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

CANDIDATES' ITEM RESPONSE ANALYSIS REPORT ON THE DIPLOMA IN SECONDARY EDUCATION EXAMINATION (DSEE) 2022

CHEMISTRY

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732 CHEMISTRY

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FOREWORD

The National Examinations Council of Tanzania (NECTA) administered Diploma in Secondary Education Examinations (DSEE) in May 2022. The Candidates' Item Response Analysis Report (CIRA) in Chemistry subject has been prepared to provide feedback to college tutors, parents, guardians, students, policy makers, education quality assurers and other education stakeholders, on the candidates' performance in this year. Among other purposes, DSEE enables education stakeholders to evaluate the effectiveness of the education system and its delivery.

The report is intended to highlight the factors behind for the observed performance. The performance was good in three topics, average in three topics and weak in five topics. It was observed that some of the factors contributed to high scores to some candidates include sufficient knowledge of concepts, adequate skills for solving numerical problems, and understanding of the principles of teaching and learning. On the other hand, weak performance in some topics was contributed by poor mastery of the content assessed.

It is hoped that, the analysis presented in this report will enable the education stakeholders to identify proper measures to be taken in order to improve the teaching and learning of chemistry. Also the given recommendations will be useful instrument for enhancing the candidates' performance in future examinations administered by the Council.

Finally, the Council would like to thank all individuals who participated in the preparation of this report.

Athumani S. Amasi
EXECUTIVE SECRETARY

1.0 INTRODUCTION

This report presents the performance of candidates who sat for DSEE 2022 in Chemistry subject. The examination comprised two papers, which were 732/1 Chemistry 1 (Theory paper) and 732/2 Chemistry 2 (Practical paper). Theory paper consisted of 14 questions in two sections, namely A and B where the practical paper was comprised of three questions.

The examination assessed the candidates' competences in applying knowledge and skills acquired in chemistry to solve day-to-day life challenges, manage chemistry laboratory and assess learners' achievement according to the content and objectives stipulated in the 2009 syllabus.

The analysed data revealed that 1,793 (99.6%) out of 1,815 (100%) candidates who sat for the examination passed while 8 (0.4%) candidates failed. Generally, the performance in 2022 has dropped by 0.4 per cent compared to 2021 where all candidates (100%) passed. Table 1 summarizes the comparison of candidates' performance between the year 2021 and 2022.

Table 1: Comparison of Candidates' performance in Chemistry Examination between 2021 and 2022

Year	candidates	Number of Candidates and Percentage					
		Passed	Grades				
			A	B	C	D	F
2021	679	679	9	148	444	78	0
		100%	0.1%	21.5%	64.6%	11.4%	0%
2022	1,815	1,793	0	90	1,121	582	8
		99.6%	0%	5.0%	62.3%	32.3%	0.4%

Table 1 shows that, 1,793 (99.6%) candidates passed in DSEE 2022, whereas 679 (100%) candidates passed the examination in 2021. The statistical data indicate that the performance in grades A and B was higher in 2021 than in 2022 where no candidate scored grade A.

The report is organised into five sections, namely introduction, analysis of the candidates' performance in each question, analysis of performance in each topic, conclusions and recommendations. In addition, a summary of performance of topics tested in Chemistry paper 1 and Chemistry paper 2 is given in Appendices I and II respectively.

The analysis has sorted the performance into three categories, namely good (70 - 100) represented in this report by green colour, average (40 - 69) denoted by yellow colour and poor (0 - 39) marked by red colour.

2.0 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION

This part analyses both statistical data and candidates' responses on each question in both Chemistry paper 1 and 2 separately. The statistics in each question are presented with the aid of figures or tables while the description of responses are supported by the use of extracts.

2.1 732/1 Chemistry 1: Theory Paper

The Chemistry theory paper comprised of two sections, A and B. Section A consisted of ten short answer questions, each carrying 4 marks. Section B had four structured questions and each carried 15 marks. The candidates were required to answer all the questions in sections A and B.

2.1.1 Question 1: General Chemistry

This question had two parts, (a) and (b) as follows:

In an experiment to determine the structure of an atom, Rutherford bombarded positively charged alpha particles to the atoms of a gold foil and observed the following:

(a) Most of the alpha particles passed through the gold foil without suffering any deflection.

(b) Very few particles rebounded completely on hitting the gold, foil. What is the interpretation of each of the observations?

The question was attempted by 1,815 (100%) candidates. Generally, the performance in this question was weak since 1,630 (89.8%) candidates scored below 2.0 marks out of which 1,580 (87.1%) candidates scored zero mark. The performance is further summarized in Figure 1.

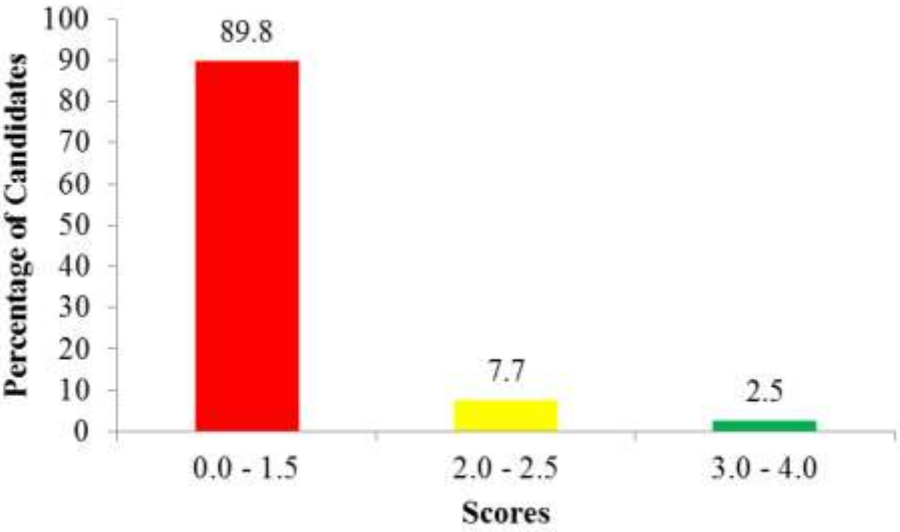


Figure 1: *Distribution of Candidates' Scores in Question 1*

Figure 1 shows that 89.8 per cent of the candidates scored from 0 to 1.5 marks, 7.7 per cent scored from 2.0 to 2.5 marks while 2.5 per cent scored from 3.0 to 4.0 marks.

Candidates who scored low marks (89.8%) gave incorrect responses. In attempting part (a), some of the candidates responded by giving irrelevant answers to the question why most alpha particles passed through the gold foil without suffering any deflection in the Rutherford's gold foil scattering experiment. The candidates did not understand that the gold foil consisted of atoms whose large part is empty or hollow and thus the alpha particles penetrated easily through the gold foil. Common misconceptions of candidates included suggesting that the gold foil was thin, soft and others responded that gold leaf is a good conductor, which is not correct. Also, some of the candidates incorrectly associated penetration of alpha particles with the presence of electrons in atoms. In part (b), some of the candidates incorrectly associated the rebounding of few alpha particles with the presence of electrons around the nucleus. In another case, candidates gave partial answers by referring to alpha particles being charged without specifying the type of charge. The candidates were supposed to know that few particles of alpha were repelled by positively charged centre that has concentrated mass (nucleus). A sample of incorrect responses from one of the candidates is shown in Extract 1.1.

(a) Most of the alpha particles passed through the gold foil without suffering any deflection because the nucleas of the atom are closed and electrons envolved around the nucleus through

b) Because the size of the nucleus are very small. So the atom cannot be destroyed or created by the process.

Extract 1.1: A sample of incorrect responses to question 1.

In extract 1.1, the candidate incorrectly stated revolution of electrons in an attempt to account for the penetration of alpha particles in gold foil in part (a). Similarly, in part (b) he/she incorrectly gave a statement regarding Dalton atomic theory instead of accounting for the rebounding of some particles on the gold foil.

On the other hand, candidates who scored high marks (2.5%) managed to give correct interpretation regarding the observation that most of the alpha particles passed through the gold foil without suffering any deflection in part (a). For instance, one candidate wrote: *Most of the alpha particles passed through the gold foil without suffering any deflection because of the large space on the atom is empty just possessed by electrons revolving around.* The candidates also managed to state that few alpha particles which fall on nucleus rebounded from gold foil since the nucleus carries positive charge. The correct responses given indicate that the candidates had adequate knowledge of the properties and structure of atom. Extract 1.2 shows a sample of good responses from one of the candidates.

1

a) Most of the alpha particles passed through the gold foil without suffering any deflection, Because of the large space on the atom is empty space just possessed by orbit and electrons revolving around.

b) Very few particles rebounded completely on heating the gold foil, Because of the presence of the nucleus at the center of the atom containing protons (positive charges).

Extract 1.2: A sample of correct responses to question 1.

In extract 1.2, the candidate gave correct reasons in both part (a) and (b) to justify the observations. This implies that the candidate had sufficient knowledge of atomic structure.

2.1.2 Question 2: Chemical Kinetics, Energetics and Equilibrium

In this question, candidates were required to write the order of reaction with respect to Br_2 and H_2, together with overall order of reaction in rate equation: $R=k[Br_2]^2[H_2]^1$.

This question was attempted by 1,815 (100%) candidates. Generally, the performance of candidates in this question was average as 1,171 (64.5%) candidates scored 2.0 marks or above while 644 (35.5%) failed. Distribution of candidates' scores is summarized in Figure 2.

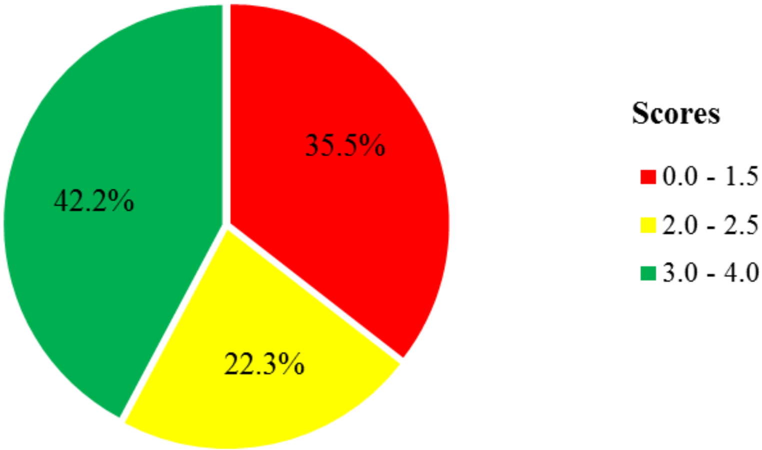


Figure 2: *Distribution of Candidates' Scores in Question 2*

Figure 2 shows that those who scored from 0 to 1.5 marks were 35.5 per cent, 2.0 to 2.5 marks were 22.3 per cent and 3.0 to 4.0 marks were 42.2 per cent.

Most of the candidates (64.5%) gave the correct order of reaction with respect to both Br_2 and H_2 and the overall order of reaction. The correct response indicates that the candidates had adequate knowledge of the concept of rate law equation. A sample of good responses in this question is presented in Extract 2.1.

2

$Rate = K[Br_2]^2[H_2]^1$

$Rate = K[Br_2]^m[H_2]^n$, $m=2$, $n=1$.

• The order of reaction with respect to $[Br_2]$ is 2

• The order of reaction with respect to $[H_2]$ is 1.

• Over all order of reaction is $1+2=3$.

The over all order of reaction is 3.

Extract 2.1: A Sample of good responses to question 2.

In Extract 2.1, the candidate correctly gave order of reaction with respect to bromine gas, hydrogen gas and finally the overall order of the reaction.

On the other hand, those who scored low marks (35.5%) gave partial responses to the question. Some of them changed the order of reaction with respect to Br_2 and H_2 while others incorrectly multiplied 2 and 1 to get the overall order of reaction instead of adding 2 and 1. Some candidates ended up copying the rate law equation without stating the order of reaction while others stated the order of reaction without indicating the reactant concerned. In stating the overall order of reaction, some candidates gave wrong formula for the equilibrium (KC) contrary to the demand of the question. Furthermore, some of the candidates gave units of rate of reaction instead of giving the order of reaction. Extract 2.2 indicates a sample of incorrect responses from one of the candidates.

2

Solution

Rate $= k[Br_2]^2[H_2]^1$

but

Rate $= \frac{\text{Something}}{\text{Time}}$

Rate $= \frac{dR}{dt}$

$dR/dt = \frac{d\,k[Br_2]^2[H_2]^1}{dt}$

$dR \int dt = d\,k[Br_2]^2[H_2]^1$

$X = kt$

(i) The order of reaction is zero order

(ii) Overall of reaction is $X = kt$

Extract 2.2: A sample of incorrect responses to question 2.

In extract 2.2, the candidate incorrectly differentiated the rate law equation and concluded that the order of reaction is zero. He/she also stated that the overall order of reaction is X = kt instead of 3. The incorrect responses indicate that the candidate had inadequate knowledge of rate of chemical reaction.

2.1.3 Question 3: Volumetric Analysis

The question consisted of two parts and it was asked as follows:

(a) *A chemistry teacher instructed his students to dissolve exactly 20 g of sodium hydroxide (NaOH) pellets in one dm^3 of solution. Name and explain such kind of a solution.*

(b) *What is the molarity of a solution that has 0.491 g of NaOH dissolved in 400 cm^3 of solution?*

The question was attempted by 1,815 (100%) candidates.

Generally, the performance of candidates in this question was good as 1,513 (83.4%) candidates scored 2.0 marks or above while 302 (16.6%) failed. The summary of performance in this question is shown in Figure 3.

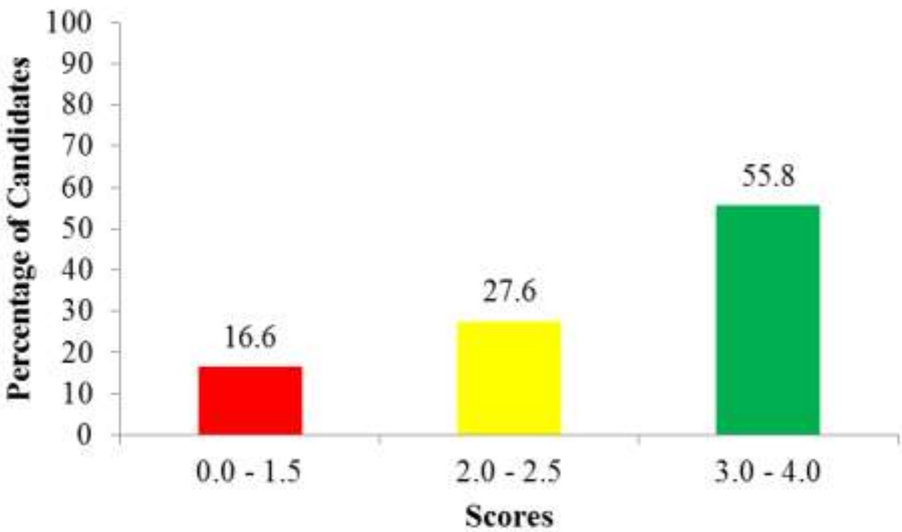


Figure 3: *Distribution of Candidates' Scores in Question 3*

Candidates who scored from 0 to 1.5 marks were 16.6 per cent, 2.0 to 2.5 marks were 27.6 per cent and 3.0 to 4.0 marks were 55.8 per cent.

Analysis of candidates' responses indicates that those who scored high marks (55.8%) correctly named the solution as a standard solution in part (a). Also, the candidates stated clearly that a standard solution is formed by dissolving a known mass of a substance in a known volume of water. In part (b), the candidates correctly calculated the molarity of the solution made by dissolving 0.491 g of NaOH in 400 cm^3 of solution. Furthermore, they calculated the concentration and molarity by using molar mass and concentration. The correct responses given in this question indicates that the candidates had adequate knowledge of Volumetric Analysis. Extract 3.1 shows a sample of good responses to question 3.

3 (a) The kind of solution is standerd solution
— standerd solution is the solution whose concentration is known, Hence when the student disolves 20g of sodium hydroxide into one dm^3 of solution their intended to get the concentration of asolution.

(b) Molarity = $\frac{\text{Concentration (Conc)}}{\text{molar mass (Mr)}}$

but

Con = $\frac{\text{Mass}}{\text{volume}}$ = $\frac{0.491g}{0.4dm^3}$ = 1.2275 g/dm^3

Molarity = $\frac{1.227 g/mol dm^3}{40g/dm^3 mol}$

Molarity = 0.03M.

Extract 3.1: A Sample of good responses to question 3.

In extract 3.1, the candidate identified the solution and gave a correct explanation in part (a). Similarly, in part (b), he/she calculated molarity by using correct formulae and finally reached into a correct answer.

On the other hand, candidates who scored low marks (16.6%) gave partial answers to part (a). For instance, some of them named the solution as a saturated solution instead of standard solution. Others incorrectly termed the solution as a molar solution, which implies that they did not understand that a molar solution should have a molarity that equals to one and not necessarily the one formed by dissolving substance in one litre. Also most candidates in this category gave inappropriate explanations to justify the name of the solution. For example, some stated that the solution is a concentrated one while others wrote that the solution is a diluted one. In attempting part (b), some of the candidates used inappropriate formulae to calculate molarity of the solution. For example, one candidate divided volume to the mass of sodium hydroxide. Another candidate incorrectly wrote; *Molarity = Concentration* × *Molar Mass* instead of assuming that concentration is the product of molarity and molar mass. Others did the calculation without converting the volume of the solution into litres. In addition, some of the candidates gave explanations instead of calculations in part (b). The incorrect responses indicate that the candidates lacked sufficient knowledge of Volumetric Analysis. Extract 3.2 shows a sample of incorrect responses to question 3.

3 The name of solution is hydrochloric acid

a)

→ Hydrochloric acid (HCL) and the kind of a solution is dilution law. It help to identify and calculate the Molarity of the concentrated ~~and~~ hydrochloric acid

→ It calculate the volume of concentrated hydrochloric acid in the experiment.

b) The Molarity of a solution that has 0·491 g of NaOH dissolve in 400cm³ of solution is 0·1M.

Extract 3.2: A sample of incorrect responses to question 3.

In Extract 3.2, the candidate named the solution as hydrochloric acid instead of a standard solution. He/she pointed outstated the importance of the dilution law instead of naming the solution as a standard one. In part (b), the candidate gave incorrect molarity and did not show the mathematical procedure involved.

2.1.4 Question 4: Electrochemistry

In this question, candidates were required to derive the degree of dissociation of weak acid. The question was asked as follows

Given that $HA\ (aq) \rightleftharpoons H^+\ (aq) + A^-(aq)$ *is an equation for the dissociation of a weak acid electrolyte, show that the degree of dissociation* (α) *is given by* $\alpha = \sqrt{\frac{Ka}{c}}$

The question was attempted by all 1,815 (100%) candidates. Generally, the performance of candidates in this question was weak since only 431 (23.8%) candidates scored 2.0 marks or above while 1,384 (76.3%) failed. This performance is summarized in Figure 4.

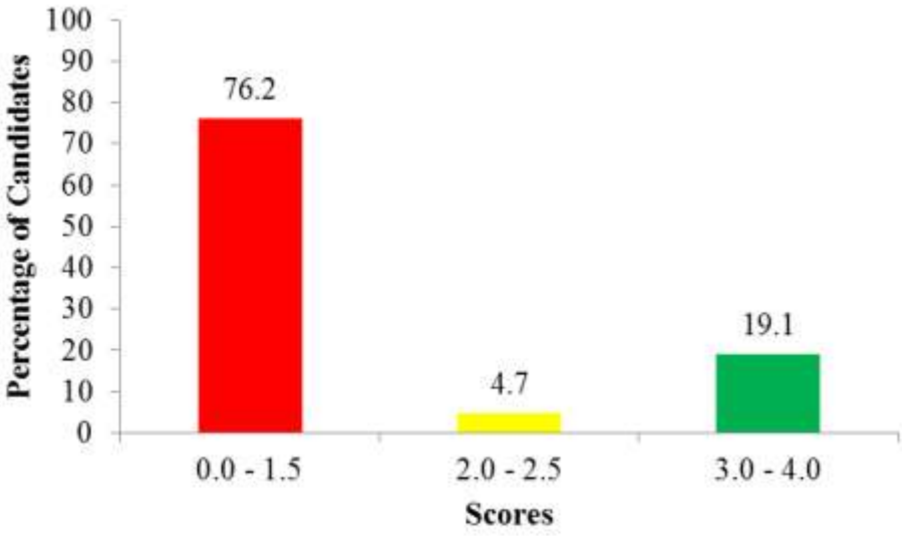
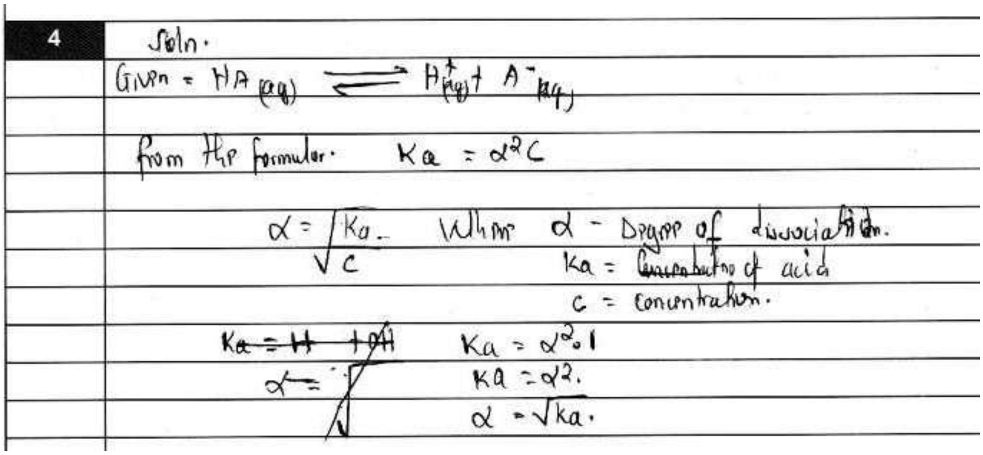


Figure 4: *Distribution of Candidates' Scores in Question 4*

Figure 4 shows that candidates who scored from 0 to 1.5 marks were 76.2 per cent, 2.0 to 2.5 marks were 4.7 per cent and 3.0 to 4.0 marks were 19.1 per cent.

Candidates (76.2%) who scored low marks failed to derive the formula for the degree of dissociation. Some of them indicated incorrect concentrations of the components at equilibrium. For example, one candidate indicated the degree of dissociation in the initial concentrations instead of the final concentrations of the products of dissociation. Another candidate wrote αc instead of $c(1-\alpha)$ as the final concentration of HA(aq) at equilibrium. Other candidates incorrectly introduced the concept of partial pressure instead of concentration during derivation. Also, there were candidates who copied the question without deriving the degree of dissociation. Generally, the candidates did not indicate correct moles of ions before and at equilibrium, and therefore failed to present the equation for degree of dissociation (α). Extract 4.1 shows a sample of incorrect responses to question 4.



4

Soln.

Given = $HA_{(aq)} \rightleftharpoons H^+_{(aq)} + A^-_{(aq)}$

from the formular. $Ka = \alpha^2 C$

$\alpha = \sqrt{\frac{Ka}{C}}$ Where α - Degree of dissociation.

Ka = Concentration of acid

c = concentration.

~~$Ka = H + OH$~~ $\quad Ka = \alpha^2 \cdot 1$

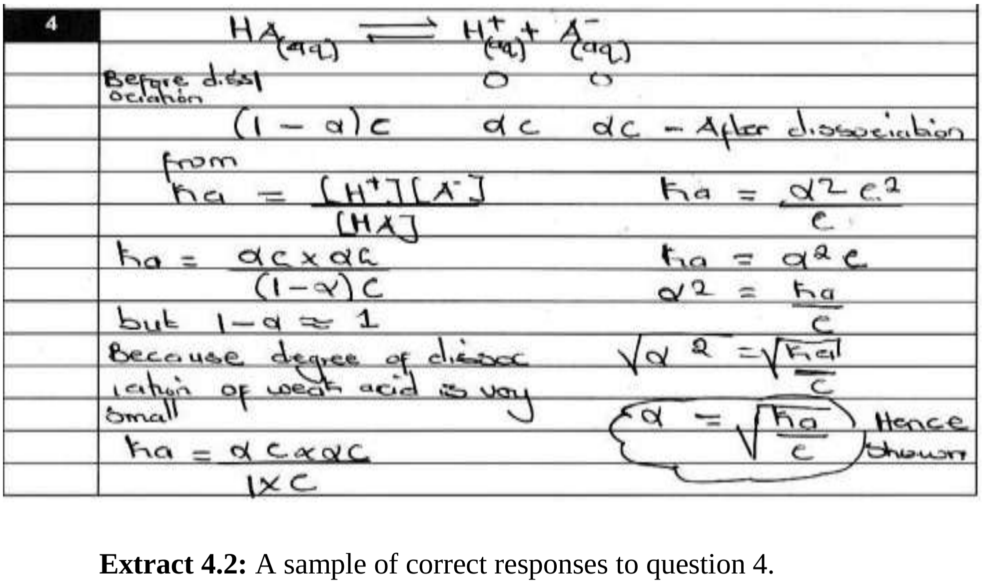
$\alpha = \sqrt{\ }$ $\quad Ka = \alpha^2.$

$\alpha = \sqrt{ka}.$

Extract 4.1: A sample of incorrect responses to question 4.

In Extract 4.1, the candidate skipped some stages and finally gave a wrong degree of dissociation.

Conversely, candidates who scored high marks (19.1%) correctly showed the initial concentrations before dissociation and the concentrations after dissociation. They also did the calculation part correctly by relating degree of dissociation (α) with acid dissociation constant (ka) and concentration (C). This shows that the candidates had sufficient knowledge of Electrochemistry on Ostwald's dilution law. Extract 4.2 shows a sample of correct responses to this question.



4

$HA_{(aq)} \rightleftharpoons H^+_{(aq)} + A^-_{(aq)}$

Before dissociation $\quad 0 \quad 0$

$(1-\alpha)c \quad \alpha c \quad \alpha c$ - After dissociation

from

$ka = \frac{[H^+][A^-]}{[HA]}$ $\qquad ka = \frac{\alpha^2 c^2}{c}$

$ka = \frac{\alpha c \times \alpha c}{(1-\alpha)c}$ $\qquad ka = \alpha^2 c$

$\alpha^2 = \frac{ka}{c}$

but $1-\alpha \approx 1$ Because degree of dissociation of weak acid is very small

$\sqrt{\alpha^2} = \sqrt{\frac{ka}{c}}$

$\alpha = \sqrt{\frac{ka}{c}}$ Hence shown

$ka = \frac{\alpha c \times \alpha c}{1 \times c}$

Extract 4.2: A sample of correct responses to question 4.

In extract 4.2, the candidate wrote the dissociation equation correctly, showed the concentrations properly and derived the correct formula of calculating degree of dissociation of weak acids.

2.1.5 Question 5: Transition Metals

This question required the candidates to briefly explain why ammonia molecule readily coordinate with cation of the transition metals but ammonium ion (NH_4^+) does not.

The question was attempted by 1,815 (100%) candidates. Generally, the performance of candidates in this question was weak since 516 (28.5%) candidates scored 2.0 marks or above while 1,299 (71.5%) failed. Moreover, 1,011 candidates (55.7 %) scored zero. The distribution of the candidates' scores in this question is shown in Figure 5.

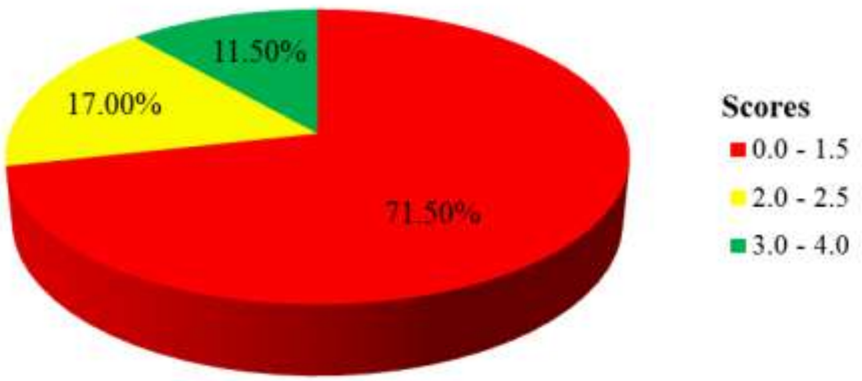


Figure 5: *Distribution of Candidates' Scores in Question 5*

Figure 5 shows that 71.5 per cent of the candidates scored from 0 to 1.5 marks, 17.0 per cent scored from 2.0 to 2.5 marks and only 11.5 per cent scored from 3.0 to 4.0 marks.

The candidates (71.5%) who scored low marks failed to relate the concept of coordinate bond in relation to vacant orbital and free electrons, especially lone pair electrons possessed by ammonia molecule. For example, one candidate explained that *because ammonia molecule has variable oxidation state, ability to form color and is paramagnetic while ammonium ion does not.* This response is incorrect because variable oxidation state is a characteristic of transition metals rather than ammonia. Another candidate incorrectly responded the “ammonia molecules have no free ions that allow the reaction with other element but NH_4^+ have free ions that allow the incoming charge that can react.” Some of the candidates focused their explanation on the size of ammonia and ammonium ion, which was not correct. Furthermore, some candidates explained the difference based on polarity of ammonia and ammonium which does not account for the observation. Generally, majority of the candidates who scored low marks had insufficient knowledge about complex compounds and ligands.

Extract 5.1 shows an example of incorrect responses to question 5.

5	Ammonia molecules readily coordinate with
	cations of the transition metal because
	they have no free ions that arrow to
	react with other element but NH_4^+ do
	es not form compl coordinate because
	have free ions. that allow the inte
	incoming charge that can be react
	with free ions in NH_4^+.

Extract 5.1: A sample of incorrect responses to question 5.

In Extract 5.1, the candidate cited the concept of free ions, which is contrary to the demand of the question.

On the other hand, few candidates (11.5%) who scored high marks managed to explain the reason why ammonia molecule form coordinate bond with transition metal but NH_4^+ cannot. The candidates explained the concept of lone pair of electrons which is the root of the answer. For example, one candidate explained that *ammonia molecule has lone pair to be donated to empty orbital of transition metal, while ammonium ion does not have electron to donate in forming coordinate bond with transition metals*. Extract 5.2 shows a sample of correct responses to this question.

5	Presence of lone Pairs on ammonia mole-
	cule NH_3 allow it to coordinate with the
	transition metals. NH_4^+ Can not Coordinate
	with transition metals since it has no
	lone Pairs

Extract 5.2: A sample of correct responses to question 5.

In Extract 5.2, the candidate gave correct and brief explanation as per the demand of the question.

2.1.6 Question 6: Organic Chemistry

The question consisted of parts (a) and (b). In part (a), candidates were required to complete the reactions in which (i) methyl benzene reacted with bromine under $FeBr_3$, (ii) methyl benzene reacted with bromine under UV-light. In part (b) they were required to account for the formation of products in part (a).

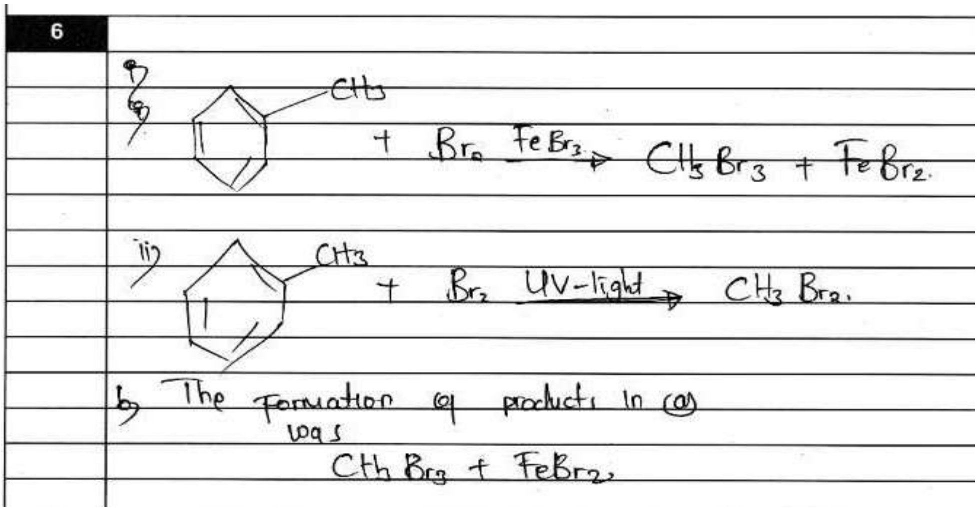
The question was attempted by all 1,815 (100%) candidates. Generally, the performance in this question was weak since only 140 (7.8%) candidates scored 2.0 marks or above while 1,675 (92.2%) failed. Table 2 summarizes the performance in this question.

Table 2: Candidates' Performance in Question 6

Scores	Percentage (%)	Remarks
0.0 – 1.5	92.2	Weak
2.0 – 2.5	6.7	Average
3.0 – 4.0	1.1	Good

Table 2 shows that 92.2 per cent of the candidates scored from 0 to 1.5 marks, 6.7 per cent scored from 2.0 to 2.5 marks and 1.1 per cent scored from 3.0 to 4.0 marks.

Candidates (92.2%) who scored low marks gave incorrect products for the two reactions in part (a). For instance, some of the candidates wrote benzene with a substituent group CH_3Br. Principally, the substituent group should be CH_2Br because CH_3Br violates bonding rules. Other candidates wrote bromo-cyclohexane as one among the products and linear structures as the major products instead of aromatic compounds. Those candidates considered the reactions to be additional ones instead of substitutional reactions. In part (b), the candidates gave incorrect explanation to account for the formation of different products formed in the reactions in part (a). Some candidates incorrectly considered the reactions in (a)(i) and (a)(ii) as nucleophilic and electrophilic substitutional reactions. Other candidates who did not understand the requirement of the question named the products formed from the two reactions. This indicates that the candidates had insufficient knowledge of Organic Chemistry. Extract 6.1 is an example of incorrect responses from one of the candidates.

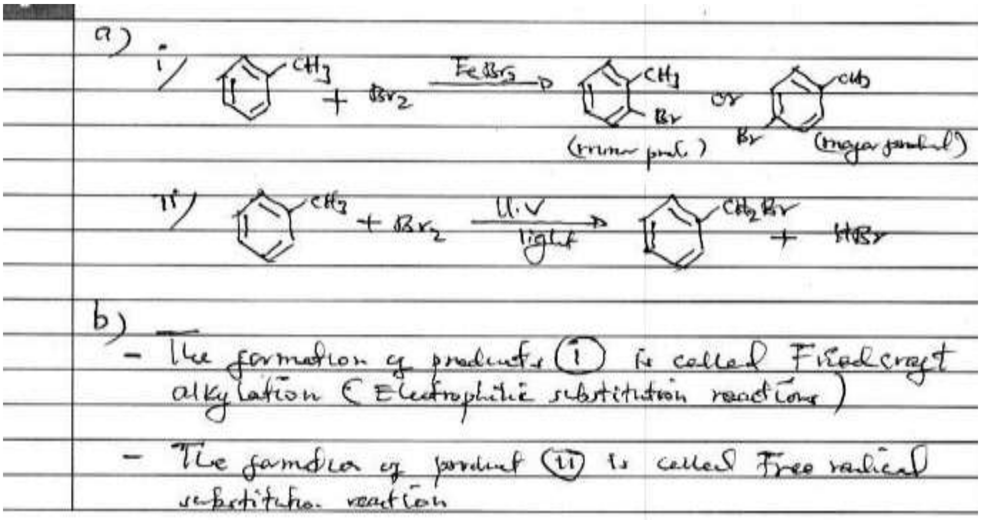


Extract 6.1: A sample of incorrect responses to question 6.

In Extract 6.1, the candidate wrote incorrect products in part (a) and re-wrote some of the products in part (b) contrary to the requirement of the question.

The candidates who scored from 2.0 to 2.5 marks either completed the reactions in part (a) without giving an account for the products formed or gave explanations which were partially correct. This was the reason for their average score.

On the other hand, candidates (1.1%) who scored high marks gave correct products of the two reactions given. In part (a)(i) the products were para or ortho methyl benzene while in (a)(ii) the product was bromomethyl benzene. In part (b), the candidates gave correct account of the products formed in (a). They explained that in the presence of catalyst, electrophilic substitution reaction took place. Furthermore, the candidates justified that in presence of UV-light, free radical substitution reaction took place.
Extract 6.2 shows a sample of correct responses to question 6.



Extract 6.2: A sample of correct responses to question 6.

In extract 6.2, the candidate gave the correct products in part (a) including the minor product. In part (b), he/she stated the concepts behind the different product formed.

2.1.7 Question 7: Principles of Teaching and Learning of Chemistry

In this question, the candidates were required to give six activities on how to prepare a lesson by using an inquiry based learning approach to teach the topic of acids and bases. The question was attempted by 1,815 (100%) candidates. The general performance in this question was weak since only 162 (8.9%) candidates scored 2.0 marks or above while 1,653 (91.1%) failed. The distribution of the candidates’ scores is summarized in Table 3.

Table 3: Candidates' Performance in Question 7

Scores	Percentage (%)	Remarks
0.0 – 1.5	91.1	Weak
2.0 – 2.5	1.2	Average
3.0 – 4.0	7.7	Good

Table 3 shows that 91.1 per cent of the candidates scored from 0 to 1.5 marks, 1.2 per cent scored from 2.0 to 2.5 marks and 7.7 per cent scored from 3.0 to 4.0 marks.

Candidates (91.1%) who scored low marks, including 86.7 per cent who scored zero did not give correct activities on how to prepare a lesson using inquiry based learning approach. Some of the candidates wrote methods of teaching such as group discussion and demonstration. Others gave teaching approaches, including student centred approach and competence based approach. Other misconceptions included writing summaries and questions on acids and bases. For example, one candidate wrote *I will ask students to give really examples of acids and bases.* Furthermore, some candidates responded by giving differences between acids and bases as a result of failure to understand the requirement of the question. Extract 7.1 presents an example of incorrect responses to question 7.

7

i) Ask
ii) Observation.
iii) Creat
iv) Interview.
v) Assessgment.
vi) Quiz.

Extract 7.2: A sample of incorrect responses in question 7.

In Extract 7.2, the candidate incorrectly outlined different terms that do not satisfy the demand of the question.

On the contrary, candidates (7.7%) who scored high marks wrote correct activities or scientific procedures which correspond with the application of the inquiry approach. For instance, one candidate wrote: *inquiry learning approach involves; identification of problem, hypothesis formulation, experimentation, data collection, data interpretation and finally conclusion.* The candidates in this category had adequate knowledge of principles of teaching. Extract 7.2 shows an example of correct responses to question 7.

7

Inquiry learning approach: Is the principle of teaching of chemistry which use investigation process in learning. The following are the way of prepare the lesson using an inquiry based

Identification of the problems of the acid and base: Through using this concept will be identifying

Hypothesis formulation: This will enable to identify the acid and base by testing different chemical.

Experimentation: This will enable to practice during teaching and learning by scientifical method

Data collection: of Acid and Base, Through collecting those information which have been discovered.

Data interpretation: To interprete that data collected from acid and base so will enable to teach.

Conclusion: This to provide the conclusion about the topic of acid and base to be taught in the specific area.

Extract 7.2: An example of correct responses to question 7.

In extract 7.2, the candidate correctly gave six activities that can bring about inquiry learning.

2.1.8 Question 8: Volumetric Analysis

The question required candidates to account for the use of methyl orange indicator during titration of HCl against Na_2CO_3, and the use of phenolphthalein indicator in titration of HCl against NaOH.

The question was attempted by 1,815 (100%) candidates. Generally, candidates' performance was average as 773 (42.6%) candidates scored 2.0 marks or above while 1,042 (57.4%) candidates failed. The distribution of candidates' scores in this question is summarized in Figure 6.

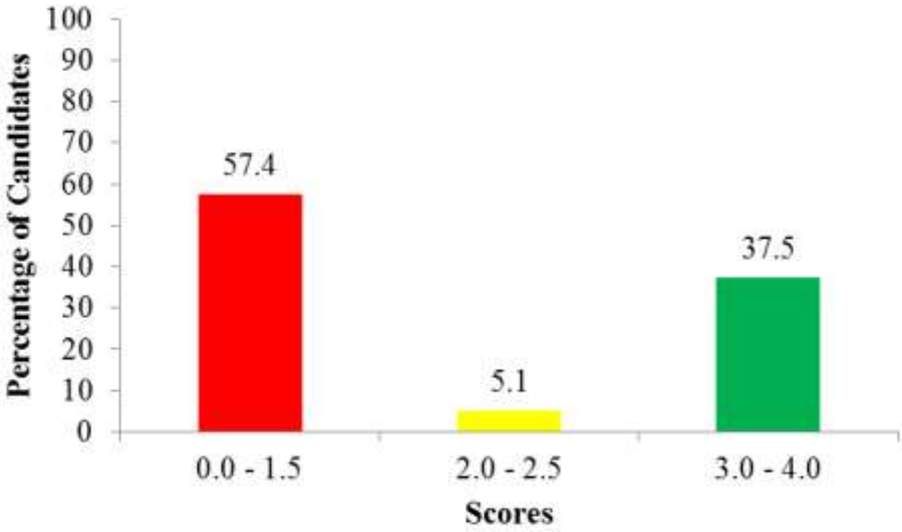


Figure 6: *Distribution of Candidates' Scores in Question 8*

Figure 6 shows that 57.4 per cent of the candidates scored from 0 to 1.5 marks, 5.1 per cent scored from 2.0 to 2.5 marks and 37.5 per cent scored from 3.0 to 4.0 marks.

The candidates (37.5%) who scored high marks accounted for the selection of appropriate indicators during acid-base titration. They explained that methyl orange indicator is used in a titration between a strong acid and a weak base. In this case HCl is a strong acid while Na_2CO_3 is a weak base. In the other case, phenolphthalein indicator was used because in a titration involving strong acid and strong base any indicator is appropriate. For example, one candidate wrote: *methyl orange indicator is useful when strong acid react with weak base. To complete reaction HCl against* Na_2CO_3*, methyl orange indicator is used*. However, in the titration of HCl (strong acid) against NaOH (strong base), either methyl orange or phenolphthalein indicator may be used, thus the choice of phenolphthalein indicator was just optional. The correct responses provided in this question indicate that the candidates had adequate knowledge of Volumetric Analysis. Extract 8.1 displays a sample of correct responses to question 8.

8 - For the first experiment, the two involved solution was titratio-
n between strong acid and weak base, therefore the suitable
indicator for the reaction to react completely was Methyl orange.
But if the teacher could use P.O.P the reaction could not
react completely.

- For the second experiment, the two involved solution in titra-
tion was between strong acid ie HCl against strong base
NaOH, thus any of the indicator could be suitable
and thus why a teacher used P.O.P as an indicator
but also he was also able to use M.O and the reaction
could react completely the same as when POP was used
as the indicator.

Extract 8.1: A sample of correct responses to question 8.

Furthermore, the candidates (5.1%) who scored from 2.0 to 2.5 marks gave a variety of correct and incorrect responses. For example, some of them focused their responses on the concept of double indicators. Such responses imply that the candidates had partial knowledge of choice of indicators in Volumetric Analysis.

Contrarily, the responses of candidates who scored low marks (57.4%) show that the candidates had inadequate knowledge of Volumetric Analysis. Most of them gave incorrect responses such as *methyl orange is used to determine strong acid and weak base*, *phenolphthalein indicator is used to determine weak acid and strong base.* Other candidates incorrectly regarded the indicators as acids and bases. For example, one of the candidates wrote, *methyl orange is weak acid and work best in acidic medium, while phenolphthalein indicator is weak base and work better in basic medium*. The fact is that indicators are used in titration to mark end points but they are neither acids nor bases. Basically, candidates in this category had insufficient knowledge of the concept of Volumetric Analysis. Extract 8.2 shows a sample of incorrect responses to question 8.

8	i) In the First titration of HCL and Na_2CO_3 using the Methyl orange because Hydrochloric acid is strong acid and sodium carbonate also is strong base so that when we use Methyl orange we use on the acid and base which are all strong. ii) In the second titration of HCL and NaOH using phenolyphthalein, because hydrochloric is strong acid and sodium hydroxide is the weak base, so that the phenolyphthalein used on the weak base and strong acid on the reaction.

Extract 8.2: A sample of incorrect responses to question 8.

In Extract 8.2, the candidate incorrectly termed sodium carbonate as a strong instead of a weak base. In the titration which involved phenolphthalein indicator he/she considered sodium hydroxide as a weak base instead of a strong base.

2.1.9 Question 9: Planning and Preparation for Teaching

In this question, the candidates were required to give three factors to consider when preparing a chemistry lesson for Form One class.

The question was attempted by 1,815 (100%) candidates. The general performance of candidates in this question was average as 1,232 (67.9%) scored 2.0 marks or above while 583 (32.1%) failed. The candidates' performance is summarized in Figure 7.

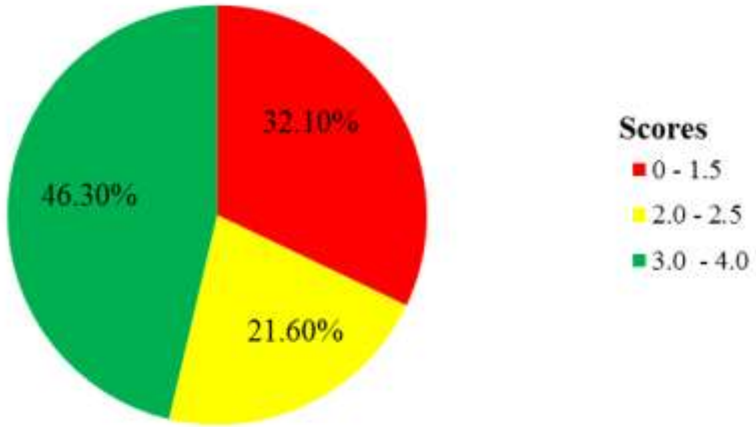


Figure 7: *Distribution of Candidates' Scores in Question 9*

Figure 7 shows that 32.1 per cent of the candidates scored from 0 to 1.5 marks, 21.6 per cent scored from 2.0 to 2.5 marks and 46.3 per cent scored from 3.0 to 4.0 marks.

Candidates (46.3%) who scored high marks listed down three factors to consider when preparing a lesson for Form One class. For example, one candidate wrote; *i) cognitive ability of the students, ii) number of students in the class, iii) content to be taught*. Some of the candidates explained the need for the teacher to determine the complexity and level of difficulty of the subject matter. The candidates were aware that before teaching, a teacher should consider mental ability of the students, size of the class and the content/topic to be taught. Also some candidates explained that the teacher should prepare teaching and learning materials that will suit the lesson. The correct responses given by the candidates indicate that they had adequate knowledge of planning and preparation for teaching. Extract 9.1 shows a sample of correct responses given by one of the candidates.

9 Three factors to be considered when preparing a a chemistry lesson plan for Form one class?.

(i) Cognitive ability of the students, so as to specify the good specific objectives which corelated to their cognitive nature example mention, analyse and list down.

(ii) Number of the students present in the class; so as to choose suitable teaching and learning method.

(iii) Content to be taught; This help to prepare the lesson plan which is very relevant to the level of the students.

Extract 9.1: A sample of correct responses to question 9.

On the other hand, candidates who scored low marks (32.1%) either gave one correct point or did not manage to provide any correct point. For instance, some of the candidates wrote incorrect points on teaching materials such as *writing summary notes, giving reference books, class journal* and *attendance list*. Although these materials are associated with teaching and learning, they are not among the factors to be considered in planning a lesson. Also, other candidates listed stages of organizing lesson plan such as introduction, specific objectives, reflection and conclusion. Some candidates did not respond to the question. Candidates in this category had inadequate knowledge of planning and preparation for teaching. Extract 9.2 shows a sample of incorrect responses from one of the candidates.

9

i) Syllabus

ii) Textbooks

iii) School timetable

Extract 9.2: A sample of incorrect responses to question 9.

In Extract 9.2, the candidate wrote curriculum materials instead of factors to be considered during lesson preparation.

2.1.10 Question 10: Organic Chemistry

The question required the candidates to study the reaction for benzene against electrophile-nucleophile molecule with symbol E-NU under catalyst to form benzene substituted with E together with molecule H-NU. The candidates were then required to propose a reaction mechanism involving three steps for the reaction.

The question was attempted by 1,815 (100%) candidates. The general performance was weak as only 91 (5.0%) candidates scored 2.0 marks or above while 1,724 (95.0%) candidates failed. Table 3 illustrates the distribution of these scores.

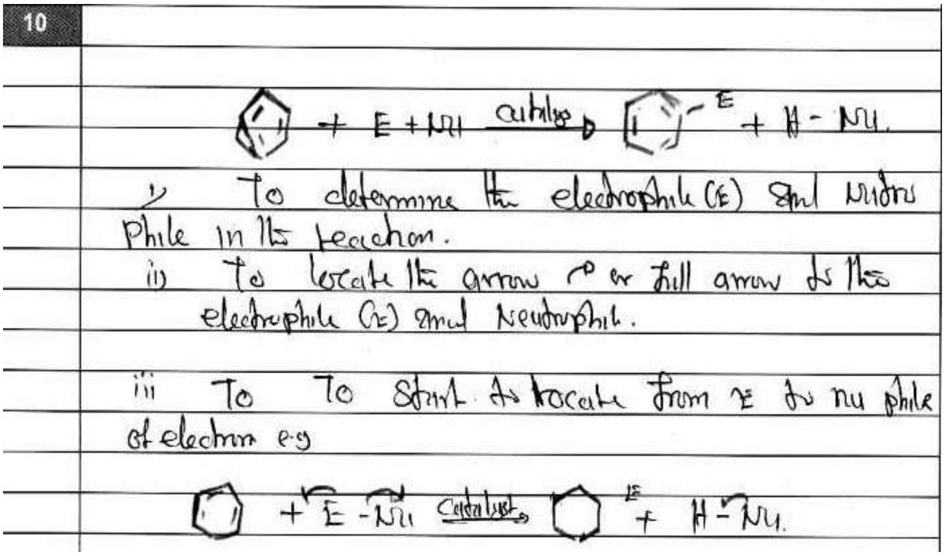
Table 3: Candidates' Performance in Question 10

Scores	Percentage (%)	Remarks
0.0 – 1.5	95.0	Weak
2.0 – 2.5	1.7	Average
3.0 – 4.0	3.3	Good

As indicated in Table 3, 95.0 per cent of the candidates scored from 0 to 1.5 marks, 1.7 per cent scored from 2.0 to 2.5 and 3.3 per cent scored from 3.0 to 4.0 marks.

Most of the candidates (95.0%) who scored from 0 to 1.5 marks, failed to give correct reaction mechanism involving three steps. Some of them wrote incorrect reaction mechanism involving four steps. For instance, they first showed splitting of electrophile-nucleophile instead of the nucleophile attacking the catalyst (generation of electrophile). In the second stage they wrote nucleophile reacting with catalyst instead of benzene ring attacking the electrophile. In the third stage, they showed the electrophile reacting with benzene instead of formation of the final product and regeneration of the catalyst. In the fourth stage they indicated hydrogen atom breaking off the benzene ring, a step which was supposed to be shown in the third stage.

Other candidates showed two instead of three steps while some drew curved arrows incorrectly. For instance, some of the candidates drew arrows toward the nucleophile and away from the electrophile. Basically, the curved arrows originate from nucleophile toward electrophile. Additionally, some of the candidates in this category listed factors affecting organic reaction instead of showing the reaction mechanism required. A sample of incorrect responses is shown in Extract 10.1.


10

+ E + Nu catalyst E + H - Nu.

i) To determine the electrophile (E) and nucleo phile in the reaction.

ii) To locate the arrow or full arrow to the electrophile (E) and Neudrophil.

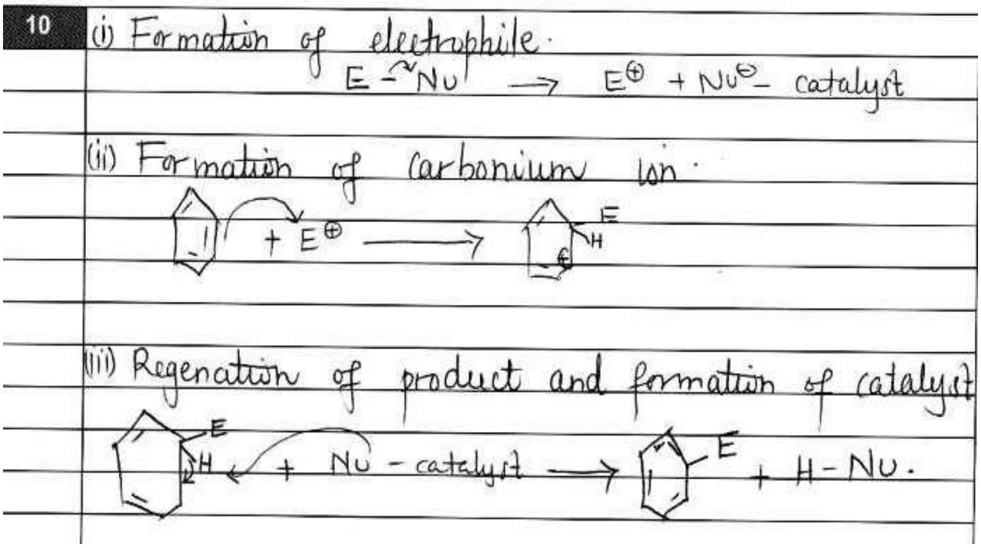
iii To To Start to locate from E to nu phile of electron e.g

+ E - Nu Catalyst E + H - Nu.

Extract 10.1: A sample of incorrect responses to question 10.

In Extract 10.1, the candidate gave unclear explanation instead of proposing the reaction mechanism for electrophilic substitution of benzene.

Candidates (3.3%) who scored high marks gave the correct reaction mechanism for electrophilic substitution of benzene. They showed the first stage correctly in which electrophile was formed by interaction of the catalyst with the electrophile – nucleophile. In the second step, the candidates indicated a benzene ring attacking the electrophile. In the third step they showed hydrogen splitting from the ring. Generally, the candidates had sufficient knowledge about Organic Chemistry. Extract 10.2 shows a sample of correct responses from one of the candidates.



Extract 10.2: A sample of correct responses to question 10.

In extract 10.2, the candidate gave three steps required for the electrophilic substitution reaction of benzene. Furthermore, he/she indicated the curved arrows originating from electron rich species to electron deficiency species (electrophile).

2.1.11 Question 11: Chemical Kinetics, Energetics and Equilibrium

In this question, candidates were required to calculate standard heat of formation of propane given that the heat of combustion of propane (C_3H_8) is -2220.2 kJmol-1 and the heat of formation of carbon dioxide (CO_2) and that of water (H_2O) as -393 kJmol^{-1} and -285 kJmol^{-1} respectively.

The question was attempted by 1,815 (100%) candidates. Generally, the performance in this question was weak as 1,159 (63.9%) of the candidates scored 6.0 marks or above while 656 (36.1%) candidates failed. A summary of the candidates' performance in this question is shown in Figure 8.

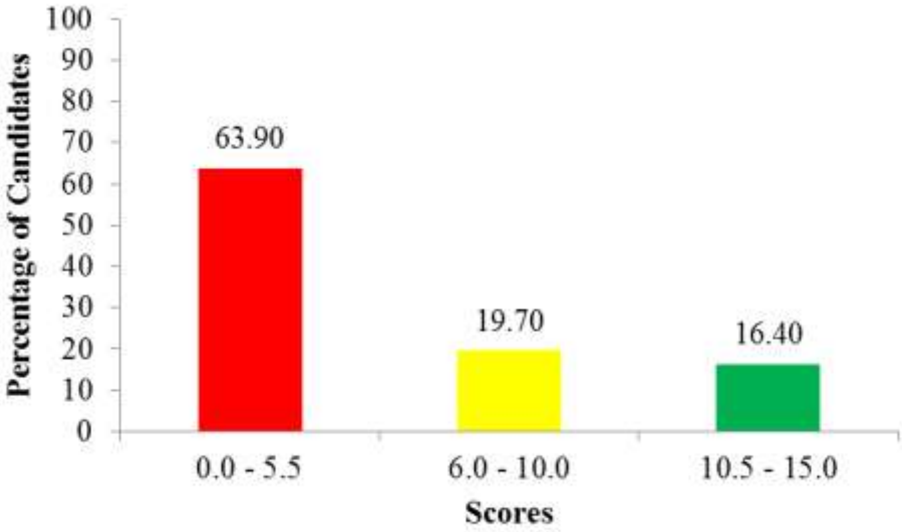


Figure 8: *Distribution of Candidates' Scores in Question 11*

Figure 8 shows that 63.9 per cent scored from 0 to 5.5 marks, 19.7 per cent scored from 6.0 to 10 marks and 16.4 per cent scored from 10.5 to 15.0 marks.

Candidates (63.9%) who scored low marks failed to carry out the calculations and present chemical equations for the combustion process. Others managed to write the data given but they either presented some chemical equations erroneously or failed to calculate the heats. Others could not balance the heats given with appropriate stoichiometric ratios. In addition, the candidates had challenges in applying Hess's law to calculate heat of reaction. Generally, responses by the candidates showed lack of basic numerical skills and inability to write chemical formula which resulted in failure to accomplish the calculations. Extract 11.1 shows a sample of incorrect responses from one of the candidates.

11. Calculate the heat of formation of propane.

- Combustion of propane In the presence of oxygen librated carbondioxide and water.

- Combustion of carbondioxide and water.

propane = C_6H_{10}

$C_6H_{10} \xrightleftharpoons{O_2} CO_2 + H_2O = -2220.2$ kJ/mol.

$2CO_2 + H_2O \rightleftharpoons 2CO_2 + H_2O_2$

$2CO_2 + 3H_2O \rightleftharpoons 2CO_2 + H6O_3$

$2CO_2 + 3H_2O \rightleftharpoons 2CO_2 + H_6O_3$

$2CO_2 + H6O_3 \rightleftharpoons 2CO_2 + 3H_2O$

$C_6H_{10} \xrightleftharpoons{17O_2} 6CO_2 + 5H_2O$

$C_6H_{10} \xrightleftharpoons{17O_2} 6CO_2 + 5H_2O$

$2CO_2 + H_6O_3 \rightleftharpoons 2CO_2 + 3H_2O$

11 Cont.

$C_6H_{10} + 2CO_2 \rightleftharpoons CO_2 + H_2O + C_4H$

$C_6H_{10} + 2CO_2 \rightleftharpoons CO_2 + H_2O + C_5H_8$

Standard heat of formation of propane

$C_6H_{10} + 2CO_2 \rightleftharpoons CO_2 + H_2 + C_5H_8$.

Extract 11.1: A sample of incorrect responses to question 11.

In Extract 11.1, the candidate failed to present the formula for propane and wrote unknown formula H_6O_3. Similarly, he/she wrote several equations without indicating the heat change for each equation on the right side.

Furthermore, the candidate wrote a chemical equation instead of giving a number representing heat of formation of propane.

The candidates (16.4%) who scored from 10.5 to 15 marks correctly presented the equation for the formation of propane and its combustion. They also presented the combustion of carbon and Hydrogen. Finally, they computed the heat correctly with correct sign and units. The ability of the candidates to carry out the calculations properly indicates that they had sufficient knowledge of the concepts of Hess law of constant heat summation. Moreover, the candidates demonstrated mastery of the basic numerical skills. Extract 11.2 shows a sample of correct responses given by one of the candidates.

11

Solution:

Required:

standard heat of formation of Propane

$3C_{(s)} + 4H_{2(g)} \rightarrow C_3H_8 \quad \Delta H_f^\theta = ?$

Given equation:

Equation (I) Combustion of Propane

$C_3H_8 + 5O_2 \rightarrow 3CO_{2(g)} + 4H_2O_{(l)}$

$\Delta H = -2220.2 KJ/mol$

equation (II) Heat of combustion of Carbondioxide.

$C_{(s)} + O_{2(g)} \rightarrow CO_2 \quad \Delta H = -393 KJ/mol.$

equation (III) Heat of combustion of water

$H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O \quad \Delta H = -285 KJ/mol.$

According to the Provided equation or required equation

equation (I) are reversed.

$\cancel{3CO_{2(g)}} + \cancel{4H_2O_{(l)}} \rightarrow \underline{C_3H_8} + \cancel{5O_{2(g)}}$

$\Delta H = +2220.2 KJ/mol$

equation (II) are multiplied by (3).

$\underline{3C_{(s)}} + \cancel{3O_{2(g)}} \rightarrow 3\cancel{CO_2} \quad \Delta H = (3 \times -393 KJ/mol)$

equation (III) are multiplied by (4)

$\underline{4H_2} + \cancel{\frac{4}{2}O_{2(g)}} \rightarrow 4\cancel{H_2O} \quad \Delta H = (4 \times -285 KJ/mol)$

11 Cont.

Remained equation after the similar products Cancel out

$3C_{(s)} + 4H_{2(g)} \rightarrow C_3H_{8(g)}$

$\Delta H_f^\circ (C_3H_8) = +2220.2\ kJ/mol + (3 \times -393) + (4 \times -285)$

$\Delta H_f^\circ (C_3H_8) = -98.8\ kJ/mol.$

$\therefore$ standard heat of formation of propane $\Delta H_f^\circ (C_3H_8)$

$= -98.8\ kJ/mol.$

Extract 11.2: A sample of correct responses to question 11.

In extract 11.2, the candidate wrote well balanced chemical equations. He/she arranged the chemical equations as required and calculated the heat of formation of propane correctly.

2.1.12 Question 12: Environmental Chemistry

In this question the candidates were required to illustrate with four points, the causes of soil pH in the garden soil which has been tested and found to have a pH value of 4.10.

The question was attempted by 1,815 (100%) candidates. Generally, the performance in this question was good as 1,729 (95.3%) candidates scored average or above while 86 (4.7%) candidates failed. The performance of candidates in this question is summarized in Figure 9.

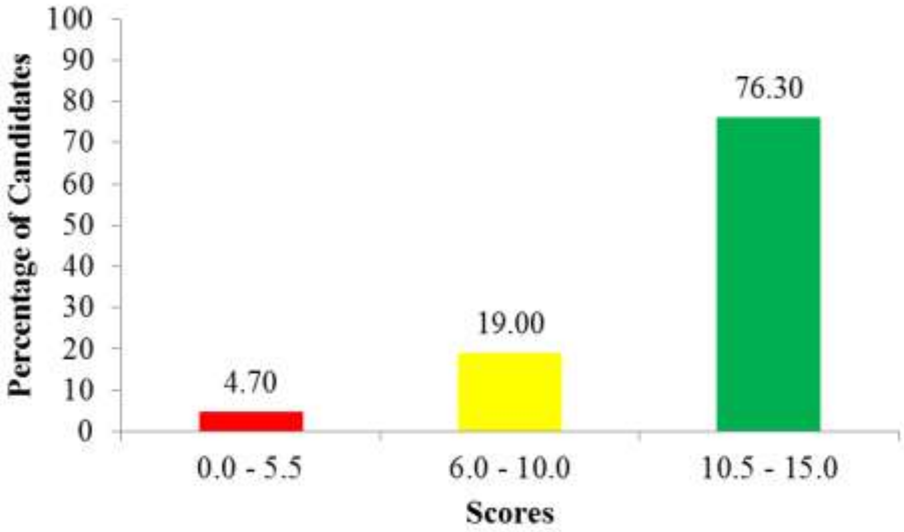


Figure 9: *Distribution of Candidates' Scores in Question 12*

Figure 9 shows that 4.7 per cent of the candidates scored from 0 to 5.5 marks, 19.0 per cent scored from 6.0 to 10.0 marks and 76.3 per cent scored from 10.5 to 15.0 marks.

Most of the candidates (76.3%) who scored from 10.5 to 15.0 marks gave a correct definition of soil pH and correct points on the causes of soil pH in the garden with a soil pH value of 4.10. Those candidates managed to realize that the soil was acidic because the pH value given was less than 7. The candidates were also knowledgeable of the causes of acidic soils such as introduction of acidic fertilizers into the soil. The correct answers given indicate that the candidates had adequate knowledge of the concept of soil pH. Extract 12.1 shows a sample of correct responses given by one of the candidates.

2

Soil pH; refer to the ~~negative~~ negative concentration of hydrogen ion to base ten that a soil consist. The soil pH is used to determine the plant that can be grown in acidity soil or basic soil. According to the experiment of chemistry teacher in soil pH which obtained was 4.10 means the soil was acidic soil. The following are the causes of acidic soil

Heavy rainfall and excess irrigation; The heavy rainfall and excess irrigation lead to the remove of nutrients such as Nitrate, carbonate and phosphorous which leave the large land with maximum of Aluminium ions and hydrogen ions which is acidic in nature hence the remain soil will be acidic soil.

Macroorganism and animal respiration; Their Macroorganism which live in a soil and other plant ~~res~~ where undergo respiration lead to the release of CO_2 which when hydrolysis lead to the formation of carbonic acid in the soil. example of such organism are bacteria.

$CO_2 + H_2O \rightleftharpoons$ ~~HCOOH~~ H_2CO_3

Addition of acidic fertilizer in the soil. Through acidification process the soil can became acidic due to the use of acidic fertilizer such as $Al_2(SO_4)_3$.

Industrial activities; The ~~industrial~~ industrial activities ~~such~~ can cause the soil to became acidity due to the expression of CO_2 in the atmosphere when when hydralized lead to the formation of acidic ~~&~~ rain and when fall in the land lead to soil acidic, but also it can be through

12 Cont. the accumulation of wastes ~~into~~ on the land which contain acid when penetrating they can cause the acidic soil.

Conclusion; These are some causes of acidic soil which can affect the plant growth and some organism can not live in the area which contain acid. But they can used for plantation of crops that grow in the acidic soil.

Extract 12.1: A sample of correct responses to question 12.

In extract 12.1, the candidate wrote a correct definition of soil pH and gave factors which facilitate formation of acidic soils.

On the other hand, candidates (4.70%) who scored low marks failed to explain correctly the causes of soil pH. Some of the incorrect points given by the candidates include rainfall, altitude, soil texture, soil aeration and colour of the soil. Those candidates did not understand that such soil parameters do not affect soil pH. Similarly, some of the candidates mentioned liming as one among the causes of soil pH of 4.10. They failed to recall that liming is done in order to make the soil basic (increase soil pH). The candidates did not realize that low pH is caused by the increase of acidic materials in the soil. Failure to attempt the question correctly indicates that the candidates lacked adequate knowledge of Environmental Chemistry. An example of poor responses is shown in Extract 12.2.

12 Soil PH reper to ability of the soil to be classified in PH range that belong's soil. The following are the causes that show the soil PH is 4.10 as follows;

Acidity of the soil; that occur when the soil has been obtained in form of acidity that could emphasize the soil PH to be that.

Nutrients applied to the soil in the ground that enable the range of soil pH belong's to that range

Extract 12.2: A sample of incorrect responses to question 12.

In Extract 12.2, the candidate gave an incorrect definition of soil pH and contradicting explanation in paragraph 2. In the third paragraph, the candidate simply mentioned nutrients as one of the factors without specifying that it is nutrients which add acidity to the soil.

2.1.13 Question 13: Analysis of O-Level Chemistry Curriculum Materials

In this question, candidates were required to give the importance of analyzing chemistry syllabus before the commencement of teaching in five points.

The question was attempted by 1,815 (100%) candidates. Generally, the performance of candidates in this question was good since 1,645 (98.6%) of the candidates scored 6.0 marks or above while 26 (1.4%) failed. A summary of the performance of candidates is shown in Table 4.

Table 4: Candidates' Performance in Question 13

Scores	Percentage (%)	Remarks
0.0 – 5.5	1.4	Weak
6.0 – 10.0	8.0	Average
10.5 – 15.0	90.6	Good

Table 4 shows that candidates who scored from 0 to 5.5 marks were 1.41 per cent, from 6.0 to 10.0 marks were 8.0 per cent and from 10.5 to 15.0 marks were 90.6 per cent.

The candidates (90.6%) who scored high marks managed to analyze the importance of making syllabus analysis before the commencement of teaching chemistry. They wrote a suitable introduction, elaborated points on the importance of syllabus analysis precisely in the main body and gave a commendable conclusion. They organized their work into paragraphs each starting with a key sentence. Sentences within the same paragraph had coherence of ideas. Principally, the candidates had sufficient knowledge of Analysis of O-Level Chemistry Curriculum Materials. A sample of correct responses to question 13 is shown in Extract 13.1.

13

Syllabus: Refers to the curriculum material which contain a list of topic to be covered from simple to complex and also contain goals and specific objectives. Syllabus analysis is the process of break down parts of syllabus inorder to facilitate teaching and learning process. During preparation of scheme of work syllabus have was very important due to the different reasons.

The following are the importances of syllabus analysis before preparation of scheme of work. Such as:-

Syllabus helps teacher to teach prepare and to teach the right content to the learners: Through syllabus analysis a teacher have got a knowledge of what content is true to the level of the learners during teaching and learning process. Since syllabus contain an arrangement of topic for all class example Ordinary level syllabus contain topics of form one up to form four.

Syllabus direct teacher to prepare scheme of work according to level of the learners: Through syllabus analysis a teacher have an ability to prepare a scheme of work according the to level of the learners in the class. It help teacher to prepare the scheme of work out of syllabus because it can affect the final evaluation of the learners since they do not cover the content matter of the specific subject during teaching and learning process.

Syllabus helps a teacher to know goals and specific objectives of the subject matter: A teacher through syllabus analysis can simplify the process of preparation of scheme of work since have already know the goal and objectives to cover at the end of topic and course subject. Through preparation of scheme of work during teaching and learning process a teacher have ability to prepare a lesson plan from a scheme of work as well as lesson notice from scheme of work.

Cont.

Syllabus direct and regulate the speed of teaching through indicating numbers of periods for each topic: Through syllabus analysis before preparation of scheme of work for teaching and learning process a teacher can know the speed of teaching inorder to cover the subject content through teaching and learning process. And finally to make assessment and evaluation.

Syllabus directs a teaching and learning methods as well as teaching and learning materials or aids: All teaching and learning method and materials used or help to facilitate and to simplify teaching and learning process through raising learners interests and encourage active participation of the learners and also help to motivate learners during teaching and learning process.

Generally: Scheme of work help teacher during preparation of lesson plan which help teacher to teach systematically and also to manage time since have a direction to teach inorder to follow five stage in lesson development which are Introduction, New knowledge, Application, Reflection and conclusion and Also scheme of work helps teacher to prepare assessment activities such as Test and examination.

Extract 13.1: A sample of correct responses to question 13.

In extract 13.1, the candidate correctly explained the importance of syllabus analysis in six points. The candidate started by defining syllabus in the introduction and in the conclusion part he/she gave summary of the use of scheme of work in teaching.

On the other hand, the candidates (1.4%) who scored low marks failed to respond correctly to most parts of the question. For example, some of the candidates explained the importance of schemes of work in classroom teaching. These candidates did not understand the demand of the question. Others explained the curriculum materials such as books and teaching/ learning materials instead of the importance of syllabus analysis. Also some candidates explained the structure or framework of lesson plan. Similarly, some of the candidates explained how to use a syllabus instead of the importance of syllabus analysis. Candidates' responses indicate that they had inadequate knowledge on curriculum materials. Extract 13.2 shows a sample of incorrect responses given by one of the candidates.

13 Scheme of work is the procedure used to prepared the lesson when teaching the subject by delivery from the syllabus. Scheme of work are very important in teaching and learning chemistry in order to make the teaching and learning progress well.

The following are the important commencement of teaching process by scheme of work used as follows:

It helps to direct teacher to ~~chose~~ teach well. This means that due to systematic well prepared of the scheme of work by to or the teacher they make the reference to the covered area by teaching the subject as well as impossible without fear or enxiety from the teacher.

It helps to make a teacher to be competent when teaching and learning the lesson - By using The syllabus and well organization of good scheme of work the teacher well competent and encoraged to teach systematically. This will increased the confidence of the student and teacher outside and inside the school administration.

It helps to direct the teach to complete the topic or subject at a specific period of time. The scheme of work should implemented by The teacher to show The direction on each of The topic to be taught at The specific time to be taught.

It make any area which are not well covered when teaching and learning process. Due to the availability of good administration process to the school it essential to have a keep record of the term ~~it~~ in order to know the area or subject which are lower performance or higher performance by evaluate each subject and teacher to know the area which are not covered at particular time.

It helps to show the direction of teacher and student evaluation. By each period of time scheme of work may show the extra curriculum such as sport and game

13 Cont. home work individual assignment in order to ~~..~~ know the lesson which are well taught and by the performance of evaluated. Assessment will be important to evaluation of the lesson.

All in all above explaination above are the important think which scheme of work when the teacher used to teach systematically by using a syllabus ~~by~~ of preparation of teacher and school at higher ness.

Extract 13.2: A sample of incorrect responses to question 13.

In Extract 13.2, the candidate responded correctly by describing the importance of schemes of work instead of the importance of syllabus analysis.

2.1.14 Question 14: Assessment in Chemistry

In this question, the candidates were required to analyze five points on the significance of keeping records of continuous assessment.

The question was attempted by 507 (73.7%) candidates. Generally, the performance in this question was good as 15,79 (87.0%) candidates scored 6.0 marks or above while 236 (13%) failed. A summary of candidates' performance is shown in Figure 10.

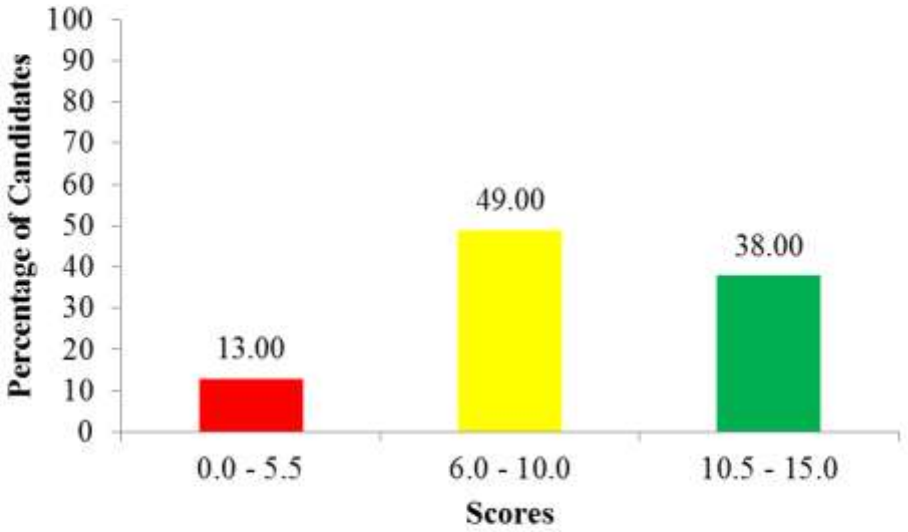


Figure 10: *Distribution of Candidates' Scores in Question 14*

Figure 14 shows that 13.0 per cent of the candidates scored from 0 to 5.5 marks, 49.0 per cent scored from 6.0 to 10.0 marks and 38.0 per cent scored from 10.5 to 15.0 marks.

Candidates (38.0%) who scored high marks gave five points on the significance of keeping records of continuous assessment. The candidates gave correct points such as it helps the teacher to plan for remedial classes for the low achievers, it enables the teacher to plan for revision, and records are used to process the final results of individual student at the end of a term or year. The appropriate responses given by the candidates indicate that they had adequate knowledge on Assessment in Chemistry. Extract 14.1 represents a sample of correct responses in question 14.

14. keeping records of continuous assessment
is the process of keeping records of continuous
assessment into the file for future use.
The continuous assessment it can be assessed
through test examination quiz Home work
Assignment project portfolio in order to know
the development of students in schools. The
following are the important of keeping records
of continuous assessment.
It help for future reference when the
teacher keep the continuous assessment in the
file, sometimes it can be used for future
reference. Example when a teacher compare the
~~student of~~ performance of students in the previous class
with present, you should use the continuous
assessment.
It help for decision making during
the decision making to know the progressive
~~differ~~ development of students in school it
must be use keeping records results to know
the weakness and strength of the students.
It help to predict the future performance
through keeping records of continuous assessment
in the file, it help teacher to predict the
performance of each students due to results
or scores of each students per each continuous
assessment. Example if is good or bad.
It help to know strength and weakness
of the learners through continuous assessment
such as Test, Quiz help teacher or students
to know their weakness and strength of the learners
Example if the results is good or very bad, and

14 Cont. how to improve them or how to help them students
with the problem of difficult performance may
be through remedial class more exercise.
It help to compare students through
continuous assessment such as assignment
Test examination, it help teacher to compared
student score in the class after arranged the
scores. Example the teacher it can know the students
who performed well than others and who performed
poor than others.
Therefore keeping records of continuous
assessment in school it very important, when
the teacher follow it because it help to
evaluate students improve teaching and
learning process and understanding of their
learners increased in schools.

Extract 14.1: A sample of correct responses to question 14.

Conversely, candidates (13.0%) who scored low marks failed to explain the significance of keeping records of continuous assessment. Some of them even failed to give a suitable introduction when attempting the question. Others gave partial responses by mentioning some points without giving appropriate explanations. Few candidates listed the tests which are included in the continuous assessment. For example, one of the candidates mentioned project work and midterm tests. Also there were candidates who repeated points on the significance of keeping records of continuous assessment. For example, one candidate explained that *keeping record provide background performance of student, it helps in maintaining student performance, it shows teacher's work to administration, and finally it enables teacher on confidence.* Similarly, some candidates did not understand the requirement of the question and thus gave irrelevant descriptions. Additionally, some of the candidates copied the question without attempting it. This implies that the candidates lacked adequate knowledge of Assessment in Chemistry. Extract 14.2 shows a sample of incorrect responses provided by one of the candidates.

14.

Assessment means to analysis and evaluating
what you targeted in the process of tea
ching and learning process The following
are the importance of assessment in any
task:-

To deduce method of ~~on~~ teach
ing a given task:- t assessment inform
a given ~~prof~~ teacher or ~~tool~~ tutor about
t the development of a given task.

To deduce strategies of overco
ming a particular task:- Through asse
ssment a tutor come up with new
strategies more active than the previou
s so a

Extract 14.2: A sample of incorrect responses to question 14.

In Extract 14.2, the candidate gave incorrect points and the sentences used in explanation lacked coherence of ideas.

2.2 732/2 Chemistry 2: Practical Paper

The chemistry practical paper assessed understanding and competences of candidates in carrying out experiments to prove theoretical facts and principles. The paper had three alternatives, namely 732/2A Chemistry 2A, 732/2B Chemistry 2B and 732/2C Chemistry 2C. Each alternative had three questions. Question 1 was about volumetric analysis while questions 2 and 3 assessed Chemical Kinetics and Qualitative analysis respectively. Each candidate was required to answer all the three questions from one of the alternatives. The analysis of candidates' responses in each question is as follows:

2.2.1 Question 1: Volumetric Analysis

In the question the candidates were required to carry out titration experiment and answer the subsequent questions.

This question was attempted by 1,815 (100%) candidates. Data analysis showed that the performance was good since 1,356 (91.1%) candidates passed while only 459 (25.3%) candidates failed. Figure 11 shows the distribution of candidates' performance.

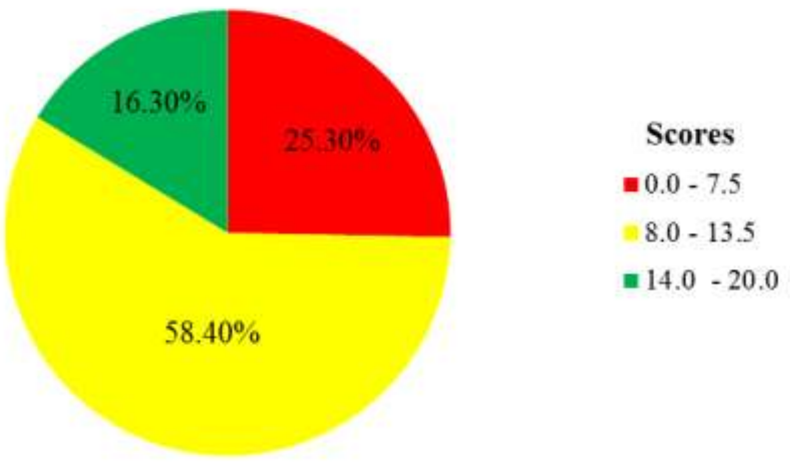


Figure 11: *Distribution of Candidates' Scores in Question 1*

Figure 11 shows that candidates who scored from 0 to 7.5 marks were 25.3 per cent, 8.0 to 13.5 marks were 58.4 per cent and from 14.0 to 20.0 marks were 16.3 per cent.

The instructions and questions for each paper were as follows:

2.2.1.1 732/2A Chemistry 2A

In alternative paper 2A, the candidates were required to perform titration using hydrochloric acid solution denoted as **B**, sodium carbonate denoted as **A** using Methyl orange (MO) indicator. They were instructed to follow systematic procedures as follows:

*Measure 10 ml of solution **A** and dilute it with distilled water up to 150 cm^3 of solution using a measuring cylinder. Then titrate **A** (from the burette), against 20.00 cm^3 or 25.00 cm^3 of **B** (in a titration flask) using **MO** until the end point. Record the results including one rough and three accurate volumes in a tabular form.*

After titration, candidates were required to answer the following questions:

(a) (i) *What is the volume of the pipette used?*
(ii) *Present your results in an appropriate tabular form.*

(b) *What is the colour of the indicator before and at the equivalence point?*

(c) *Calculate the concentration of HCl in solution **B** in mol dm^{-3}.*

(d) *Calculate the concentration (in mol dm^{-3}) of Na_2CO_3 after dilution of solution **A**.*

(e) *Calculate the concentration (in mol dm^{-3}) of Na_2CO_3 before dilution of solution **A**.*

(f) *If the diluted 10 ml of solution **A** contains 0.888 g of impure sodium carbonate, what is the percentage composition of sodium carbonate in the solution?*

(g) *If solution **A** was made by dissolving a known mass of impure sodium carbonate and distilled water was added to make the solution up to 250 cm^3 in a graduated flask, give one reason why the impure sodium* *carbonate was dissolved in water first and then made up to 250 cm^3 of solution, rather than being dissolved in 250 cm^3 of distilled water.*

Analysis of candidates' responses showed that, those who scored high marks answered most parts of the question correctly. In part (a) the candidates recorded accurate measurements of volume of the acid **A** in the table of results and gave the volume of pipette used. Furthermore, they calculated titre volume by taking the average of the volumes of acid used which was supposed to be around 20 cm^3. They also identified the colour change observed, which was from yellow to pink in part (b). In part (c), they wrote well balanced chemical equation for the chemical reaction involved. The candidates used stoichiometric ratios obtained from the equation to calculate concentration of hydrochloric acid. The correct measurements and reaction equations enabled them to solve part (c). Also, the candidates calculated the concentration of sodium carbonate before and after dilution in parts (d) and (e) respectively. In part (f), the candidates calculated the percentage composition of solution A by considering both concentrations before and after dilution. Finally, the candidates gave the correct reason for dissolving sodium carbonate in a small volume of water followed by dilution rather than dissolving it directly in a large volume of water. Extract 15.1 shows a sample of correct responses from one of the candidates.

1	
9 ii	The volume of pipette used was 20cm³

Burette reading	Pilot	I	II	III
Final reading cm^3	19.80	~~40.00~~ 39.80	19.90	40.00
Initial reading cm^3	0.00	19.80	0.00	19.90
Volume used cm^3	19.80	20.00	19.90	20.10

The colour of indicator yollow and at equivalent point it pink.

c concentration of HCl in mol/dm^3.

From

$$\text{concenc} = \frac{\text{Mass (g)}}{\text{Volume } dm^3}$$

where Mass = 3.65 g

volume = $1 dm^3$.

so

$$\text{concentration} = \frac{\cancel{36}\ 3.65 g}{1 dm^3}.$$

Concentration = $3.65 g/dm$.

Therefore

$$\text{from} = \text{Molarity} = \frac{\text{concentration } g/dm^3}{\text{Molar mass } g/mol}$$

Molar mass HCl = $1 + 35.5 = 36.5$

$$= \frac{3.65 g/dm^3}{36.5 g/mo}$$

$$= 0.1 mol/dm^{-3}.$$

Concentration $= 0.1 mol/dm^3$

1 Cont. Calculate the concentration of sodium carbonate in mol/dm³

d

The avarge of ~~acid~~ used =

$= \frac{(20.00 + 19.90 + 20.10)\ cm^3}{3}$

$= 20\ cm^3$

From Molarity of Na_2CO_3 = $\frac{\text{Molarity of HCl} \times \text{Volume of HCl} \times \text{number of mole of HCl}}{\text{number of mole } Na_2CO_3 \times \text{Volume } CO_3}$

Data

Molarity of acid HCl = 0.1M

Volume of acid = 20cm³

Number of mole of HCl → 2

Number of mole of base → 1

Volume of base used → 20cm³

$Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O$

$= \frac{0.1m \times 20 \times 1}{20 \times 2}$

$= 0.05M$

Therefore concentration 0.05 mol/dm³

1 Cont.

e before dilution of Na_2CO_3 with solution.

From dilution law.

~~AA~~ ~~Contration~~

$$\frac{C_1V_1}{V_2} = \frac{C_2V_2}{V_2}$$

$$C_2 = \frac{0.05 \times 20}{20}$$

$$C_2 = 0.05 \text{ mol dm}^{3}.$$

where C_1 = concentration after dilution
V_1 = volume after dilution
C_2 = concentration before
V_2 = volume beforu

~~Mass =~~

$$conc = \frac{mass}{volume}$$

$$= \frac{0.888\,g}{10}$$

$$= 0.0889/dm^3.$$

$$= \frac{\text{concentration of pure}}{\text{concentration of impure}} \times 100$$

$$= \frac{0.05 mol/dm^3}{0.088 mol/dm^3} \times 100$$

$$= 56.8\%$$

The percentage composition

g because It can cause explosion in the air sometimes Its poisons

Extract 15.1: A sample of correct responses to question 1 Chemistry 2A.

Extract 15.1, shows that in part (a), the candidate titrated the given solutions and recorded the volume of acid correctly, and in part (b) he /she gave correct molecular and ionic equations. The accurate volume recorded facilitated the calculations performed in part (c).

On the other hand, those candidates who scored low marks failed to understand the requirement of the question and others lacked basic knowledge of volumetric analysis. Consequently some of the candidates recorded correct readings of initial and final volumes of acid but made summation instead of subtraction to get the required difference (titre volume). Others wrote the reaction equation which was not correctly balanced as they used incorrect stoichiometric coefficients of the reacting species.

Also, there some of the candidates used incorrect formula to calculate the molarity of the acid. For instance, one candidate wrote:

$$Ma = \frac{Mb\times Vb\times nb}{na\times Va} \text{ instead of } Ma = \frac{MbVb\,na}{nbVa}$$

Others did not apply the coefficients used in balancing the neutralization equation in the calculation specifically the number of moles of base (nb) in

$$Ma = \frac{MbVb\,na}{nbVa}.$$

There was also the challenge of writing correct chemical formula of some of the compounds in part (b) as one candidate wrote:

$HSO_4(aq) + NaOH \longrightarrow SO4Na + H_2O(l)$ instead of

$H_2SO_4(aq) + NaOH \longrightarrow Na_2SO_4 + H_2O(l)$.

The candidates' responses show lack of understanding and competence in volumetric analysis. A sample of incorrect responses from one of the candidates is shown in Extract 15.2.

1

@ (i) The volume of pipette used is $20cm^3$

ii)

Titre vol cm^3	PILOT	1	2	3
Final Vol(cm^3)	18.00	15.60	25.80	25.80
Initial vol(cm^3)	0.00	0.00	10.00	~~10~~.00
Volume used(cm^3)	18.00	15.60	15.80	25.80

(a) i) The volume of pipette used is $20cm^3$

(ii)

Titre volume cm^3	PILOT	1	2	3
Final volume cm^3	18.00	15.60	25.80	25.80
initial volume ~~used~~ cm^3	0.00	0.00	10.00	10.00
∴ Volume used cm^3	18.00	15.60	15.80	15.80

Average volume $\frac{1+2+3}{3} = \frac{15.60+15.80+15.80}{3} = 15.7cm^3$

b The colour of Indicator before was Orange and at the equivalence point is Yellow.

(c) $\text{Concentration} = \frac{\text{Mass}}{\text{volume}}$

$= \frac{3.65g}{1dm^3}$

$= 3.65 \text{ mol/dm}^3$

1 Cont.	
	∴ The concentration of HCl in solution B is ~~3.65g~~ 3.65 mol/dm^{-3}
d	Dilution Law:
	$M_c V_c = M_d V_d$
	$M_d = 0.1M$
	$V_d = 15.7cm^3$
	$M_c = ?$
	$V_c = 20cm^3$
	$M_c = \frac{M_d V_d}{V_c}$
	$M_c = \frac{0.1M \times \cancel{1.5}\ 15.7cm^3}{20cm^3}$
	$M_c = 0.09\ M$
	Conc of Na_2CO_3 = Molarity × Molarmass
	= 0.09M × 106g/mol
	= 9.54 mol/dm^3
(e)	~~Concentration~~ Molarity = $\frac{\text{Conc}}{\text{Molar Mass}}$

1 Cont.	
e	conc = Molarity × Molar mass
	= ~~106~~ 0.09 × 106g/mol
	= 9.54.
	= 9.54 mol/dm^3
(F)	$\frac{3.65}{0.888} \times 100\%$
	= 24 %
(g)	Because sodium carbonate is soluble in water

Extract 15.2: A sample of incorrect responses to question 1 Chemistry 2A.

In Extract 15.2, the candidate wrote incorrect final titre volumes and stated a colour change from orange to yellow instead of yellow to pink. He/she also wrote incorrect molecular and ionic chemical equations and consequently failed to carry out the calculations appropriately. Also, the candidate wrote hydrogen ion as H_2^+ instead of H^+ which is the acceptable notation.

2.2.1.2 732/2B Chemistry 2B

In this question, candidates were required to determine the amount of water of crystallization of sodium carbonate from a bottle containing anhydrous sodium carbonate which was left uncovered and labeled **T1**.

Sodium carbonate (Na_2CO_3) coded **T1** with unknown concentration; solution **T2** containing 3.65 g of hydrochloric acid (HCl) in 1 dm^3 and **MO** methyl orange indicator.

The candidates were required to measure 10 cm^3 of **T1** and dilute it with distilled water up to 150 cm^3 in a volumetric flask. They were directed to transfer the resulting solution into a beaker provided then pipette 20.00 cm^3 (or 25.00 cm^3) of the obtained solution and then transfer the pipetted solution into a conical flask.

The instructions were as follows: *Titrate **T2** (from the burette), against **T1** (in the titration flask) using MO until the end point. Record the results including one rough and three accurate titrations in a tabular form.*

They were then required to answer the following questions:

(a) *(i) What is the volume of the pipette used?*
(ii) Present your results in an appropriate tabular form.

(b) *Why a burette and a pipette must be rinsed with the solution which they are to be filled with?*

(c) *Why a titrating flask should not be rinsed with the solution which they are to be filled with?*

(d) *Calculate the concentration of $\boldsymbol{T_2}$ in mol dm^{-3}.*

(e) *Calculate the concentration of diluted $\boldsymbol{T_1}$ in mol/dm^3.*

(f) *Determine "X" in $Na_2CO_3{\cdot}XH_2O$ if the diluted 10 cm^3 solution contains 2.145 g of hydrated sodium carbonate.*

The analysis of candidates' responses revealed that those who scored high marks wrote the volume of the pipette used which was either 20.0 or 25.0 cm^3 in part (a). They also tabulated data of volume used in three columns apart from the pilot. In parts (b) and (c), they gave appropriate precautions related to rinsing burette, pipette and titrating flask. For instance, one candidate wrote in part (b) that *rinsing this way reduces water that may be sticking on the surface of burette or pipette*. In part (c) another candidate mentioned correctly that *in rinsing the titrating flask, the liquid on the flask surfaces causes titre volume to increase*. In part (d), they applied the information given in the question and used appropriate formula to get molarity of T2 (HCl) through the following procedure:

$$\text{molarity (T2)} = \frac{\text{mass concentration}}{\text{molar mass}} = \frac{2.92\ \text{g/l}}{36.5} = 0.08\ \text{M}$$

Using this molarity, they could get the molarity of **T1** (Na_2CO_3) as follows:

$$\text{molarity (T1)} = \frac{\text{volume of acid} \times \text{molarity of acid}}{\text{volume of base} \times \text{number of moles of acid}}$$

$$\text{molarity (T1)} = \frac{25 \times 0.08}{2 \times 25} = 0.04\ \text{M}$$

Molarity (T1) = 25×0.08/2×25 giving 0.04 M. Also, some candidates used a pipette of 20 cm^3 instead of 25 cm^3. In part (e), the candidates wrote correct equations and used a correct formula to get the concentration of anhydrous sodium carbonate which was 5.3 g/dm^3. In part (f), the candidates used a formula that relates molarity concentration and molar mass appropriately, hence they obtained the water of crystallization equivalent to 10. Extract 16.1 provides an example of correct responses in parts (d) to (f).

1 Cont.

$$\text{Molarity} = \frac{\text{Concentration}}{\text{Molar mass.}}$$

But.

Molarity of base = ?

Molarity of acid = ?

From $\frac{MaVa}{MbVb} = \frac{na}{nb}$.

where by.

Ma = Molarity of acid

Va = Volume of acid.

Mb = Molarity of base

na = Number of acid

nb = Number of base

from the data given.

$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$.

Number of acid (Na) = 2.

Number of base (Nb) = 1.

Volume of acid (Va) = $20cm^3$

Volume of base (Vb) = $20cm^3$.

Molarity of acid (Ma) = 0.1 M

Molarity of base (Mb) = ?

But.

$$\text{Concentration of acid} = \frac{\text{Mass of acid}}{\text{volume of acid.}}$$

$$\text{Concentration of acid} = \frac{3.65g}{1dm^3}$$

Concentration of acid = $3.65g/dm^3$

But.

1 Cont.

Molarity of acid = $\frac{\text{Concentration of acid}}{\text{Molar mass of acid. (HCL)}}$

Molarity of acid = $\frac{3.65\,g/dm^3}{\text{Molar mass of acid (HCL).}}$

But

Molar mass of (HCL) = 36.5 g/mol

But.

~~But~~ Molarity of acid = $\frac{3.65\,g/dm^3}{36.5\,g/mol.}$

Molarity of acid = 0.1M

But.

Molarity of base (Mb) = ?

From $\frac{MaVa}{MbVb} = \frac{na}{nb}.$

$Mb = \frac{Ma\,Va\,nb}{na\,Vb}$

$Mb = \frac{0.1M \times 2\,cm \times 1}{2 \times 20}$

$Mb = \frac{2}{40}$

$Mb = 0.005M$

∴ Molarity of base = 0.005M

But.

~~Aat~~ Molarity of base = $\frac{\text{Concentration of base}}{\text{Molar mass of base } Na_2CO_3}$

$0.005 = \frac{\text{Concentration of base}}{67}$

∴ Concentration of T_2 = 3.35 mol/dm³

ley.

(e) Concentration of diluted T_1 in mol/dm³

1 Cont.

from

$$\text{Molarity of acid } (T_2) = \frac{\text{Concentration of acid}}{\text{Molar Mass of acid}}$$

Molarity of acid (T_2) = 0.1M.

Molar mass of of acid = 36.5g/mol

But.

Concentration of acid = Molarity of acid × Molar mass of acid

= 0.1M × 36.5g/mol.

Concentration of acid = 3.65mol/dm³.

(f). To determine "x" in $Na \cdot XH_2O$

from:

$$\text{Concentration} = \frac{\text{Mass}}{\text{volume}} = \frac{2.145g}{10\,cm^3 \times 100} =$$

$$\text{Concentration} = 0.002145g/dm^3$$

$$\frac{\text{Mass of Pure}}{\text{Mass of impure}} = \frac{\text{concentration of pure}}{\text{concentration of impure.}}$$

∴ The value of x in '$Na_2CO_3 \cdot XH_2O$' is 10

$Na_2CO_3 \cdot 10H_2O$.

Extract 16.1: A sample of correct responses to question 1 Chemistry 2B.

In extract 16.1, the candidate correctly responded to parts (a), (b), (c) and applied relevant formulae to obtain the required parameters in parts (d), (e) and (f).

On the contrary, candidates who scored low marks wrote the correct volume of pipette used (20/25 cm^3) but failed to give correct reasons in both part (b) and (c). For instance, in part (b) one candidate wrote that *rinsing burette and pipette help to neutralize the acid*. Another candidate incorrectly responded to part (c) that *rinsing the titrating flask will inhibit the indicator to work properly*. Failure of the candidates in parts (d), (e) and (f) was due to the use of inappropriate formulas as well as incorrect substitution of data and errors in operation of numbers. For example, in attempting part (d), some of the candidates divided molar mass over concentration instead of taking concentration over molar mass to get molarity of the acid (HCl). Similarly, in part (e), some of the candidates answered that a mole ratio of acid to base equals to 1:1 instead of 2:1 respectively. Majority of the candidates in this category gave incorrect answers in this part due to the use of incorrect formula; they exchanged the positions of **na** and **nb** in the formula

$Mb = \frac{Ma \times Va \times nb}{Vb \times na}$ Also, some of the candidates failed to convert units when attempting part (f). For example, one candidate calculated the concentration of impure sodium carbonate by dividing 2.145 g by 150 cm^3 of water. The candidates were supposed to convert volume of water from cm^3 into dm^3 before dividing in order to avoid mismatch of units. Extract 16.2 shows a sample of incorrect responses from one of the candidates.

1 Table showing a systematic qualitative analysis experiment to identify the cation and the

ii)

Table of results

Burette reading	Pilot	1	2	3
Final reading	18.00	35.90	17.90	36.00
Initial reading	0.00	18.10	0.00	17.90
volume used	18.00	17.80	17.90	18.10

a) i) The volume of pipette used was $20 cm^3$

d) Concentration of T_2 in mol/dm^3

data.

mass of HCl = 3.65g.

Volume of HCl = $1dm^3$.

Concentration $= \frac{Mass}{Volume}$

Concentration $= \frac{3.65}{1dm^3}$

$= 3.65g/dm^3$

from.

molarity $= \frac{Concentration}{Molar\ mass}$

$= \frac{3.65g/dm^3}{36.5g/mol}$

$= 0.1 mol/dm^3$.

∴ The Concentration of T_2 in mol/dm^3 was $0.1 mol/dm^3$

1 Cont. e) Concentration of diluted T_1 in mol/dm

Titre value $= \frac{17.80 + 17.90 + 18.10}{3}$

$= 17.93\ cm^3$

volume of T_2 used was $17.93\ cm^3$.

volume of $T_1 = 20\ cm^3$
molarity of $T_2 = 0.1 mol$
molarity of $T_1 = ?$
$n_{T_1} = ?,\ n_{T_2} = ?$
from
Balanced reaction

$Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O$

$Na_2CO_3 + HCl \rightarrow$ ~~NaHCO~~ $NaCl + NaHCO_3$

$HCl + NaHCO_3 \rightarrow NaCl + CO_2 + H_2O$

mole ratio $= 1:1$.
from

$$\frac{M_{HCl}V_{HCl}}{M_{Na_2CO_3}V_{Na_2CO_3}} = \frac{n_{HCl}}{n_{Na_2CO_3}}$$

$$M_{T_1} = \frac{M_{HCl}V_{HCl}n_{Na_2CO_3}}{V_{Na_2CO_3}n_{HCl}}$$

$$M_{T_1} = \frac{0.1 \times 17.93 \times 1}{20}$$

$M_{T_1} = 0.089 mol. \approx 0.1 mol/dm^3$
∴ Concentration of diluted T_1 was $0.089 mol/dm^3$

1 Cont. f) X in $Na_2CO_3.XH_2O$.
from.

$$\text{Molarity} = \frac{\text{Concentration}}{\text{molar mass.}}$$

Concentration $= 0.089 \times 106$
Concentration of anhydrated
$Na_2CO_3 = 9.434\ g/dm^3$.

c) A titrating flask should not be rinsed with the solution which they are to be filled with, because the solution which rinse in a conical flask

Extract 15.4: A sample of incorrect responses to question 1 Chemistry 2B.

In Extract 16.2, the candidate used units of mol/dm^3 instead of g/dm^3 in part (e). In part (f), he/she calculated concentration by multiplying molar mass and molarity instead of dividing mass of sodium carbonate to volume of water. Similarly, the reason stated by the candidate in part (c) was incorrect. However, the candidates gave correct answers in parts (a) and (d).

2.2.1.3 732/2C Chemistry 2C

In this question, the candidates were provided with a sample of sodium hydroxide which is required to be standardized:
They were provided with solution containing 6.3 g/dm^3 of oxalic acid as a primary standard solution denoted as **TT**; solution of sodium hydroxide of unknown concentration denoted as **PP** and **POP** (phenolphthalein indicator).

The instruction was as follows:

*(i) Pipette 20 cm^3 (or 25 cm^3) of solution **PP** into a conical flask and add 2 to 3 drops of **POP**. Then transfer **TT** into the burette and take initial reading.*

*(ii) Titrate **TT** against **PP** using two drops of the indicator to the end point. Repeat the procedure to obtain three more titre value and record the results in a tabular form.*

The questions were:

(a) (i) What is the volume of the pipette used?
(ii) Present your results in an appropriate tabular form.
(b) Why oxalic acid is considered as primary standard substance in this experiment?
*(c) In which part of the meniscus (lower or upper) of the solution **TT** in the burette will you read? Briefly, explain.*
(d) Why it is not advised to hold the pipette from its bulb?
(e) What is the colour change of the indicator for the reaction between sodium hydroxide and oxalic acid.
*(f) Calculate the concentration of solution **TT** in mol dm^3.*
*(g) Calculate the concentration of **PP** in mol dm^3.*

The analysis of candidates' responses showed that the candidates who scored high marks attempted part (a) correctly by giving volume of pipette used, filling the table of results and calculating titre volume. In part (b), the candidates gave correct reasons for oxalic acid to be recorded as primary standard solution. For instance, they gave answers such as *it is very stable, it has high purity and it does not dissociate or associate in air*. In part (c), the candidates pointed out that the lower meniscus was preferred because of its clarity when colourless solutions were used. Further analysis of candidates responses revealed that the correct reason for citing error in the experiment was given in part (d). In part (e), most of the candidates answered correctly that the colour change during titration was from pink to colourless. In part (f), the candidates wrote the balanced chemical equation for the reaction in which the ration of acid to base was 1:2 respectively. Likewise, the candidates attempted the calculations in parts (g) and (h) correctly by calculating the molarity of acid (0.05 M) and base (0.1 M). A sample of correct responses is shown in Extract 17.1.

~~Pilot Pilot~~ ~~1 2 3~~

~~final reading~~

~~Initial reading~~

~~Total volume used,~~

Table of result,

	Pilot	1	2	3
Final reading (cm³)	20.10	40.10	20.00	40.10
Initial reading (cm³)	00.00	20.10	00.00	20.00
Total volume used (cm³)	20.10	20.00	20.00	20.10

$$\text{Volume total (cm}^3) = \frac{1+2+3}{3}$$

$$= \frac{20+20+20.10}{3}$$

$$\text{Volume used (cm}^3) = 20\,cm^3$$

(a) The part of the menscus is lower of the solution TT in the burette because it assist to detect the specific change of colour from colourless to pink,

(b) It considered as primary standard because it is soluble to form solution, hence it liberate carbondioxide

$$C_2O_4^{2-}{}_{(aq)} \longrightarrow 2CO_{2(g)} + 2\bar{e}$$

1 Cont.

(d) Because the pipette it is very delicate hence when hold the pipette from its bulb it is easy to cause the pipette to break also during pipette it is difficult to see when the solution rise to the meniscus point.

(e) The reaction of sodium hydroxide and oxalic acid the colour change from colourless to pink.

(f) Calculate the concentration of TT in mol dm⁻³

Solution,

$$\text{Molarity (TT) mol dm}^{-3} = \frac{\text{Concentration TT g/dm}^3}{\text{Molar mass TT g/mol}}$$

$$\text{Molarity} = \frac{6.3\text{g/dm}^3}{\text{Molar mass } (H_2C_2O_4)}$$

$(1\times2) + (12\times2) + (16\times4)$

$= 90\text{g/mol}$

$$\text{Molarity} = \frac{6.3\text{g/dm}^3}{90\text{g/mol}}$$

$$\text{Molarity} = 0.07\text{mol dm}^{-3}$$

$\therefore$ The molarity of solution TT $= 0.07\text{mol dm}^{-3}$

Extract 17.1: A sample of correct responses to question 1 Chemistry 2C.

Extract 17.1, shows a portion of correct responses from a candidate who fairly answered most parts of the question. However, he/she gave an incorrect reason in part (d). The correct reason in part (d) was that holding the bulb may cause rise of temperature of the pipette which will lead to expansion of its volume.

On the other hand, most of the candidates who scored low marks attempted part (a) and managed to give volume of pipette used but filled the table of results partially. Some of them calculated the titre volume incorrectly, for instance, one candidate wrote 40 cm^3 as the titre volume. The candidates who gave titre volumes quite far from the mean value (20/25 cm^3) lacked skills of either timing the end point or observing during titration. In part (b), the candidates failed to give reasons to justify the fact that oxalic acid is a primary standard solution. For instance, one candidate explained that *oxalic acid is available abundantly and not costiful.* Cost and availability are not among the criteria for a chemical to be termed a primary or a secondary standard. In part (c), some of the candidates incorrectly read the upper meniscus (instead of lower meniscus) of solution and the reasons to justify the upper meniscus were incorrect. For instance, one candidate wrote *the upper meniscus is higher than the lower meniscus*. Other candidates did not give any reason to justify the upper meniscus. In part (e), most of the candidates mentioned either pink or colourless. For instance, one candidate wrote that *colour changed to pink* instead of *colourless to pink.* In part (f), the candidates gave incorrect chemical equations and miscalculated the concentration of solution TT. For instance, some of the candidates assumed the molar mass of oxalic acid being 90 g mol^{-1} instead of 126 g mol^{-1}. This means that the candidate failed to include 36 g of water in the calculation. In part (g), some of the candidates wrote the correct formula, but they substituted incorrect data which were obtained from the previous stages such as the concentration of acid (TT) obtained in part (f). Extract 17.2 shows an example of incorrect responses from one of the candidates.

1

a) Result table.

i)

Experiment	PILOT	1	2	3
Initial volume	0.00	0.00	0.00	0.00
final volume	19.~~0~~40	18.90	18.~~8~~50	19.10
Volume Used.	19.40	18.90	18.50	19.10

Average = $\frac{18.90 + 18.50 + 19.10}{3.} = 18.8\ cm^3$

∴ Average = $18.8 cm^3$

ii) The volume of pipette Used is 20cm³

c) the Minisces is Upper or lower in 0.00ml on burete reading.

d) Is not allowed to hold the pipette from its bulb, because bulb part it Used to Measure the liquid which is needed by Measured and also is due to the accuracy reading

e) The colour change from ~~pink~~ Purple. to colourless by Using POP indicator.

f) Soln

Concentration of $H_2C_2O_4$ = 6.3 g/dm³

Mr = (1×2) + (12×2) + (16×4)

2 + 24 + 64

= 90 g/mol.

~~From~~ M = ?

~~Concent~~ From

$M = \frac{Concentration}{Molar\ Mass.}$

1 Cont.

$M = \frac{6.3\ g/dm^3}{90\ g/mol}$

$M = 0.07 \approx 0.1M.$

$\therefore$ Concentration of solution II in mol/dm^3 is $\underline{0.1M}$

g) Solution.

Data

$Ma = 0.1$

$Va = 18.8 cm^3$

$na = 1$

$Mb = ?$

$Vb = 25 cm^3$

$nb = 1$

Consider equation =

$H_2C_2O_4 + NaOH \rightarrow Na_2CO_3 + CO_2 + H_2O$

equation balanced.

$na = 1$

$nb = 1$

From: $\frac{MaVa}{MbVb} = \frac{na}{nb}$

$\frac{MaVa \times nb}{naVb} = \frac{na \times MbVb}{naVb}$

$Mb = \frac{MaVa \times nb}{naVb} = \frac{0.1 \times 18.8 \times 1}{1 \times 25} = 0.07 \approx$

$= 0.1M.$

$\therefore$ The concentration of PP in Mol/dm^3 = $\underline{0.1M.}$

Extract 17.2: A sample of incorrect responses to question 1 Chemistry 2C.

In extract 17.2, the candidate wrote titre value of 18.8 cm^3 instead of 20 cm^3 in part (a). He/she incorrectly stated that the colour changed from purple to colourless instead of colourless to pink in part (e). However, the candidate gave correct responses in parts (a)(i) and (g).

2.2.2 Question 2: Chemical Kinetics and Energetic

In alternative papers 2A and 2C, the experiment involved studying the effect of the rate of reaction by varying the concentration of sodium thiosulphate solution. In alternative paper 2B temperature was used as a variable factor for the rate of chemical reaction.

The statistics indicate that this question was attempted by 1,815 (100%) candidates. Generally, the performance was average as 850 (46.8%) candidates scored 6.0 marks or above while 965 (53.2%) candidates failed. Figure 12 shows the distribution of these data.

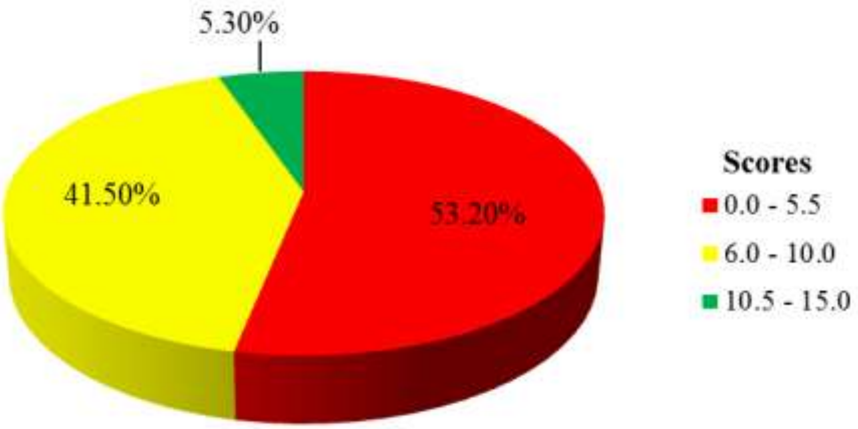


Figure 12: *Distribution of Candidates' Scores in Question 2*

Figure 12 shows that 965 (53.2%) candidates scored from 0 to 5.5 marks, 754 (41.5%) candidates scored from 6.0 to 10.0 marks, and 96 (5.3%) candidates scored from 10.5 to 15.0 marks. The analysis of the responses in each alternative is provided as follows:

2.2.2.1 732/2A Chemistry 2A

In question 2 of alternative paper 2A, the candidates were provided with 0.02 M potassium permanganate solution labelled **P1**, 0.05 M oxalic acid made up in 0.5 M H_2SO_4 labelled **P2**, a stop watch, a thermometer and other relevant materials. They were instructed to perform an experiment to assess the effect of temperature on the rate of chemical reaction by following the procedures:

(i) *Put water in a 250 or 300 cm^3 beaker about two thirds and heat the content to about 100˚C. Use this as water bath.*

(ii) *Measure 10 cm^3 of portions of **P1** and **P2** and transfer them into two separate test tubes.*

(iii) *Put the test tubes in the water bath.*

(iv) *Allow the contents of the two test tubes to warm up to 50˚C.*

(v) *Pour both solutions,* ***P1*** *and* ***P2****, into a 50 cm^3 beaker and immediately start a stopwatch and record the time taken for the purple color to disappear.*

(vi) *Repeat procedure (ii) to (v) except that instead of 50 ºC in procedure (iv) use temperatures, 60 ˚C, 70 ˚C and 80 ˚C.*

Questions

(a) *Compete the following table:*

Table of Results

Temperature, T		**1/T**	**Time**	**Rate**	**log(1/t)**
(˚C)	**(K)**	**K^{-1}**	**t(s)**	**1/t (s^{-1})**	
50					
60					
70					
80					

(b) *Write a balanced ionic equation for the reaction.*

(c) *With reference to the results in (a), explain the relationship between temperature and reaction time.*

(d) *Plot a graph of log(1/t) as a function of 1/T.*

(e) *Determine the activation energy of the reaction given that the Arrhenius equation can be expressed as* $\log\left(\frac{1}{t}\right) = \frac{-E_a}{2.303R} \times \frac{1}{T} + \log(A)$, *where* E_a *is the activation energy and R is the gas constant = 8.314 J mol^{-1} K^{-1}*

The analysis of candidates' responses revealed that most of those who scored high marks completed the table in part (a) by using correct data. They also wrote correct overall chemical equation for the redox reaction in part (b). In part (c), they stated clearly that the increase in temperature causes the decrease in the time for the reaction to be complete. This means that the candidates were aware that the rate of the chemical reaction increased with increase in temperature. In part (d), the candidates plotted the graph as required from which they responded to part (e) by calculating the energy of activation for the reaction. Extract 18.1 shows a sample of correct responses from one of the candidates.

2

TABLE OF RESULT

a

Temp(°C)	Temp(K)	$1/T$ K^{-1}	t(s)	Rate $1/t$ (s^{-1})	Log($1/t$)
50	323	3.0959×10^{-3}	23	0.04348	−1.3617
60	333	3.0×10^{-3}	16	0.0625	−1.204
70	343	2.915×10^{-3}	8	0.125	−0.903
80	353	2.83×10^{-3}	4	0.25	−0.602

b

$C_2O_4^{2-} + MnO_4^- \rightarrow CO_2 + Mn^{2+}$

oxidation

$C_2O_4^{2-} \rightarrow 2CO_2 + 2\bar{e}$

Reduction

$MnO_4^- \rightarrow Mn^{2+} + 4H_2O$

$MnO_4^- + 8H^+ \rightarrow Mn^{2+} + 4H_2O$

$MnO_4^- + 8H^+ + 5\bar{e} \rightarrow Mn^{2+} + 4H_2O$

Overall equation

$2) \; MnO_4^- + 8H^+ + 5e \rightarrow Mn^{2+} + 4H_2O$

$5) \; C_2O_4^{2-} \rightarrow 2CO_2 + 2\bar{e}$

$2MnO_4^- + 16H^+ + 10\bar{e} \rightarrow 2Mn^{2+} + 8H_2O$

$5C_2O_4^{2-} \rightarrow 10CO_2 + 10\bar{e}$

$2MnO_4^- + 16H^+ + 5C_2O_4^{2-} \rightarrow 2Mn^{2+} + 8H_2O + 10CO_2$

2 Cont.

c According to the table of result, ~~the~~ as the temperature increase, the time decrease and the rate of chemical reaction increase.

∴ therefore the temperature is inversely proportional to the time taken during chemical reaction.

d to the Graph

e from the graph

$$\text{Slope} = \frac{\Delta y}{\Delta x}$$

$$= \frac{-0.6 - -0.9}{2.8 \times 10^{-3} - 2.9 \times 10^{-3}}$$

$$m = -3000$$

but from the equation

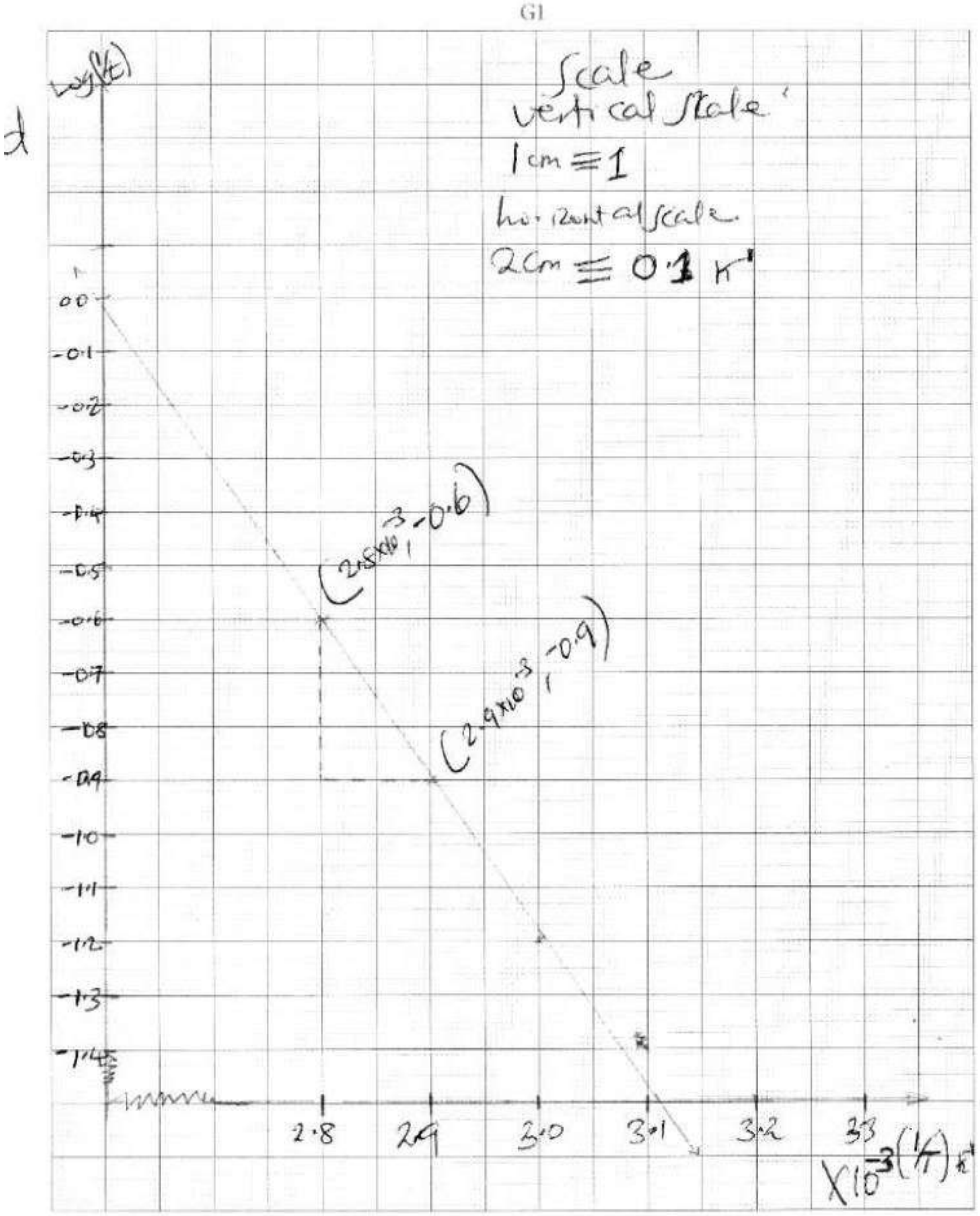
$$\text{Slope} = \frac{-Ea}{2.303R}$$

$$\frac{-3000}{1} = \frac{-Ea}{2.303 \times 8.314}$$

$$Ea = 57441.426 \text{ J}$$

∴ Activation energy = 57441.426 J

or = 57.441426 KJ



Extract 18.1: A sample of correct responses to question 2 Chemistry 2A.

In extract 18.1, the candidate correctly filled the table of results in part (a), constructed the overall chemical equation in part (b) and calculated the energy of activation in part (e). The candidate stated the relationship between the variation of temperature and time for the reaction in part (c).

He/she plotted the graph in part (d), however, he/she did not indicate the title of the graph.

On the other hand, candidates who scored low marks failed to complete the table in part (a). Most of them recorded incorrect temperature and time for the reaction to be complete. Few candidates rounded off data for the reciprocal of temperature into two instead of four decimal places. Also, some of the candidates miscalculated the reciprocals of time and temperature. In attempting part (b), some of the candidates gave incorrect products and failed to balance the overall chemical equation for the redox reaction in part (b). In commenting on the relationship of temperature with time in part (c), some candidates explained that temperature increases with time. They confused time with the rate of reaction. For instance, one candidate explained that *time is direct proportional to the temperature*. In part (d), the candidates plotted the graphs by indicating incorrect points due to failure into collect correct accurate data and wrong manipulation of the data collected. For instance, some of the candidates plotted a curve instead of a linear graph. The candidates responded to part (e) by giving incorrect slope. For example, one of the candidates did not indicate the constant 2.303 R in the formula while others used incorrect formula to calculate the energy of activation for the reaction. Also, some candidates did not calculate the slope after plotting the graph. Failure of the candidates to answer this question correctly implies that they lacked skills in thermochemistry such as recording time and analyzing data. Similarly, the candidates had inadequate skills of drawing and interpreting the graphs. An example of incorrect responses is given in Extract 18.2.

2

a) Table of results.

Temperature	T	1/T	Time	Rate	log (1/t)
C	K		t(s)	1/t (s^{-1})	~~-1.097~~
50	323	3.09×10^{-3}	13	0.08	-1.09
60	333	3.0×10^{-3}	9	0.1	-0.4
70	343	2.9×10^{-3}	4	0.25	-0.6
80	353	2.83×10^{-3}	2	0.5	-0.3

b) $MnO_4 + SO_4 \longrightarrow Mn^+ + S + SO_2$

Reduction

$MnO_4^- \longrightarrow Mn^{2+}$

$MnO_4^- \longrightarrow Mn + 4H_2O$

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

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

Oxidation.

$C_2O_4 \longrightarrow CO_3$

$C_2O_4^{-2} \longrightarrow 2CO_3$

$C_2O_4^{2-} \longrightarrow 2CO_3 + 2e^-$

Overall rxn

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

$5\{ C_2O_4^{2-} \longrightarrow 2CO_3 + 2e^-$

$2MnO_4^- + 16H^+ + 10e^- \longrightarrow 2Mn^{2+} + 8H_2O$

$5C_2O_4^{-2} \longrightarrow 10CO_3 + 10e$

$\therefore 2MnO_4^- + 16H^+ + 5C_2O_4^{-2} \longrightarrow 2Mn^{2+} + 8H_2O + 10CO_2$

2 Cont.

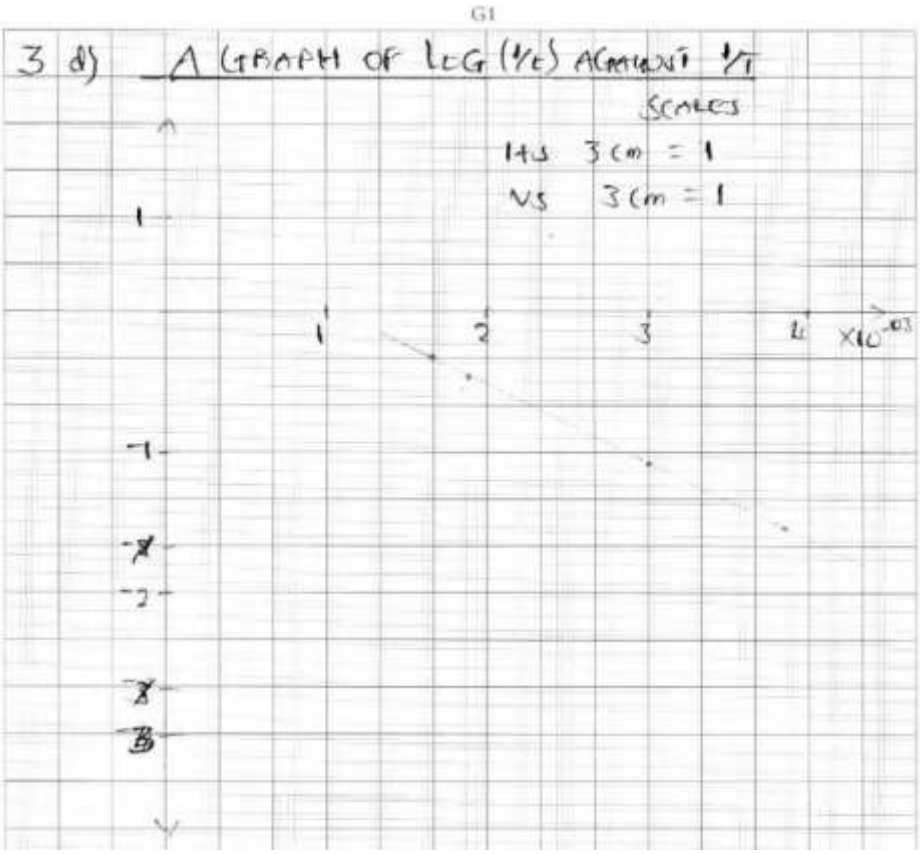
e) $\log \frac{1}{t} = \frac{-Ea}{2.303R} \times \frac{1}{T} + \log(k)$

$\frac{-1.09}{1} = \frac{-Ea}{2.303\times8.314} \times \frac{1}{323} + \log(0.08)$

$Ea \times \log 0.08 = \frac{16422.067}{\log 0.08}$

$-Ea = -1.5427 \times 10^{-04}$

$Ea = 1.5427 \times 10^{-4}$



Extract 18.2: A sample of incorrect responses to question 2 Chemistry 2A.

In Extract 16.2, the candidate recorded time which is nearly half the actual data in part (a). However in part (b), the candidate gave correct overall chemical equation for the reaction. In part (d) the candidate sketched an incorrect graph without labelling the axes. The candidate calculated activation energy in part (e) by substituting data from the table instead of the graph.

2.2.2.2 732/2B Chemistry 2B

In alternative paper 2B, the candidates were provided with the following scenario: Students were debating about the heat of reaction when dissolving anhydrous copper(II) sulphate and hydrated sodium thiosulphate in water. The argument was whether such reaction releases or absorbs heat. You are consulted to help to find the correct answer for their debate. In the process of undertaking the task, you are required to use the following:

R1: Anhydrous copper(II) sulphate ($CuSO_4$);
R2: Hydrated sodium thiosulphate ($Na_2S_2O_3.5H_2O$);
Distilled water, thermometer, plastic beaker (100 cm^3), 100 cm^3 measuring cylinder and a stopwatch.
Perform the experiment through the activities in the procedure and then answer the questions that follow.

Procedure

(i) *Measure 50 cm^3 of distilled water and transfer it in the plastic beaker. Record the initial temperature in degree centigrade as **T** initial.*
(ii) *Weigh 4.0 g of **R1** and transfer the salt into the measured water in (i) and immediately start a stopwatch while stirring gently the mixture with a thermometer.*
(iii) *Record the temperature in every 1-minute time interval five times.*
(iv) *Clean and dry the beaker ready for the second experiment.*
(v) *Repeat step (i) to (iii) except that instead of 4.0 g of **R1** in step (ii), use 6.0 g of **R2**.*
(vi) *Record temperature in 1-minute time interval five times.*

Questions

(a) *Draw and fill the results in the appropriate table.*
(b) *Plot the graphs of temperature as a function of time for both $CuSO_4$ and $Na_2S_2O_3.5H_2O$ solutions in the same graph axes and show the final temperature attained for each reaction.*
(c) *State which salt caused exothermic or endothermic reaction among the two salts. Support your answer with a reason.*
(d) *Calculate the heat change for each process using the following constants:*
Density of water = 1 g/cm^3
Specific heat capacity of water (cp) = 4.2 $J\ g^{-1}\ {}^oC^{-1}$

The candidates who scored high marks tabulated the data recorded appropriately in part (a). The candidates plotted the graph accordingly by indicating the title of the graph, labelling the axes, showing all points clearly, and indicating appropriate scale in part (b). In part (c) they identified copper(II) sulphate as the salt causing exothermic reaction and hydrated sodium thiosulphate as the one causing endothermic reaction. In part (d), they calculated the heat change for each process by using data, the constants given and correct formula. In addition, the candidates gave final answers with the correct unit of heat change (Joule). Basically, the candidates had adequate skills of performing heat experiments, plotting graphs and drawing conclusion based on the nature of the graph. Extract 19.1 is a sample of correct responses from one of the candidates.

2

Solution

a/ Table of Results

$R_1 = 4g$

mass (g)	Time (min)	Temperature (T) °c
$R_1 = 4g$	1	37
	2	36
	3	35
	4	34
	5	33

and when,

$R_2 = 6.0g$

Time (min)	Temperature (°c)
1	24
2	25
3	26
4	27
5	28

Table of Results

Time (min)	Temp (°c) R_1	Temp (°c) R_2
1	37	24
2	36	25
3	35	26
4	34	27
5	33	28

2 Cont.

c/ The salt which caused exothermic reaction is Anhydrous copper (R_1) since the heat is evolved or given out.

And

The salt which caused endothermic reaction is R_2 Hydrated sodium thiosulphate ($Na_2S_2O_3 \cdot 5H_2O$) since the Heat is absorbed as a result there is increase in Temperature.

d/ Solution

Given

Density of water $= 1g/cm^3$

Specific heat capacity of water, (cp) $= 4.2Jg^{-1}{}^{\circ}C^{-1}$

Heat change = Required

From

$$\Delta H = \text{mass} \times \text{specific heat capacity} \times \Delta\theta$$

$$\Delta H = (1g/cm^3 \times \text{Volume}) \times 4.2Jg^{-1}{}^{\circ}C^{-1} \times 29^{\circ}C$$

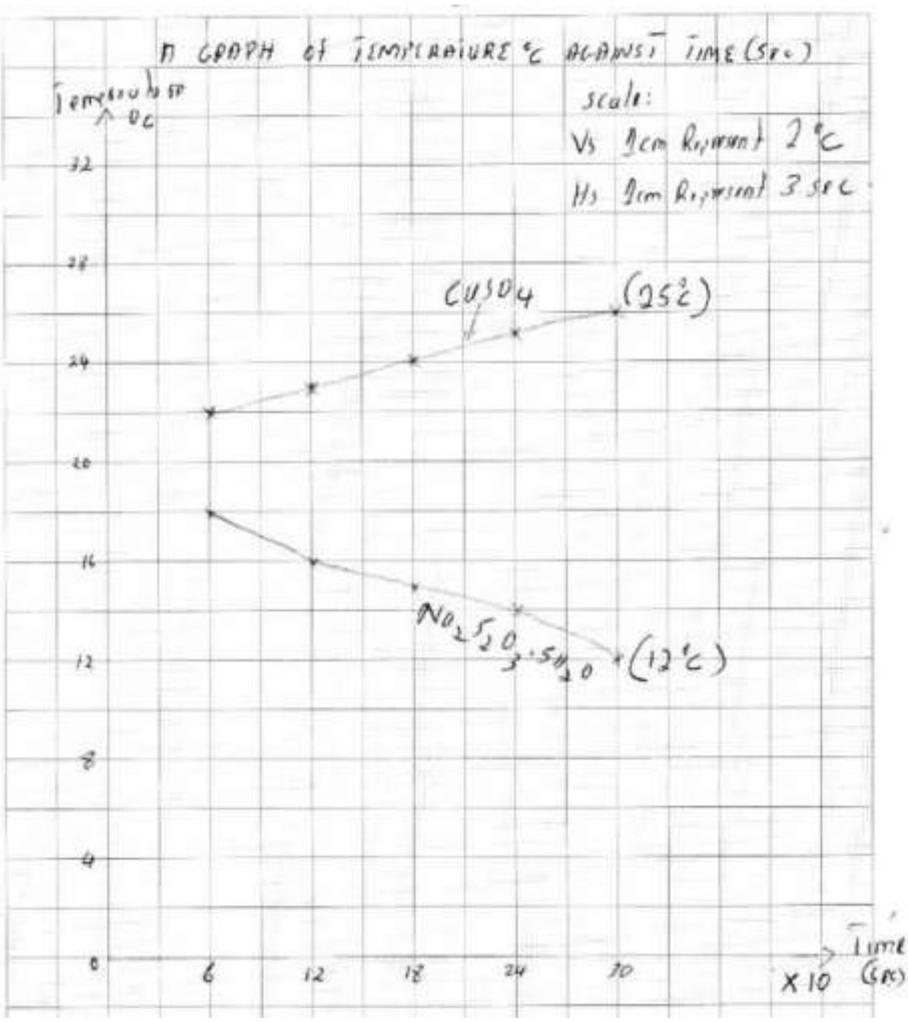
$$\Delta H = (1g/cm^3 \times 50cm^3) \times 4.2Jg^{-1}{}^{\circ}C^{-1} \times 29^{\circ}C$$

$$\Delta H = (50 \times 4.2 \times 29)\,J$$

$$\Delta H = 6090\,J$$

Note: $\Delta\theta = 29^{\circ}C$ (Initial Temp…)

$\therefore$ The Heat change is 6090J



Extract 19.1: A sample of correct responses to question 2 Chemistry 2B.

In Extract 19.1, the candidate correctly recorded the data, drew the two graphs and calculated the heat change for both copper(II) sulphate and hydrated sodium thiosulphate.

On the other hand, candidates who scored low marks recorded the data incorrectly in part (a). Most of the candidates in this category recorded temperature with significant positive deviation from the expected range (20 - 35^0C). For instance, one candidate recorded temperature ranging from 30^0C to 50^0C. Also, some of the candidates recorded the data with significant negative deviation from the acceptable range.

For instance, one candidate recorded a temperature of 10^0C which is minus 10^0C from the minimum temperature of 20^0C. In part (b), the candidates plotted the graph however, with incorrect data. Also, some of the candidates did not give heading to the graphs plotted. Similarly, some candidates did not indicate scale used together with others who did not label the axes of the graphs sketched. In part (c), there were candidates who incorrectly identified copper(II) sulphate as the salt causing endothermic reaction and hydrated sodium thiosulphate as the one causing exothermic reaction instead of the vice-versa. Other responses of the candidates termed both salts as endothermic. Part (d) was performed poorly by all candidates in this category. They calculated the heat change for each process by using either incorrect data or formula. For instance, one candidate calculated heat change for hydrated sodium thiosulphate by taking the product of specific heat capacity of water (4.18 $Jg^{-1}K^{-1}$), density (50 g cm^{-3}) and change in temperature (5 K), thus he/she wrote 1,045 joule. The candidate could not even calculate mass of water by using density and volume. In addition, the candidates failed to observe agreement of units during calculation. Generally, the candidates had inadequate skills of performing experiments in thermochemistry, plotting graphs and lack of sufficient numerical skills. An example of incorrect responses is given in Extract 19.2.

2	~~Tc~~
	~~Temperature~~
(a)	Table results .

Temperature °C		Time sec
R_1	R_2	
30	20	60sec
35	25	120 sec
40	28	180 sec
45	30	240 sec
50	35	300sec

(b) The graph of (R_1 and R_2)°C Vs Time

(c) CuSO4 is the salt that caused endothermic reaction below because the according to the nature of graph the temperature of CuSO4 are given in through the surrounding environment . while Na2S2O3.5H2O cause exothermic reaction because of more amount of heat which are still given out of the sorrounding environment

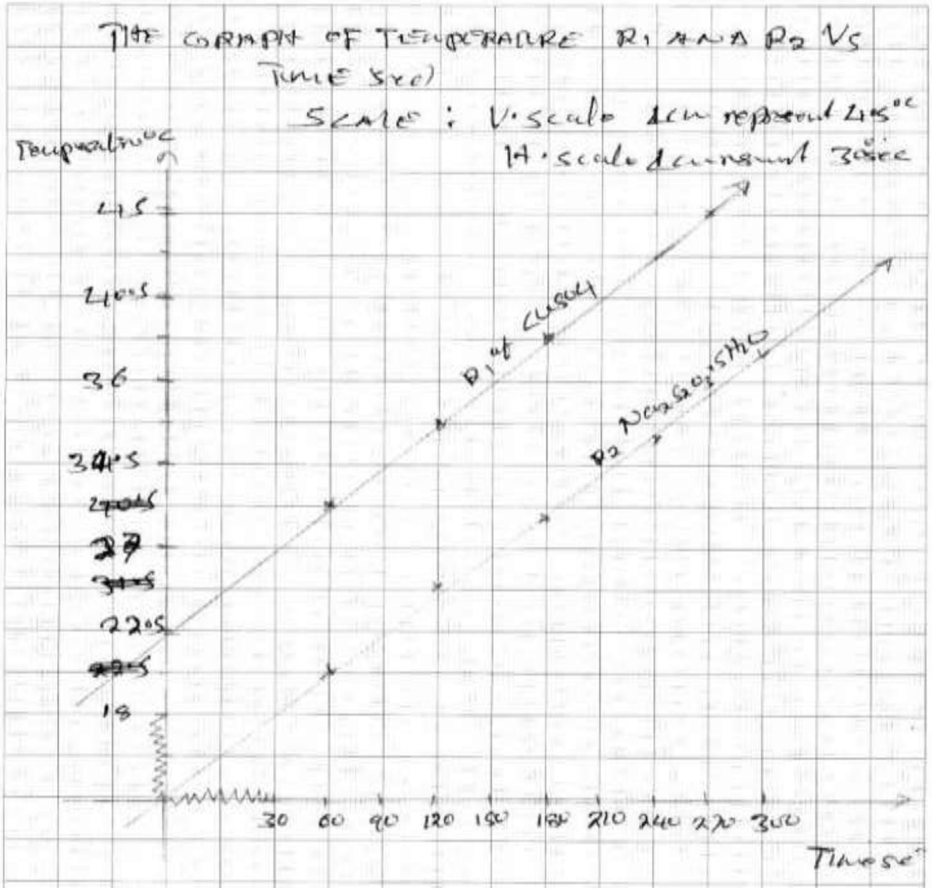
(c) CuSO4 is the salt that caused endothermic reaction because the salt absorb more heat from the sorrounding environment which allow temperature to given in while Na2S2O3.5H2O undergo ~~exthe~~ exothermic because the heat are removed in the surrounding environ

2 Cont.	
	ment and the temperature are given out from the sorrounding environment .
(d)	

$\Delta H =$

From Heat = $\frac{M \cdot \Delta T}{MP}$

$2.4 = 1 \times \Delta T$



Extract 19.2: A sample of incorrect responses to question 2 Chemistry 2B.

In Extract 19.2, the candidate got incorrect data of time in part (a), wrote unclear formula in part (d) and obtained a graph indicating that the reaction of hydrated sodium thiosulphate was exothermic instead of endothermic.

2.2.2.3 732/2C Chemistry 2C

In this question, the candidates were required to study the heat of reaction of different salts when dissolved in water. You are provided with the following materials:

***D1**: 2.0 g of ammonium nitrate*
***D2**: 2.0 g of calcium chloride*
Distilled water
Thermometer
100 cm^3 plastic beaker

Perform the experiment through the given procedure and then answer the questions that follow.

Procedure:

(i) *Measure 50 cm^3 of distilled water and transfer it into a plastic beaker.*
(ii) *Insert a thermometer into the distilled water in the plastic beaker and record the temperature of the water.*
(iii) *Add **D1** into the beaker containing distilled water and immediately start a stopwatch while stiring gently with your thermometer to dissolve the salt.*
(iv) *Record the temperature of the solution after every 30 seconds for four (4) minutes.*
(v) *Repeat steps (i) to (iv) except that instead of **D1** in step (iii) use **D2**.*

Questions

(a) *Present the results in a tabular form.*
(b) *Calculate the heat of solution for 2 g of each salt in water (assume that no heat is lost to the surroundings).*
(c) *State whether the process of dissolving salt **D1** or **D2** is endothermic or exothermic. Give one reason to support your answer.*

The analysis of candidates' responses showed that those who scored high marks correctly tabulated temperature recorded at intervals of 30 seconds. The temperatures recorded implied that the reaction of sample **D1** (ammonium nitrate) was endothermic while that of **D2** (calcium chloride) was exothermic. In part (b), the candidates used the correct formula to calculate heat of solution of ammonium nitrate and calcium chloride separately. Moreover, the candidates managed to calculate mass of the solution by multiplying density and volume. Extract 20.1 is a sample of correct responses from one of the candidates.

2	
	TABLE OF RESULT.
a	(table below)

	Final temp	Initial temp.	change in temp	volume cm^3	Mass of D and D2(g)
Exp. 1	23	25	-2	2	2
Expe 2.	27	25.	2.	2.	2.

b From, the formular:

$\Delta H = \rho V C \Delta T$.

For the first experiment

$\Delta H = 1g/cm^3 \times 2cm^3 \times 4.2 \times (-2)$.

$\Delta H = -16.8J$.

∴ For the first experiment of the D_1 the heat of the solution = $-16.8J$.

For the second experiment

$\Delta H = \rho V C \Delta T$.

$\Delta H = \cancel{2} \times 2 \times 4.2 \times 2$.

$\Delta H = 1 \times 2 \times 4.2 \times 2$.

$\Delta H = 16.8 J$.

∴ For the second experiment of the D_1 the heat change = $16.8J$.

~~But for the Heat/solution salt in water is given by: Moles of water = Molarity x volume. =~~

c i/ The process of dissolving salt D_1 is endothermic because amount of heat is absorbed from the surrounding.

2 Cont.

b ii/ The process of dissolving salt D_2 is exothermic because it involved for the loweing temperature to the surrounding.

Extract 20.1: A sample of correct responses to question 2 Chemistry 2C.

In Extract 20.1, the candidate recorded time correctly, solved the heat of reaction using correct formula and identified the type of the reactions based on heat change.

On the contrary, the candidates who scored low (0 to 5.5) marks failed to answer the question correctly. The candidates answered part (a) by filling the table partially. For example, some of the candidates did not indicate the column of maximum temperature change. Also, some candidates wrote the temperature for ammonium nitrate without putting the negative sign which implies that the temperature was decreasing. Furthermore, majority of the candidates in this category answered parts (b) and (c) incorrectly. For instance, some of the candidates did not introduce the volume of 50 cm^3 in the formula during calculation. Similarly, other candidates did not use the density of water during calculation. The unit of energy is Joule which however, many candidates failed to indicate in the final answers. In order to calculate heat change properly, the candidates were supposed to multiply density, volume, specific heat capacity and temperature change. In part (c), some of the candidates confused the terms endothermic and exothermic process. For instance, one candidate stated wrote that D1 is exothermic while D2 is endothermic. The reasons given by some of the candidates were not a valid justification of the answers. For instance, one candidate wrote, *D1 is endothermic because there is energy change*. Another candidate wrote *D2 is exothermic since the temperature changed slow*. The incorrect responses suggest that the candidates had inadequate knowledge of thermochemistry and lacked sufficient skills for data collection. Extract 20.2 shows an example of incorrect responses.

Temperature of water was 29°C

(a) Table of result.

Time(S)	D1T°C	D2T°C	D1 T(K)	D2(K)
30	27	~~29~~ 31	300	304
60	27	~~29~~ 31	300	304
90	27	~~29~~ 31	300	304
120	27	~~29~~ 31	300	304
150	27	~~29~~ 31	300	304
180	27	~~29~~ 31	300	304
210	27	~~29~~ 31	300	304
240	27	~~29~~ 31	300	304

(b) for

D 1 = 2g of ammonium nitrate.

Data given.

Mass = 2g

$\Delta T = T_2 - T_1 = 27 - 29 = -2$

C

$\Delta H = MC\Delta T$

but

$C = \frac{mass}{volume} = C = \frac{2}{\cancel{2}\times10^{-3}}$

$C = \frac{2}{0.05}$ $C = 40$

2 Cont.

b recall

$\Delta H = M\Delta T C$

$\Delta H = 2 \times 40 \times -2$

$\Delta H = J -160 JK$

∴ heat of solution D1 was −160JK

for D2.

from.

$\Delta H = MC\Delta T$

$M = 2g$

$C = 40$

$\Delta T = 2$

$\Delta H = 2 \times 40 \times 2$

$\Delta H = 160 JK$.

∴ heat of solution for D2 was 160JK.

(c) D1 was exothermic reaction because give out heat and the heat change was negative.

D2 was endothermic reaction because there is heat gain and the heat change was positive.

Extract 20.2: A sample of incorrect responses to question 2 Chemistry 2C.

In Extract 20.2, the candidate used mass of water equal to 2 g instead of 50 g. The candidate assigned the specific heat capacity of water as equal to 40 instead of 4.18 J $K^{-1}Kg^{-1}$ thus got incorrect answers. In part (c), the candidate confused exothermic process with endothermic one. Nonetheless, the candidate properly tabulated the collected data in part (a).

2.2.3 Question 3: Qualitative Analysis

Qualitative analysis assessed the competence of candidates in carrying out practical activities and making informed observations and inferences of the salts under investigation. The sample salts given were lead (II) nitrate

($Pb(NO_3)_2$ in alternative paper 2A, zinc nitrate ($Zn(NO_3)_2$ in paper 2B and sodium chloride (NaCl) in paper 2C. In all the three alternative papers, the experiments to be performed were guided.

This question was attempted by 1,815 (100%) candidates. Generally, the performance was good since 1,446 (79.7%) candidates scored 6.0 marks or above while 72 (20.3%) candidates failed. Figure 13 shows the distribution of these data.

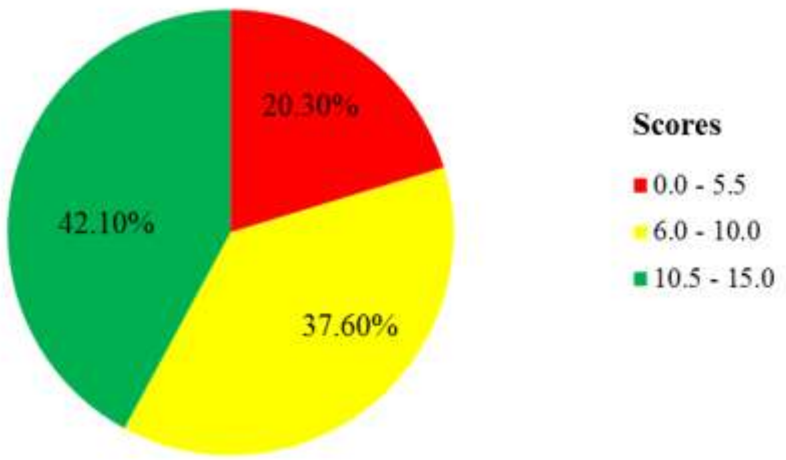


Figure 13: *Distribution of Candidates' Scores in Question 3*

The data in Figure 13 show that 42.1 per cent scored from 0 to 5.5, 37.6 per cent scored from 6.0 to 10.0 marks and 20.3 per cent of the candidates scored from 10.5 to 15 marks.

2.2.3.1 732/2A Chemistry 2A

In alternative paper 2A question 3 was as follows:

Sample from the industry was brought to the college laboratory as X. Perform systematic qualitative analyses to identify the cation and anion which cause the contamination of water. Prepare a relevant Table showing the qualitative analysis results. Base your experiment on the listed tests and then answer the questions that follow:

*(i) Appearance of sample **X**.*

(ii) Action of heat on sample X in a test tube.

(iii) Action of dilute sulphuric acid on a solid sample.
(iv) Action of concentrated sulphuric acid on solid sample.
(v) Flame test.
(vi) Solubility of the sample.
(vii) Action of dilute hydrochloric acid to a sample solution.
(viii) Action of aqueous ammonia to the original sample solution followed by ammonium oxalate.

Questions

(a) What are the cation and anion present in the water source?
(b) Write the reaction equation to indicate what took place in test (iii).

The analysis of candidates' responses showed that, those who scored high (10.5 to 15.0) marks identified the cation and anion which constituted the sample given. The cation was Ca^{2+} while the anion was CO_3^{-2} . In order to arrive at the correct answers, the candidates identified the appearance of sample X, stated the action of heat, action of dilute acids and action of concentrated sulphuric acids on substance X. They also performed flame test, investigated solubility in water, stated the effect of dilute hydrochloric acid and clarified the reaction of substance X with ammonia solution. The candidates wrote exact observation and gave correct inferences about each of the two ions present in substance X. Furthermore, the candidates gave the correct chemical equation for the reaction of calcium carbonate with dilute sulphuric acid. Extract 21.1 is an example of correct responses in this question.

3

TABLE OF RESULT

~~OBSERVATION~~ ~~Ø~~

	EXPERIMENT	OBSERVATION	INFERENCE
i)	The solid sample "X" appeared was white colour in powder form.	White powder observed.	CO_3^{2-} and HCO_3^- may be present except CO_3^{2-} of NH_4^+ K^+ and Na^+
ii)	To a little amount of solid sample "X" into a clean and dry test tube were heated.	Colourless gas evolved which turn lime water milky	CO_3^{2-} and HCO_3^- may be present.
iii)	To a little amount of solid sample "X" dilute sulphuric acid were added	Colourless gas evolved	CO_3^{2-} and HCO_3^- may be present
iv)	To a little amount of solid sample "X" conc. sulphuric acid were added.	Effervescence of a colourless gas which turns lime water milky observed	CO_3^{2-}, HCO_3^- may be present

3 Cont.	Experiment	Observation	Inference
v)	By using glass rod were in conc. HCL were heated in non-luminous flame	Brick red were observed	Ca^{2+} may be present.
vi)	To a little amount of solid sample "X" enough amount of distilled water were added to dissolve it.	The solution were soluble in cold water	CO_3^{2-} of Na^+, K^+, NH_4^+ may be present.
vii)	To a little amount of solid sample "X" into a clean and dry testtube small amount of dil. HCL were added.	Effervescence of a colourless gas which turns lime water milky were observed	CO_3^{2-} and HCO_3^- may be present.
viii)	To a little amount of solid sample "X" into a clean and dry testtube aqueous ammonia were added followed by ammonium oxalate.	White precipitate were observed.	Ca^{2+}, Sr^{2+}, Ba^{2+} may be present.

	To a little amount of solid sample "X" into clean and dry testtube $MgSO_4$ were added in dropwise	White precipitate is formed before warming the contents	CO_3^{2-} Confirmed
	To a little amount of samp "X" aqueous ammonia soln were added followed by aqueous ammonium oxalate	White precipitate is formed	Ca^{2+} Confirmed.
(a)	Cation is Ca^{2+} and anion CO_3^{2-}		
(b)	$H_2SO_4 + CaCO_3 \longrightarrow CaSO_4 + H_2O + CO_2$		

Extract 21.1: A sample of correct responses to question 3 Chemistry 2A.

In Figure 21.1, the candidate gave fairly correct observations, inferences, balanced chemical equation, cations and anions.

On the other hand, the candidates who scored low (0 to 5.5) marks failed to write appropriate observation in each stage. For instance, one candidate responded to stage (i) on the appearance of the sample by stating that *it is a solid substance* rather than commenting on colour and aspects such as being in powder form. In stage (iii), some of the candidates responded that the gas which evolved had no effect on litmus paper while it actually did. The candidate might have been misled by the use of dry litmus paper instead of a damp one to test the gas. Similarly, in giving inference concerning flame test, some of the candidates mentioned anions instead of cations. For instance, one candidate wrote *chloride ion may be present*. Also, some of the candidates wrote partial responses regarding inference. For example, one candidate responded to part (vii) by writing *carbonate confirmed* instead of *carbonate ions confirmed*. In addition some of the candidates had a problem of noticing colours. For instance, in part (i) on the observation there were candidates who wrote *milky powdered substance* instead of white powdered substance. Generally, candidates in this category had inadequate skills on analyzing chemical samples. Extract 21.2 presents a sample of incorrect responses to the question.

3	N			
	N			
	No	Procedures	Observation	Inferance
	i)	Appearance of X	White	Transitional metal absent
	ii)	Action of heat on sample X	colourless droplet formed on the cooler part of test tube	Hydrated salt may be present
	iii	Action of dilute sulphuric acid on solid sample		HCO_3^- & CO_3^-
	IX	Action of concentrated sulphuric acid on solid sample.		
	V	Flame test.		K^+
	VI	Solubility of the sample	Insoluble in hot or cold water	CO_3^{2+}
	VII	Action of dilute HCl ~~sulphuric~~ acid on sample solution.	Effervescent colourless gas turn lime water milky.	CO_3^{2-}, HCO_3^-
	VIII	Action of aqueous ammonia to original sample solution followed by ammonia oxalate.	Effer	CO_3^{2-}, HCO_3^-,

3 Cont.	
	(a) cation present ~~K~~ is K^+
	b) Anion present are HCO_3^- and CO_3^-

Extract 21.2: A sample of incorrect responses to question 3 Chemistry 2A.

In Extract 21.2, the candidate left the table with unfilled gaps and wrote incomplete responses in the inference column. He/she identified the cation as potassium instead of calcium and identified anions HCO_3^- and CO_3^- instead of CO_3^{2-}.

2.2.3.2 732/2B Chemistry 2B

The question was as follows:

*The sample salt was brought to your college as sample **R**. Perform a systematic qualitative analysis experiment to identify the cation and the anion present in the sample. Base your experiment on the listed tests and then answer the questions that follow:*

*(i) Appearance of sample **R***
*(ii) Action of heat on sample **R** in a test tube*
(iii) Action of dilute sulphuric acid on the solid sample
(iv) Action of concentrated sulphuric acid on solid sample
(v) Flame test
(vi) Solubility of the sample
(vii) Confirmatory test for the anion
(viii) Confirmatory test for the cation

Questions

(a) Prepare a relevant Table showing the analysis results.
(b) What are the cation and anion present in the sample?
(c) Write the reaction equation to indicate what took place in test (iv).

The analysis of candidates' responses shows that, those who scored high (10.5 to 15.0) marks reported properly on the eight tests (i - viii) by giving the observation and inferences in a standard table of results. The candidates correctly identified the cation which was Pb^{2+} and the anion which was NO_3^- (nitrate ion). In addition, most of the candidates showed correct products formed from the chemical reactions involved during procedure (i) to (viii) including the reaction of the sample with concentrated sulphuric acid in part (c). For example, one of the candidate gave products of the thermal decomposition of sample R in part (ii) as follows:

$$2Zn(NO_3)_2 \xrightarrow[\Delta]{} 2ZnO + 4NO_2 + O_2$$

Generally, the candidates had adequate knowledge of chemical analysis. Extract 22.1 shows a sample of correct responses from one of the candidates.

3

(a) To prepare a relevant Table of showing The analysis results.

Experiment to be performed	Expected observations	Inference.
(i) Appearance of sample R		
(a) Colour	White	Transition metal are ~~absent~~ absent
(b) Texture	Crystalline form	NO_3^-, SO_4^{2-}, Cl^-, $C_2O_4^{2-}$, CrO_4^{2-}, NO_2^-, CH_3COO^- and $Cr_2O_7^{2-}$ may be present.
(c) ~~Deqi~~ Deliquescence	Absorbs water from the atmosphere to form solution	NO_3^- Cl^- and SO_4^{2-} may be present.
(ii) Action of Heat on a solid sample R in a test tube.	Cracking sound with ~~a~~ evolution of brown gas.	$Pb(NO_3)_2$ may be present.
(iii) Action of dilute sulphuric acid on the solid sample	Brown fumes evolve which turn wet blue litmus paper red and ~~intensive~~ ~~intensify~~ intensify on addition of copper turnings	NO_3^- may be present.

3 Cont.		
(iv) Action of Concentrated sulphuric acid on a solid sample	Brown fumes evolve which turn ~~wet~~ wet blue litmus paper red, and intensify on addition of copper turnings	NO_3^- may be present.
(v) Flame test	~~Flame to~~ Blue grey	Pb^{2+} or Sb^{2+} may be present.
(vi) Solubility of the sample	soluble in cold water	NO_3^-, CH_3COO^-, HCO_3^- may be present
(vii) Confirmatory test for the anion	Brown ring is formed at the junction of the liquids	NO_3^- confirmed.
(viii) Confirmatory test for the ~~ani~~ cation	Brown fumes evolve	NO_3^- confirmed.

3 Cont.

(b) The Cation is Pb^{2+}

~~Anion~~ The anion is NO_3^-

The equation is $Pb(NO_3)_2$

(c). To write the reaction equation to indicate what took place in

Lead ~~Nitr~~ Nitrate ~~+~~ plus sulphuric acid is equal to lead sulphate plus water plus nitrogen oxide.

$Pb(NO_3) + H_2SO_4 \longrightarrow \cancel{PbSO_4}\ PbSO_4 + H_2O + NO_2$

Extract 22.1: A sample of correct responses to question 3 Chemistry 2B.

Extract 22.1, shows fairly correct responses from a candidate who gave appropriate observations and inferences for the tests performed. Also, the candidate wrote the correct chemical reaction showing the action of concentrated sulphuric acid on the solid sample of lead(II)nitrate).

On the other hand, candidates who scored low (0 to 5.5) marks failed to perform the tests and observe the outcomes appropriately. They also gave incorrect inferences on the preliminary and confirmatory tests about lead(II)nitrate (sample R). For instance, one candidate responded to step (i) on observation by writing *A solid salt*. The response of the candidate referred to the state of matter of sample R instead of its appearance which was supposed to be *white, crystalline substance*. Another candidate commented on observation in step (iii) by writing *a colourless gas was evolved*. This implies that the candidate had inadequate skills of observation during experiment. Other common misconceptions observed include assigning an incorrect charge to both lead ion and nitrate ion. For example, one candidate incorrectly assigned lead ion a charge of 4+ instead of 2+. Similarly, another candidate assigned nitrate ion a charge of 2- instead of 1-. Also, some candidates drew a table with unfilled gaps, which indicates lack of adequate knowledge of qualitative analysis. Furthermore, in writing the chemical equation for the reaction between the sample and dilute sulphuric or hydrochloric acid, some candidates gave incorrect products. Extract 22.2 is a sample of incorrect responses to the question.

3	Experiment	Observation	Inference.
	(i) Appearance of sample R	white	transition metal are absent may be absent.
	Texture	Crystalline form	NO_3^-, SO_4^{2-}, Cl^-, CO_3^{2-}, CrO_4^{2-}, NO_2^-, CH_3COO^- and $Cr_2O_7^{2-}$ may be present.
	(ii) A small amount of sample R into the test tube and then heat.	Brick red	Ca^{2+} may be present.
	(iii) A small amount of sample R in the test tube, followed by small amount of dilute sulphuric acid.	Effervescence of a colourless gas which turn lime water milky.	CO_3^{2-}, HCO_3^- may be present.
	(iv) A small amount of solid sample R in a test tube then addition of concentrated sulphuric acid.	Effervescence of a colourless gas which turn lime water milky.	CO_3^{2-}, HCO_3^- may be present.
	(v) A small amount of sample R put into test tube followed by small amount concentrated HCl then heat	Brick red	Ca^{2+} may be present.
	(vi) A small amount of solid sample R dissolved in water.	Insoluble in water	CO_3^{2-} may be present.

3 Cont.	Experiment	Observation	Inference.
	(vii) ~~Warm the solution~~ thereafter about		Ca^{2+} Confirmed.
	(viii) Warm the solution and add $(NH_4)_2CO_3$ if no precipitate are formed.	Brown solution is formed	CO_3^{2-} Confirmed
	(b) Cation is Ca^{2+}		
	Anion is CO_3^{2-}		
	(c) $Ca^{2+} + CO_3^{2-} \longrightarrow CaCO_3$		

Extract 22.2: A sample of incorrect responses to question 3 Chemistry 2B.

In Extract 22.2, the candidate gave incorrect responses to most parts of the question with exception of procedure (vi) in which he/she reported correctly the observation and inference. In parts (d) and (c) he/she identified the cation and anion as Ca^{2+} and CO_3^- instead of Pb^{2+} and NO_3^-.

2.2.3.3 732/2C Chemistry 2C

The question in alternative paper 2C was as follows:

*The candidates were required to perform a systematic qualitative analysis experiment to identify the cation and the anion present in the sample **Q**. Base your experiment on the listed tests and then answer the questions that follow:*

*(i) Appearance of sample **Q**.*
*(ii) Action of heat on sample **Q** in a test tube.*
(iii) Action of dilute sulphuric acid on the solid sample.
(iv) Action of concentrated sulphuric acid on the solid sample.
(v) Flame test.
(vi) Solubility of the sample.
(vii) Confirmatory test for the anion.
(viii) Confirmatory test for the cation.

Questions

(a) Prepare a relevant Table showing the qualitative analysis results.
(b) What are the cation and anion present in the sample?
(c) Write the reaction equation to indicate what took place in test (iv).

The analysis of candidates' responses showed that, those who scored high (10.5 to 15) marks wrote accurate observations and inferences. This means that the candidates performed all procedures involved in the experiment with competence. They were also knowledgeable in interpreting the results and giving plausible conclusions. In that case, the candidates managed to identify the cation which was zinc (Zn^{2+}) and the anion which was chlorine (Cl^-). With such scientific findings, the salt was zinc(II)chloride ($ZnCl_2$). Extract 23.1 presents an example of correct responses from one of the candidates.

	EXPERIMENT	OBSERVATION	INFERRENCE
i	Appearance of Sample Q	white Crystalline	
ii	~~Action of heat on sample Q~~ in a test		

(a)

	EXPERIMENT	OBSERVATION	INFERENCE.
i/	Appearance of Sample.		
	ⓐ Colour	white	Transition metal are absent.
	ⓑ Texture.	Crystalline form	NO_3^-, SO_4^{2-}, Cl^-, $C_2O_4^{2}$, CrO_4^{2}, NO_2^-, CH_3COO^- and CrO_7^{2+} may be present.
	ⓒ Deliquescence	Absorb water from the atmosphere to form Solution	NO_3^-, Cl^- and SO_4^{2-} may be present
ii	Action of heat on Sample Q in a test tube	Colourless gas evolved which turn wet litmuss paper from blue to red and form dense white fumes with ammonia gas.	Cl^- may be present.

3 Cont.

	EXPERIMENT	OBSERVATION	INFERENCE
iii	Action of dilute Sulphuric acid on the Solid Sample.	No gas evolved	SO_4^{2-} and Cl^- may be present
iv	Action of concentrated Sulphuric acid on the Solid Sample.	Colourless gas with irritating smell evolved, which turns wet litmus paper from blue to red and forms dense white fumes with ammonia gas	Cl^- may be present
v	Flame test	Bright yellow	Na^+ may be present
vi	Solubility of the sample.	Soluble in cold water	Cl^- may be present except those of Ag^+ and Pb^{2+}
vii	Confirmatory test to the anion. • To transfer about $1cm^3$ of the extract into test tube, Add dilute HNO_3 followed by $AgNO_3$ Solution	White precipitate Soluble in dilute ammonia Solution is formed	Cl^- confirmed

3 Cont.

	EXPERIMENT	OBSERVATION	INFERENCE:
viii	Confirmatory test to the cation. ~~Wash the precipitate by acid~~ To the solution of the Sample add dilute NaOH Solution until in excess	White precipitate Soluble in excess	Zn^{2+} confirmed

(b) The cation present in the sample is Cl^-

The anion present in the Sample is Zn^{2+}

(c) Reaction equation to indicate what took place in test iv is:

~~$ZnCl_2 + H_2SO_{4(aq)} \rightarrow ZnSO_3 + HCl_2 + SO_{2(g)}$~~

$ZnCl_{2(s)} + H_2SO_{4(aq)} \rightarrow ZnSO_{4(aq)} + 2HCl_{(g)}$

Extract 23.1: A sample of correct responses to question 3 Chemistry 2C.

In Extract 23.1, the candidate presented correct observations and inferences in part (a) and indicated the correct ions in part (b). He/she wrote a correct chemical equation representing the reaction of zinc chloride with concentrated sulphuric acid in part (c).

In contrast, the candidates who scored low (0 to 5.5) marks gave incorrect observations and inferences in part (a). For instance, some of the candidates showed that bubbles of gas were evolved when sample Q (zinc(II)chloride) was treated with dilute sulphuric acid. In fact, there was no gas which evolved because zinc chloride does not react with dilute sulphuric acid. In reporting about the flame test, some of the candidates incorrectly described the characteristic colour of non-luminous flame which is blue while sample Q did not impact any characteristic colour. Similarly, there were candidates who associated the flame with the characteristic colour of either iron or copper metal. Thus, they incorrectly confirmed for the presence of sodium ions in the inference part. Others reported the presence of calcium ions instead of zinc ions. Moreover, some candidates filled the table of results partially, leaving some gaps on the observation and inference columns. This means that the candidates had inadequate skills of conducting qualitative analysis experiments. Extract 23.2 shows a sample of incorrect responses to this question.

3	SN	EXPERIMENT	OBSERVATION.	Reference
	1.	a. Colour of sample Q	White colour observed	transitional metal absent.
		b. Texture of solid sample	Crystaline form observed	NO_3^-, SO_4^{2-}, Cl^-, CO_3^{2-}, CrO_4^{2-}, NO_2, CH_3COO^- and $Cr_2O_7^{2-}$ may be present
		c. Deliquence of sample Q	~~Absor~~ Absorption of water from atmosphere was observed.	NO_3^-, Cl^- and SO_4^{2-} may be present.
	II.	b. 0.5g of sample Q was introduced in the clean and dry test tube	Colourless gas evolves which turn wet blue litmus paper from blue to red with and form dense white fumes with ammonia gas	Cl^- may be present.
	III.	0.5g of sample Q was transfered in the clean and dry test tube		

3 Cont.	followed by the addition of the dilated Sulphuric acid	No gas was evolved	SO_4^{2-}, Cl^- may be present
IV.	0.5g of Solid sample Q was transfered into dry and clean test tube followed by addition of few drops of the Concentrated H_2SO_4	colourless gas with Chocking smell which turn wet litmus paper from blue to red and form dense white formed with ammonia gas.	Cl^- may be present.
V.	the glass rod was dipped in Concentrated Hcl in a watch glass then heated in the non-luminous frame.	Bright yellow was observed	Na^+ may be present
VI:	0.5g of solid sample was introduced in then test tube followed by addition of water.	soluble in cold water was observed	Na^{2+} K^+ NH_4^+ may be present
VII.	Transfering 0.5g of solid Sample into the test tube followed by addition of the HNO_3 and $AgNO_3$ Solution.	White precipitate soluble in diluted ammonia is formed	Cl^- confirmed
VIII.	To evaporate the suppernatant and use the residue formed to perform flame test.	Yellow flame	Na^+ confirmed

b. The Cation of solid sample is Na^+ and the anion of solid Sample is Cl^-.

c. $NaCl + H_2SO_4$

Extract 23.2: A sample of incorrect responses to question 3 Chemistry 2C.

Extract 23.2, shows that in step (v) the candidate wrote observation and inference on sodium instead of zinc ions. He/she mentioned cations in step (iv) instead of chloride ions in step (vi). In addition, the responses given in step (viii), parts (b) and (c) were incorrect.

3.0 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH TOPIC

3.1 Analysis of Candidates' Performance in Each Topic in Chemistry Paper 1

A total of 11 topics were examined in Chemistry paper 1. The topics covered included: *Analysis of O'level Chemistry Curriculum Materials; Planning and Preparation for Teaching; Environmental Chemistry; Assessment in Chemistry; Volumetric analysis; Chemical Kinetics, Energetics and Equilibrium; Transition Metal Chemistry; Electrochemistry; General Chemistry; Fundamentals of Teaching and Learning Chemistry* and *Organic Chemistry.*

Good performance of candidates was observed in the topics of *Analysis of O'level Chemistry Curriculum Materials* (98.6%), *Environmental Chemistry* (95.3%), *Assessment in Chemistry* (87.0%) and *Qualitative Analysis* (79.7%). The candidates attained average performance in the topics of *Planning and Preparation for Teaching* (67.9%), *Volumetric Analysis* (63.0%) and *Chemical Kinetics, Energetics and Equilibrium* (50.3%). On the contrary, the candidates had poor performance in the topics of *Transition Metal Chemistry* (28.5%), *Electrochemistry* (23.8%), *General Chemistry* (10.2%), *Fundamentals of Teaching and Learning Chemistry* (8.9%) and *Organic Chemistry* (6.4%). A summary of the candidates' performance in each topic in Chemistry paper 1 is shown in **Appendix I**.

3.2 Analysis of Candidates' Performance in Each Topic in Chemistry Paper 2

In each of the three alternatives of Chemistry Paper 2, a total of three topics were examined. The topics were *Laboratory Management*, *Volumetric Analysis*, and *Chemical Kinetics, Energetics and Equilibrium*. The candidates' performance was good in the topics of *Qualitative Analysis* (79.7%) and *Volumetric Analysis* (74.7%) and was average in the topic of *Chemical Kinetics, Energetics and Equilibrium* (46.8%). A summary of the candidates' performance in each topic in Chemistry paper 2 is shown in **Appendix II**.

4.0 CONCLUSION

Based on the evidence from both statistics and candidates' responses, it can be concluded that, the overall performance of candidates in the Chemistry subject was good. Such good performance was attributed to a number of factors including adequate knowledge and skills of most of the candidates especially in the practical paper. However, the performance was weak in five topics because some of the candidates lacked sufficient knowledge of the concepts tested. In comparison, the performance of candidates in the practical paper was better than in the theory paper, suggesting that students become more competent when they learn by doing.

5.0 RECOMMENDATIONS

In order to improve the performance of prospective candidates in chemistry examination, the following recommendations need to be taken into consideration:

(a) During teaching *Organic Chemistry*, tutors are encouraged to use reaction maps showing summary of conversion reactions so as to help learners understand reaction mechanism and chemical properties of compounds.

(b) Together with other strategies, the topic of *Fundamentals of Teaching and Learning Chemistry* should be taught with the aid of wall charts and manuals showing how to prepare a variety of teaching materials in Chemistry.

(c) In teaching the topic of *General Chemistry*, tutors are advised to use flip charts showing the atomic structure and scientific experiments behind the discovery of atomic models.

(d) During experimentation on electric conductivity of weak and strong electrolytes in the topic of *Electrochemistry*, tutors are advised to guide learners on deriving the degree of dissociation of electrolytes.

(e) During classroom teaching of the topic of *Transition Metals Chemistry*, learners can be led to distinguish ligands from species such ammonium ions which cannot donate lone pair of electrons to a central metal element.

APPENDIX I

Summary of Candidates' Performance in Each Topic in 732/1 Chemistry 1 (Theory Paper)

S/N	Topic	Question Number	Performance in each Question (%)	Performance in each Topic (%)	Remarks
1	Analysis of O'level Chemistry Curriculum Materials	13	98.6	98.6	Good
2	Environmental Chemistry	12	95.3	95.3	Good
3	Assessment in Chemistry	14	87.0	87.0	Good
4	Planning and Preparation for Teaching	9	67.9	67.9	Average
5	Volumetric Analysis	3	83.4	63.0	Average
		8	42.6		
6	Chemical Kinetics, Energetics and Equilibrium	2	64.5	50.3	Average
		11	36.1		
7	Transition Metal Chemistry	5	28.5	28.5	Weak
8	Electrochemistry	4	23.8	23.8	Weak
9	General Chemistry	1	10.2	10.2	Weak
10	Fundamentals of Teaching and Learning Chemistry	7	8.9	8.9	Weak
11	Organic Chemistry	6	7.7	6.4	Weak
		10	5.0		

APPENDIX II

Summary of Candidates' Performance in Each Topic in 732/2 Chemistry 2 (Actual Practical)

S/N	Topic	Question Number	Performance in each Question (%)	Performance in each Topic (%)	Remarks
1	Qualitative Analysis	3	79.7	79.7	Good
2	Volumetric Analysis	1	74.7	74.7	Good
3	Chemical Kinetics, Energetics and Equilibrium	2	46.8	46.8	Average