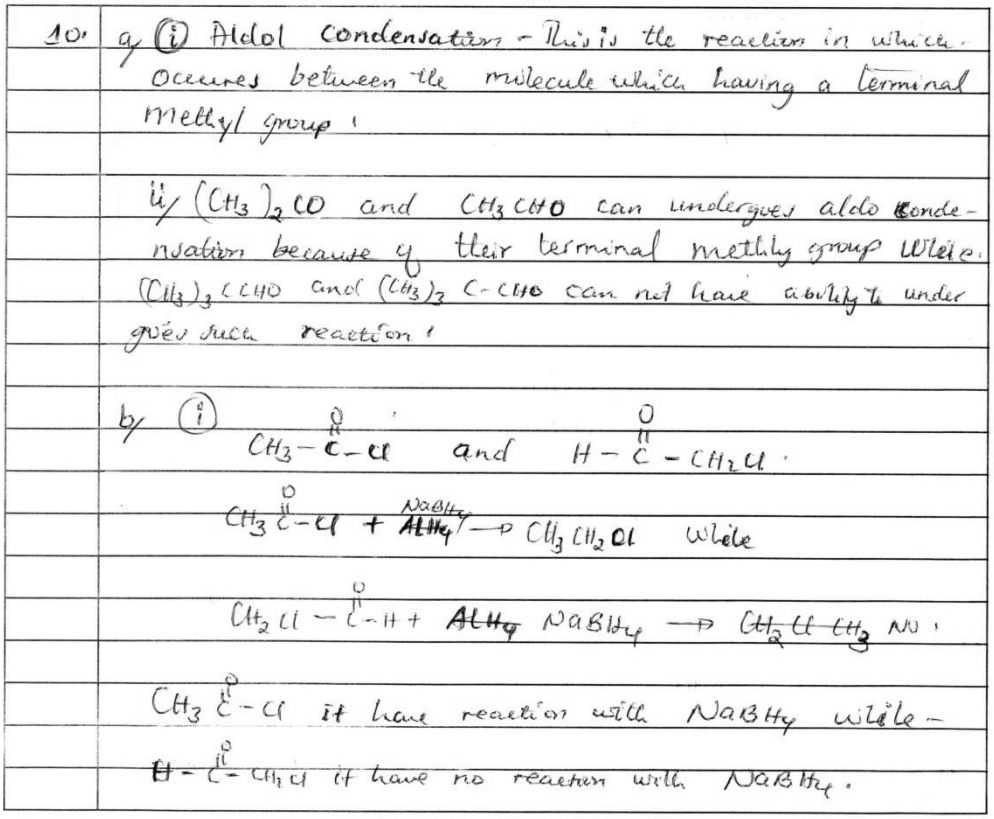


In extract 10.1, the candidate presented accurate answers clearly, but encountered difficulties in part (b) (i) & (iii) and (c) (iv). She/he failed to understand that the conversion of the compound in part (c) (iv) is treated with dilute mineral acid in the cold, hence he/she could not score full mark.

The candidates who performed poorly in this question failed to describe aldol condensation. Others had insufficient knowledge on the required organic reactions and behaviour of some organic substances which have

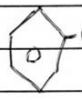
similar structures. The concept of protection and de - protection of amino group during nitration of amino benzene was the biggest problem that attributed to failure of most of the candidates in part 10 (c), since, almost all candidates who performed poorly did a normal nitration reaction of which was incorrect. Extract 10.2 shows a sample of the candidates' poor response.

Extract 10.2



10 b/ (ii) :

and

+ NaOH ⟶  + H_2O

+ NaOH $\xrightarrow[\text{ether}]{\text{dry}}$ NO - Reaction :

∴ It have reaction with NaOH under dry ether

While have no reaction with NaOH :

(iii) HCOOH and CH_3COOH :

$HCOOH + I_2 \xrightarrow{NaOH}$ NO Reaction

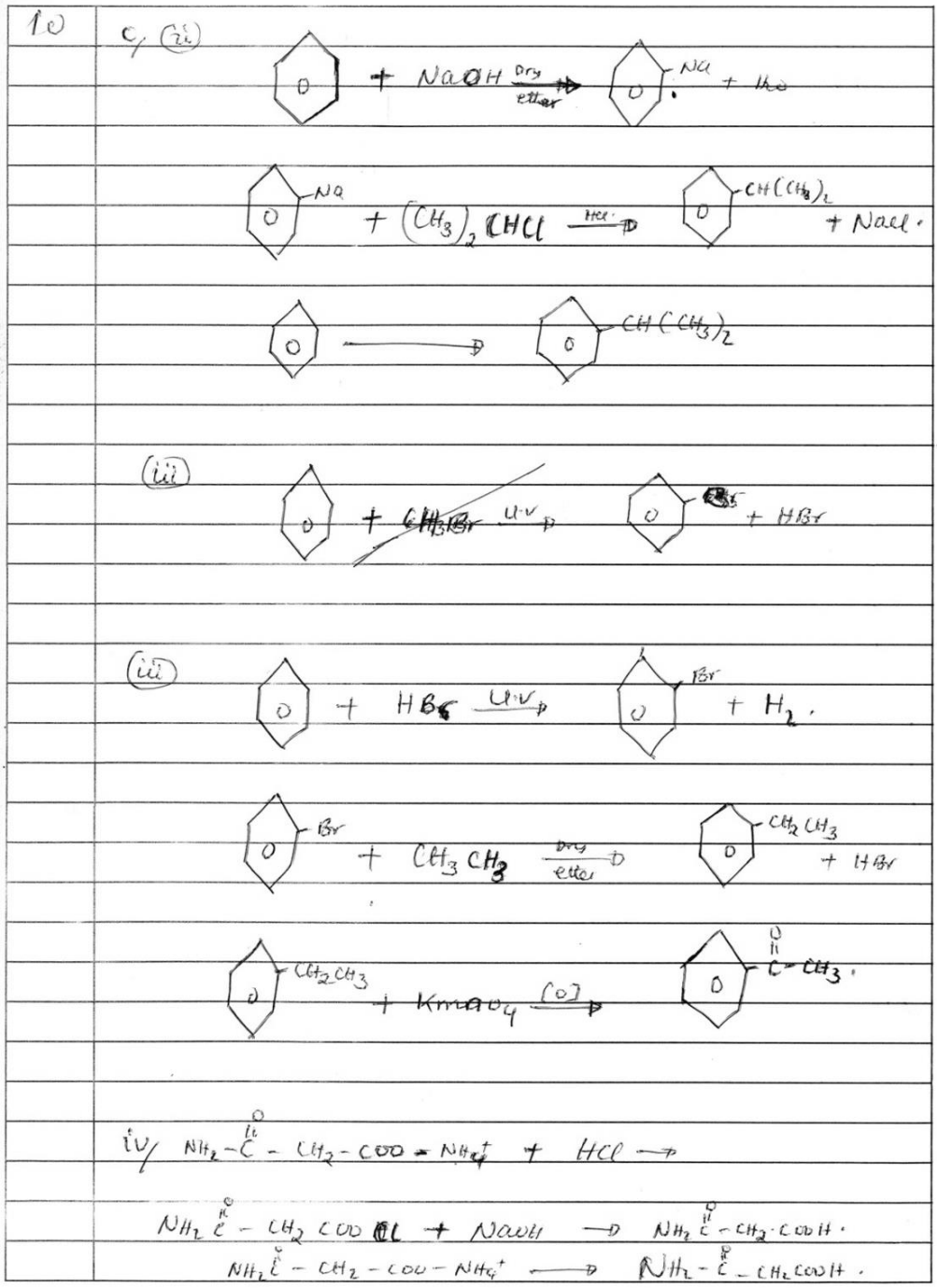
$CH_3COOH + 3I_2 + NaOH \longrightarrow CHI_3 + NaI$

HCOOH have no reaction with Iodotest because have no terminal hydrogen While CH_3COOH have reaction with Iodo test because have terminal hydrogen and bring purple colour :

c/ (i) $CH_3-CH_2-CH_2-\overset{O}{\overset{\|}{C}}-NH_2 \longrightarrow CH_3-CH_2CH_2C\equiv N$:

$CH_3CH_2CH_2\overset{O}{\overset{\|}{C}}-NH_2 + H_2O_1 \longrightarrow CH_3CH_2CH_2C=NH_2$

$CH_3CH_2CH_2C=NH_2 + HCl \longrightarrow CH_3CH_2CH_2C\equiv N$:



Extract 10.2 shows a sample of a response of the candidate who scored poor marks. The candidate gave incorrect description of aldol condensation. He/she failed to apply aldol condensation to respond to part a (ii) of the question. He/she could not distinguish between the given pairs of organic

compounds and finally he/she failed to carry out the given organic conversions.

3.0 CONCLUSION AND RECOMMENDATIONS

3.1 Conclusion

The question wise analysis of the performance in Chemistry paper One and Two for the ACSEE 2014 has shown that 69.9 percent of the candidates scored 30 percent or above of the marks allocated for each question. This indicates an overall candidates' good performance.

Further analysis on how candidates performed in different topics is summarized in Appendix (Summary of Performance of the Candidates Topic-wise). The analysis shows that 19 topics among 20 which were examined in paper 1 & 2 were good performed, 1 topic was performed averagely and no topic which was poorly performed. Good performance of candidates was contributed by good mastering of the concepts asked in the respective topics.

However, analysis on individual items indicates that, few candidates experienced difficulties in answering question items which involved basic skills on mathematics based on chemistry principles. This is evident from the analysis made in questions from content areas of chemical equilibrium and soil chemistry. This performance could be attributed by lack of mathematical skills and inadequate skills of these topics. These insufficiencies need to be dealt with both teachers and students during the learning process.

It is expected that the feedback given in this report will enable stakeholders to take appropriate initiatives to improve more the performance of candidates in ACSEE in Chemistry, taking into consideration that the subject forms a bridge for science courses in Tertiary level of Education.

3.2 Recommendations

In view of the analysis and the conclusion made in the performance of candidates in this examination, the following recommendations are made;

(i) Students should continuously be encouraged to revise all topics across the syllabus in their normal study time and during preparations for examination.

(ii) Teachers should put special emphasis on facilitating basic concepts of theoretical knowledge of the subject in daily life situation in competency based environment.

(iii) School should create conducive school environment for teaching and learning of Chemistry and other Science subjects.

(iv) Ministry of Education and Vocational Training should ensure adequate availability of learning and teaching resources to all schools so as to foster students learning.

APPENDIX A

Summary of Performance of the Candidates-Topicwise

S/n	Topic	No. of Questions	% of Candidates who Scored an average of 30 % or Above	Remarks
1	Energetics	1	95.7	Good
2	Carbonyl Compounds, Hydroxyl Compounds/Carboxylic Acids.	1	90.6	Good
3	Gases	2	86.7	Good
4	Relative Molecular Masses in Solution	1	86.1	Good
5	Carbonyl Compounds and Ammines.	1	81.4	Good
6	Electrochemistry	1	80.3	Good
7	Acids, Bases and Salts	1	77.9	Good
8	Transition Elements	1	75.5	Good
9	Periodic Classification	1	74.5	Good
10	Chemical Kinetics	1	67.7	Good
11	Halogen Derivatives of Hydrocarbons	1	67.4	Good
12	The Atom	1	66.6	Good
13	Extraction of Metal	1	62.8	Good
14	Solubility, Solubility Product & Ionic Product	1	62.5	Good
15	Aromatic Hydrocarbons	2	58.0	Good
16	Chemical Bonding	2	57.2	Good
17	Two Liquids Components	1	56.7	Good
18	Aliphatic Hydrocarbons and Aromatic Hydrocarbons	1	55.5	Good
19	Soil Chemistry.	1	50.8	Good
20	Chemical Equilibrium	2	44.0	Average