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CSEC® CHEMISTRY



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May–June 2026

CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THE CARIBBEAN SECONDARY EDUCATION CERTIFICATE® EXAMINATION

MAY–JUNE 2026

CHEMISTRY
GENERAL PROFICIENCY

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INTRODUCTION

This guide is based on the 2026 May–June examination in CSEC Chemistry. The examination comprised the following papers.

- Paper 01 — Multiple Choice
- Paper 02 — Structured Essay
- Paper 031 — School-Based Assessment (SBA)
- Paper 032 — Alternative to School-Based Assessment (private candidates)

Candidates' performance was assessed across three key profile areas: Knowledge and Comprehension (KC), Use of Knowledge (UK) and Experimental Skills (XS).

In the 2026 May–June examination, 67.74 per cent of candidates earned acceptable Grades I–III compared with 60.28 per cent in 2025 and 64.14 per cent in 2024. The percentage of candidates in the Grade I band was 23.89 per cent compared with 16.68 per cent in 2025 and 17.90 per cent in 2024.

PAPER 01 — MULTIPLE CHOICE

Paper 01 consisted of 60 multiple choice items, which were based on all sections of the syllabus.

The mean score was 38.01 (63.34 per cent) and the standard deviation 13.01. The maximum score obtained by any candidate was 60.

PAPER 02 — STRUCTURED/EXTENDED ESSAY

Paper 02 consisted of one compulsory data analysis question, two structured questions and three extended response questions.

Generally, candidates' performance was satisfactory. The maximum score obtained was 100 out of 100 marks. The mean score was 39.94 and the standard deviation 23.57.

Question 1

This question tested the following specific objectives from Section A (Principles of Chemistry) of the syllabus: A 6.2, 6.6, 7.1, 7.9 and 7.11.

Part (a) (i)

Most candidates were able to correctly define the term *acid*. However, some candidates incorrectly described the physical characteristics of acids instead of giving a definition. The most common correct responses included the following.

- An acid is a proton donor.
- A substance that produces H^+ ions in water.

The most common incorrect responses were as follows.

- An acid is a substance which is reactive and which has a low pH or a pH less than 7.
- A combination of hydrogen and other compounds.
- A corrosive substance with a low pH.

Part (a) (ii)

Many candidates were unable to define the term *normal salt* correctly. Candidates were expected to state that a normal salt is formed when all the hydrogen ions of an acid are replaced by metal ions or ammonium ions.

Many candidates defined a normal salt as a product of neutralization. Additionally, a significant number of candidates used incorrect chemistry jargon such as 'hydrogen atom', 'metal' and 'ammonium atom' as opposed to *ions* when providing a definition for normal salt.

The most common incorrect responses included the following.

- A compound that can be dissolved and release ions.
- A salt forms from replacing hydrogen with a cation.

Part (b)

Most candidates performed well on this part. Most of them were able to record the correct mass of the beaker and the precipitate from the diagrams provided in Figure 1. Candidates who did so correctly were awarded four marks.

Part (c)

Most candidates obtained four marks for subtracting correctly to obtain the mass of the precipitate formed.

Part (d)

Many candidates were able to accurately plot the points on the graph as recorded in the table for Part (c). However, most candidates could not produce two straight intersecting lines of best fit so they drew a curve through the points.

Part (e)

For Part (e), candidates were required to label the point that indicated the minimum volume of sulfuric acid required to precipitate all the silver ions from the silver nitrate and to record the volume. They were required to use the graph they plotted in Part (d) to complete this task. Many candidates did not draw two intersecting straight lines in Part (d) as required but they drew a curve. Therefore, many candidates could not correctly identify the minimum volume of sulfuric acid required. Instead, many of them incorrectly identified the maximum point on the curve as the minimum volume of sulfuric acid required.

Part (f)

Most candidates were able to score at least one mark for calculating the number of moles of silver ions in 50 cm^3 of the 0.50 mol dm^{-3} of silver nitrate solution. Some candidates used the correct formula (*moles = concentration ($moldm^{-3}$) x volume (dm^3)*).

Some candidates understood only part of the operation (0.5 x 50) or (50/1000) but struggled to complete the operation by then dividing by 1000 or multiplying by 0.5 based on the selected operation.

In addition, many candidates used mole triangles for calculating moles and this should be discouraged since it is extensively documented that doing so hinders student's problem-solving ability and conceptual thinking in the mole concept and fosters mostly rote learning.

Part (g) (i)

This part was challenging to some candidates. Most of them were unable recognize the correct mole ratio and therefore were unable to use their answer in Part (f) to correctly derive the correct mole value. The most common incorrect responses included

- moles of sulfuric acid = moles silver ions (answer from Part (f) x 2)
- stating 2:1 mole ratio without identifying the reagents in the ratio.

Part (g) (ii)

Most candidates had difficulty determining the minimum volume in Part (e) and subsequently were unable to calculate the molar concentration of sulfuric acid in the minimum volume. A few candidates used the correct formula (c*oncentration = moles [answer from Part (g) (i)]/volume [answer from Part (e) (dm^3)]*).

Part (g) (iii)

Most candidates were able to calculate the correct mass concentration of sulfuric acid. Even though their response to Part (g) was incorrect, many candidates identified that they were to use the response to Part (g) (ii) and multiply that value by 98. Candidates who did so were awarded two marks for the operation.

The most common incorrect responses included

- mass concentration of sulfuric acid = 98 g mol^{-1}/molar concentration of sulfuric acid (answer fromPart (g) (ii))
- mass concentration of sulfuric acid = molar concentration of sulfuric acid (answer from Part (g) (ii))/98 g mol^{-1}.

Question 2

This question tested the following specific objectives from Section A (Principles of Chemistry) of the syllabus: A 6.5, 8.2, 8.3, 8.4, 8.5, 9.7, 9.8 and 9.10.

Part (a) (i)

This part required candidates to define the term *electrolysis*. Many candidates earned at least one of the two available marks by recognizing that an electric current is passed through an electrolyte. Many candidates also correctly identified that electrolysis involves the decomposition or chemical change of an electrolyte, thereby obtaining full marks.

Examples of an Expected Response

- Electrolysis is a chemical change/chemical reaction/chemical breakdown produced by passing an electric current/electricity through an electrolyte.
- Electrolysis is the decomposition/breakdown of an electrolyte by the passage of an electric current/(electricity).

Common Errors and Misconceptions

Although candidates' overall performance was good, several misconceptions were evident. These were as follows.

- Many candidates only stated that electricity passes through an electrolyte and omitted the essential idea that a chemical change or decomposition occurs. Candidates who gave such responses lost one mark.
- Some candidates used imprecise terms such as 'solution', 'substance', 'compound', 'chemical' or even 'electrode' instead of electrolyte.
- Several candidates described electricity passing through a metal, liquid or ionic solid, demonstrating that they were confused about the conditions required for electrolysis.
- Some candidates focused on the movement of ions to the electrodes or oxidation and reduction at the electrodes rather than defining the overall process of electrolysis.

Recommendations for Teachers

Teachers should reinforce the precise definition of electrolysis and ensure that students understand the essential components that they are required to mention in order to gain full marks. Students should be taught that a complete definition must include a reference to

- the passage of an electric current through an electrolyte (or a molten or aqueous ionic compound).
- the resulting chemical decomposition, chemical change or chemical reaction of the electrolyte.

Teachers may find it useful to introduce the word by its roots such as

- electro = electricity
- lysis = splitting or decomposition.

This reinforces the definition: Electrolysis is the decomposition (or chemical change) of an electrolyte caused by the passage of an electric current.

In addition, teachers should

- emphasize the correct use of the term *electrolyte* and distinguish it from related terms such as *solution*, *compound* and *electrode*
- clarify that electrolysis occurs only when ions are free to move such as in molten or aqueous ionic compounds
- reinforce definitions through practical laboratory activities and demonstrations, allowing students to connect the theoretical definition with observable chemical changes during electrolysis
- encourage students to memorize standard syllabus definitions accurately while also understanding the underlying concepts.

Part (a) (ii)

This part required candidates to state why the hydroxide ions rather than the sulphate ions are discharged at the anode during the electrolysis of copper (II) sulphate using inert electrodes. This part was generally well answered. Most candidates correctly stated that hydroxide ions are lower in the electrochemical series than sulphate ions or that sulphate ions are higher in the electrochemical series. Candidates who stated either response were awarded the available mark.

Examples of an Expected Response

- Sulphate ions are less reactive/higher in the electrochemical series/require more energy.
- Hydroxide ions are more reactive/lower in the electrochemical series/require less energy.

Common Errors and Misconceptions

- Many candidates incorrectly referred to the reactivity series instead of the electrochemical series.
- Some candidates incorrectly stated that hydroxide ions are higher in the electrochemical series.
- A common misconception was that hydroxide ions are discharged simply because they are negative ions attracted to the positive anode. This does not explain the preferential discharge since both hydroxide and sulphate ions are negatively charged.

Recommendations for Teachers

Teachers should emphasize that preferential discharge is determined by the position of ions in the electrochemical series and not the reactivity series of metals. Students should understand that hydroxide ions are discharged preferentially because they are lower in the electrochemical series (or require less energy to discharge) than sulphate ions. Regular practice using the electrochemical series of both cations and anions will strengthen students' conceptual understanding and improve their precision when providing responses in the examination. The reactivity series should only be referred to when discussing the chemical reactivity of metals such as displacement reactions and reactions with acids or water. The electrochemical series should be referred to when explaining electrolysis, particularly the preferential discharge of ions at the electrodes.

Part (a) (iii)

This part required candidates to write a balanced equation, including state symbols, for the reaction at the cathode during the electrolysis of copper (II) sulphate solution using inert electrodes. Candidates' performance was mixed. While many candidates correctly wrote the half-equation for the reduction of copper (II) ions at the

cathode, a similar proportion of candidates produced incorrect equations or omitted essential details, particularly the state symbols.

Example of an Expected Response

$Cu^{2+}(aq) + 2e^- \rightarrow Cu\ (s)$

Common Errors and Misconceptions

- Many candidates wrote the oxidation half-equation instead of the required reduction half-equation at the cathode, for example, $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$.
- Some candidates incorrectly placed the electrons or ionic charges, resulting in unbalanced half-equations.
- Other candidates omitted or used incorrect state symbols, particularly for $Cu^{2+}(aq)$ and Cu(s).
- A few candidates incorrectly included $CuSO_4(aq)$ as a product or failed to write an ionic half-equation.

Recommendations for Teachers

Teachers should reinforce to students that reduction occurs at the cathode where cations gain electrons. Students should receive regular practice in writing balanced ion-electron half-equations, ensuring that both mass and charge are balanced and that correct state symbols are included. Emphasis should also be placed on distinguishing between oxidation and reduction half-equations and on identifying the correct electrode at which each process occurs.

Part (a) (iv)

This part required candidates to state two changes that occur in the electrolyte during the electrolysis of copper (II) sulphate solution using inert electrodes. This part was the most poorly answered for this question. While many candidates correctly stated that the blue colour of the copper(II) sulphate solution faded or became colourless, relatively few of them identified the second expected change — that the electrolyte became more acidic. Consequently, a significant number of candidates earned only one of the two available marks.

Examples of an Expected Response

- Blue colour of electrolyte fades/turns colourless/decolorizes.
- Electrolyte becomes acidic.

Common Errors and Misconceptions

- Many candidates described changes at the electrodes, particularly the brown or pink deposit of copper at the cathode, instead of changes occurring in the electrolyte.
- Some candidates referred to colour changes in a general manner without specifying that the blue solution faded or became colourless.
- Other candidates stated that the concentration, volume or temperature of the solution changed, which were not the expected responses.
- Some candidates mentioned a decrease in pH without clearly stating that the electrolyte became acidic.

Recommendations for Teachers

Teachers should emphasize to students that it is important read the examination questions carefully in order to interpret them correctly. Students should also be able to distinguish between changes at the electrodes and changes in the electrolyte. Practical investigations of the electrolysis of aqueous copper (II) sulphate using inert electrodes should be used to reinforce to students that as electrolysis proceeds, Cu^{2+} ions are removed from solution and this causes the blue colour to fade. It should also be reinforced that the formation of H^{+} ions cause the electrolyte to become more acidic. Students should also be encouraged to use precise scientific language when describing changes in observable properties and solution chemistry.

Part (b) (i)

This part required candidates to define each of the following terms as it relates to redox reactions: *reduction* and *reducing agent*. This part was answered very well. A significant proportion of candidates correctly defined *reduction* as *the gain of electron*s and a *reducing agent* as *a substance that loses electrons or causes another substance to be reduced*. Candidates who provided such responses earned full marks.

Examples of an Expected Response

- Reduction
    - — gain in electrons
    - — decrease in oxidation state
    - — loss of oxygen
    - — gain of hydrogen
- Reducing agent
    - — oxidized
    - — loses electrons
    - — gains oxygen
    - — loses hydrogen in a redox reaction
    - — increases in oxidation state
    - — causes reduction to take place
    - — causes another substance to gain electrons
    - — causes another to lose oxygen

Common Errors and Misconceptions

- Some candidates confused reduction with oxidation. Candidates who did so stated that reduction involves the loss of electrons or gain of oxygen.
- A few candidates provided vague or incomplete definitions. For example, some candidates described *reduction* as ‘getting smaller’ or a *reducing agent* as ‘a substance that causes a decrease’.
- Some candidates incorrectly related the term *reducing agent* to concepts from rates of reaction rather than redox chemistry.
- Although alternative definitions such as *loss of oxygen* or *gain of hydrogen* for reduction were acceptable, many candidates did not provide sufficiently precise scientific definitions.

Recommendations for Teachers

Teachers should continue to reinforce the standard definitions of redox terms using electron transfer as the primary explanation. Students should understand that reduction is the gain of electrons (or a decrease in oxidation state), while a reducing agent loses electrons, is oxidized and causes another species to be reduced. Mnemonics such as RIG (Reduction Is Gain of electrons) and OIL (Oxidation Is Loss of electrons) can be used to aid recall, but students should also be encouraged to understand the underlying redox processes and provide complete, scientifically accurate definitions in examinations.

Part (b) (ii)

This part required candidates to deduce the oxidation state of sulfur in $CuSO_4$. This part was generally well attempted. Many candidates correctly applied the rules for determining oxidation states and so they earned one mark. Candidates were unable to obtain full marks because they did not express the oxidation states correctly.

Example of an Expected Response

Cu + S + 4O = 0
(+2) + S + 4(-2) = 0
S = 8 - 2 = +6

Common Misconception

In some instances, candidates could not distinguish between an oxidation state and an ionic charge. Although many candidates correctly determined that sulfur has an oxidation state of +6 in $CuSO_4$, they lost marks because they omitted the sign (writing 6 instead of +6). In addition, some candidates expressed the oxidation states as ionic charges (2+ instead of +2). This suggests that many candidates regarded oxidation states and ionic charges as interchangeable, despite these being different chemical concepts with different methods of notation. In addition, some candidates were unable to correctly apply the rules for assigning oxidation states, suggesting weaknesses in their understanding of the oxidation state rules for compounds and polyatomic ions.

Recommendations for Teachers

Teachers should emphasize that oxidation states must always be written with the appropriate sign preceding the number (for example, +2, −2, +6). Students should be taught to distinguish clearly between oxidation states and ionic charges, as these are not written in the same format. Regular practice in applying the rules for assigning oxidation states, particularly in polyatomic ions and neutral compounds, will strengthen students' conceptual understanding and improve examination performance.

Part (c)

This part required candidates to calculate the mass of copper (in grams) which would be deposited at the cathode when 6A of current passes through the electrolytic cell for 45 minutes. This part was answered moderately well. Many candidates demonstrated familiarity with the steps involved in electrolysis calculations and were able to correctly apply the relationship $Q = It$ to determine the quantity of charge. A significant proportion of candidates earned at least three of the four marks by following the correct calculation procedure. However, relatively few candidates obtained full marks because they applied the electron-to-metal mole relationship incorrectly or made errors in the calculation.

Examples of an Expected Response

45 × 60 × 6 = 16200C

96500 × 2 = 193000C

Number of moles = $\frac{16200}{193000}$ = 0.084 mols

Mass of Cu = 0.084 × 64 = 5.38g

OR

45 × 60 × 6 = 16200C

$\frac{16200}{96500}$ = 0.1679

0.168 ÷ 2 = 0.084 mols

Mass of Cu = 0.084 × 64 = 5.38g

Common Errors and Misconceptions

Many candidates correctly calculated the quantity of charge but did not account for the fact that the reduction of Cu^{2+} requires two moles of electrons for every mole of copper deposited. As a result, they used 96 500 C instead of 2 × 96 500 C when determining the number of moles of copper. Other common errors included failing to convert the time from minutes to seconds, reversing the required mole ratio by doubling instead of halving (or vice versa), and calculating the number of moles correctly but failing to convert the value calculated to mass using the relative atomic mass of copper. These errors indicate that, while many candidates were familiar with the calculation sequence, they lacked a sound understanding of the stoichiometric relationship between electron transfer and metal deposition during electrolysis.

Recommendations for Teachers

Teachers should reinforce the stoichiometry of electrolysis by linking quantitative calculations to the balanced half-equation $Cu^{2+}(aq) + 2e^{-} \rightarrow Cu(s)$, highlighting that two faradays of charge are required to deposit one mole of copper. Students should be given regular practice in converting time to seconds, applying Q = It, using faraday's constant appropriately and converting moles to mass using the relative atomic mass. Emphasis should be placed on understanding the underlying chemistry rather than on memorizing calculation steps. This would enable students to apply the correct mole relationships confidently in a variety of electrolysis problems.

Question 3

This question tested the following specific objectives from Section B (Organic Chemistry) of the syllabus: B 1.2, 1.3, 2.5, 2.6, 2.7, 2.8, 3.1 and 3.3.

Part (a) (i)

Many candidates demonstrated that they understood the term *cracking* by giving correct definitions. However, a notable number of candidates did not achieve full marks because they did not provide key terms associated with cracking and/or they articulated their answer poorly. In many responses, candidates described generic decomposition reactions and did not refer to hydrocarbon/alkane as the starting reagent. Some candidates confused the products, especially alkene production, with starting reactants. Additionally, the descriptors larger/long-chain and smaller were frequently left out in some definitions that would have been otherwise correct. This suggests that the general breaking down of molecules was understood, yet there was a failure to specify the nature and scale of the molecules involved. Emphasis should be placed on some of these key words and descriptors for a more comprehensive response.

Part (a) (ii)

Candidates' performance on this part was generally good. They were required to state one use of bitumen. The most common correct response was *in the paving of roads*. Less common correct responses included *in roofing compounds* and *for water proofing*.

Part (b) (i)

In this part, some candidates confused the homologous series name for the IUPAC compound name. This was evident as several candidates gave the correct homologous series but they could not receive marks because they were required to give the IUPAC name. This suggests that candidates who did such did not understand the differences in organic nomenclature.

Recommendations for Teachers

More emphasis should be placed on ensuring that students are able to identify the general formula from a molecular formula since this can assist with identifying the compound. Candidates who mixed up the alkane and alkene are likely to have done so because of lack of confidence with the general formulas of these two homologous series. Students should be taught to describe the carbon to hydrogen ratios expected between alkanes and alkenes to determine the hydrogen saturation.

Part (b) (ii)

For Part (b) (ii), candidates were required to draw the fully displayed structure of Compound A. Candidates were unable to do so appropriately. A common error was not satisfying the valence of carbon (ensuring that each carbon has four bond lines always attached to it). In addition, several candidates either left three bonds or had five bonds attached to carbon atoms. It was observed that candidates most often drew three bonds on terminal

carbon atoms. They also frequently showed five bonds on carbon atoms involved in the alkene double bond. This indicated that such candidates did not account for the fact that a double bond consists of both a sigma bond and a pi bond. Additionally, it is expected that candidates would use the fully displayed structural formula inclusive of all bond lines. The showing of bond lines in substituent groups is also required (to avoid condensed formula abbreviations like CH_2, CH_3, CH_2CH_3 etc.). Teachers should emphasize to students the importance of the correct bond order/connectivity of atoms, as some candidates displayed lack of awareness of this in their diagrams.

Part (b) (iii)

Candidates were required to state the homologous series to which Compound B belongs. Candidates who did so correctly were able to obtain marks. It is possible that candidates who did not earn any marks did not know the general formula and could not translate between general formulas and molecular formulas for homologous series.

Part (b) (iv)

In this part, candidates were required to state one test that could be used to distinguish between Compound A and Compound B and to write the expected observations. Overall, candidates' performance was affected by a lack of specificity. For example, all the correct test options were qualitative tests; however, candidates were not awarded marks for stating that the tests were qualitative because they were expected to state the exact qualitative test. Some candidates knew which reagent test to select but failed to state the required chemical environment for the reaction to take place. For example, in the bromination of an alkene, bromine water is used.

Candidates must be sensitized to safety considerations when using certain chemicals; therefore, they should be aware that bromine water is usually used instead of bromine gas. While theoretically bromine gas can yield the same result, the toxicity associated with it is unfavorable for use, especially at the secondary school level. Candidates were penalized if neither their description nor test referred to aqueous bromine. Similarly, both oxidizing agents $KMnO_4$ and $K_2Cr_2O_7$ must be acidified in order to be used in qualitative differentiation of alkanes and alkenes. When describing decolorization, a few candidates incorrectly used the word 'clear' as synonymous with colourless. This is not acceptable, as clear refers to transparency and not the absence of hue/colour. Several responses were also abbreviated in that candidates only provided the final expected colour. While candidates were not penalized for doing so, it is preferable for candidates to be taught to state both the initial and final colour of the reagent that confirms a positive/negative result.

Part (c) (i)

Candidates were required to define the term *structural isomers*. Many candidates scored partial marks for relating isomerism to having different structural formulas. The common pitfalls included use of the terms '*same chemical* or *general formula*' in place of *molecular formula*. Candidates were not awarded marks for stating such. The correct term to use in organic chemistry is *molecular formula*. *Chemical formula* is a broad umbrella term that covers inorganic chemical structures, molecular formulas and structural formulas; thus, the precise term should be used. A few candidates recalled that the structure was, in some way, involved in the definition; however, some used the phrase 'structural properties' instead of *structural formula* or they spoke to the arrangement of atoms.

Part (c) (ii)

Similar to Part (b) (ii), candidates were unable to draw a fully displayed structure of one isomer of Compound B. Most candidates opted to draw the straight chain isomer of butane instead of 2-methylpropane.

Question 4

This question tested the following specific objectives from Section A (Principles of Chemistry): A: 3.6, 3.7, 4.1, 4.2, 4.4, 5.1, 5.2, 5.3, 6.5.

Part (a) (i)

Part (a) (i) assessed candidates' knowledge of the definition of isotopes. This part was generally well answered, as most candidates demonstrated familiarity with the definition of isotopes. The most correct response given was *isotopes are atoms with the same atomic number and different mass number or neutron number*. Most candidates were awarded full marks.

One key observation was the failure of most candidates to use the term *proton number* interchangeably with *atomic number* and the term *nucleon number* interchangeably with *mass number*.

Chemistry teachers should

- emphasize to students that *atomic number* is the same as *proton number* and that *mass number* can be used interchangeably with *nucleon number*.
- provide regular practice questions that require students to calculate proton, neutron and nucleon number from different nuclear notations using different elements.

Part (a) (ii)

This part assessed candidates' knowledge of the uses of radioisotopes. Overall, candidates answered this part well, as most of them demonstrated that they were familiar with the common uses of radioisotopes. A large proportion of candidates correctly identified appropriate uses and were able to score full marks. Acceptable responses included the following.

- Carbon dating
- Radiotherapy
- Cancer treatment
- Pacemakers
- Biological Tracers
- Environmental tracers
- Pest control
- Sterilization of medical equipment
- Nuclear medicine
- Leak detection in industry

The most common correct responses given were *carbon dating*, *radiotherapy*, *cancer treatment* and *pacemakers*. Most candidates were awarded both marks. A few responses were too vague. In such responses, candidates stated 'tracers', 'medicine', 'X-rays', 'MRI' and 'ultrasound', without stating the specific purpose such as trace molecules through biological systems or imaging of organs. Vague responses were not accepted unless linked to a specific

use. Additionally, most candidates appeared to have limited knowledge of environmental tracers, pest control, sterilization of medical equipment, nuclear medicine and leak detection in industry as uses of radioisotopes.

Recommendations for Teachers

Chemistry teachers should provide opportunities where students are engaged in conducting research on the use of radioisotopes different to those that are mentioned in the syllabus, as this provides opportunities for recall and for students to develop understanding of the uses of radioisotopes.

Part (b) (i)

Part (b) (i) assessed candidates' knowledge of the criteria used for placing elements in the periodic table. Generally, this part was well answered, as most candidates were able to correctly identify both criteria and so gained the full marks. Key observations were as follows.

- Although most candidates gained full marks, most of them did not use the word same when stating the number of valence electrons and number of occupied shells with regards to the criteria for placing elements in groups and periods.
- A small proportion of candidates used the terms *period number* and *group number* imprecisely which shows a weak understanding of the relationship between these terms and the number of occupied electron shells and valence electrons.
- Additionally, a small proportion of candidates used the term *electronic configuration* vaguely. This shows their inability to correctly distinguish between electronic configuration, group number and period number.

Chemistry teachers should

- reinforce the link between electronic configuration and group and period number, particularly the principle that valence electrons represent group number and the number of electron shells represents the period number
- provide more regular practice questions where candidates must write group numbers and periods numbers from electronic configurations
- emphasize the usage of a periodic table chart when teaching groups and periods so students can visually connect with the information. This generally enhances recall and understanding of the topic.

Part (b) (ii)

This part assessed candidates' understanding of the appropriate group and period Element Y is in. This part was generally well answered by most candidates, as they were able to score full marks. One key observation was that candidates were able to write both Roman numerals and Arabic numbers when representing the group and period number for Element Y, which is commendable. This shows that a lot of emphasis was placed on teaching students how to write group and period numbers from electronic configurations.

Part (c) (i)

Part (c) (i) assessed candidates' understanding of whether Elements W and X form ionic or covalent compound. Generally, this part was well done, as most candidates were able to gain full marks. Conversely, only a minority of

candidates stated 'covalent'. This shows that great emphasis was placed on teaching students how to identify ionic and covalent compounds from given binary formulas.

Part (c) (ii)

Candidates' understanding of using dot and cross diagrams to depict the formation of the bond formed between Elements W and X (magnesium fluoride) was assessed. For this part, candidates were required to possess knowledge of the procedure and the shell diagrams used to illustrate ionic bonding. Overall candidates' performance was very weak.

This part was the most poorly answered. A significant number of candidates who attempted this part scored no more than one out of three marks. Key observations were as follows.

- A large proportion of candidates were unable to write empirical formulas of binary compounds correctly.
- Although a large proportion of candidates correctly recognized the bond formation as ionic, they were unable to demonstrate the drawing of the procedural steps correctly.
- The initial step should have shown one magnesium bonded to two fluoride atoms. However, in most cases, candidates drew one magnesium atom and one fluoride atom.
- The initial stage should have shown the magnesium atom with two valence electrons, and the fluoride atom with seven valence electrons but, in most cases, candidates showed the transfer of electrons from the magnesium atom to the fluoride atom that already had eight valence electrons.
- Most candidates drew the final step of the bond formation correctly, demonstrating magnesium losing its two valence electrons and the fluoride atoms gaining those two valence electrons to form a stable electronic configuration. Candidates who did such gained one mark. However, a fairly large proportion of candidates drew only one fluoride atom instead of two in the final step. This resulted in candidates losing one mark.
- Candidates were not awarded most of the marks when they did not write the charges formed for the ions or if they wrote them incorrectly. Candidates wrote oxidation states instead of oxidation numbers which caused a large proportion of candidates to lose one mark.
- A few candidates used all crosses or all dots to represent the electrons.
- A few candidates drew covalent bonds instead of ionic bonds.

The difficulties experienced by candidates in drawing the procedural steps for ionic bond formation correctly suggest that they did not have sufficient understanding of the concept. The performance of candidates indicated that there is a significant gap in the understanding of the rules that must be followed when writing empirical formulas of binary compounds and in the understanding of the principles of ionic bonding. Therefore, candidates may need thorough practice sessions. Greater emphasis must be placed on integrating theoretical knowledge with practical skills, using models to build ionic bonds for binary compounds and ensuring students can correctly follow the principles of ionic bonding. Strengthening students' competency in these areas will improve both their conceptual understanding and their performance on the examination.

Part (d)

In this part, candidates were required to write a balanced chemical equation, including state symbols, between Element Z and hydrochloric acid. This part was satisfactorily done by most candidates. These candidates were able

to obtain the full marks awarded. However, the remaining candidates who did not score full marks were able to score at least one out of the three marks. Key observations were as follows.

- A large proportion of candidates were unable to write the correct formula specifically for ZCl_2. They wrote ZCl instead in most cases.
- Some candidates (the minority) were unable to write all the state symbols appropriately.

This indicates serious deficiencies in candidates' understanding of writing chemical equations and applying state symbols correctly. Teachers should place greater emphasis on teaching students about using rules for writing and balancing equations and writing empirical formulas of binary compounds. This will improve students' competence and examination performance.

Question 5

This question was based on Section B (Organic Chemistry) and Section A (Principles of Chemistry) of the syllabus: B: 2.2, 2.3, 2.6, 3.8, 3.10 and A 6.5.

Part (a) (i)

This part required candidates to state three characteristics of a homologous series. Expected responses were as follows.

- Same general formula
- Same functional group
- Members differ by CH_2/ 14 g
- Similar chemical properties
- Same general method of preparation
- Gradual change in physical properties

This part was generally well answered. Most candidates correctly identified at least two characteristics of a homologous series, with many earning full marks by stating that members have the same general formula, the same functional group and similar chemical properties.

Common Errors and Misconceptions

A common error was that some candidates used the phrase 'same chemical properties' instead of *similar chemical properties*. Although members of a homologous series undergo similar types of chemical reactions because they possess the same functional group, their chemical properties are not identical. Some candidates also confused the general formula with the chemical formula, while others failed to recognize that the physical properties change gradually with increasing molecular size due to the successive addition of $–CH_2–$ units.

Recommendations for Teachers

Teachers should emphasize the defining characteristics of a homologous series and the scientific distinction between same and similar. Students should understand that members of a homologous series have the same functional group and general formula but exhibit similar, not identical, chemical properties because increasing carbon chain length influences their reactivity and physical behaviour. Instruction should also reinforce that successive members differ by a $–CH_2–$ unit (relative mass of 14) and display a gradual change in physical properties, such as boiling point and viscosity. Regular comparison of homologous series members will strengthen students' conceptual understanding and precision in examination responses.

Part (a) (ii)

This part required candidates to describe the fermentation process by which ethanol is produced from carbohydrates. An example of an expected response was *fermentation is the process of breaking down /converting*

carbohydrates (starch)/fruit/sugars (glucose) by the action of enzymes/zymase/yeast in the absence of oxygen/anaerobically to form alcohol (ethanol) and carbon dioxide.

Overall, candidates' performance was satisfactory. Most of them demonstrated that they had a basic understanding of fermentation by stating that glucose (or other carbohydrates) is broken down by yeast to produce ethanol. Consequently, many candidates earned at least one mark. However, relatively few candidates provided a complete description and obtained full marks.

Common Errors and Misconceptions

The most common omission was candidates failing to state that fermentation occurs under anaerobic conditions (in the absence of oxygen), which is an essential condition for ethanol production. While many candidates identified the role of yeast, few referred specifically to the enzyme zymase. Some candidates also omitted carbon dioxide as a product or incorrectly described ethanol as being 'broken down' rather than *produced* during fermentation. This indicated that such candidates were confused about the direction of the process.

Recommendations for Teachers

Teachers should emphasize that fermentation is an anaerobic biochemical process in which glucose is converted by the enzyme zymase in yeast to ethanol and carbon dioxide. Students should be encouraged to include all essential components of the process in their responses: the substrate (glucose or carbohydrates), the biological catalyst (yeast/zymase), the absence of oxygen and the products (ethanol and carbon dioxide). Practical demonstrations of fermentation, together with the balanced chemical equation, can help students develop a more complete understanding of the process and improve the quality of their examination responses.

Part (a) (iii)

This part required candidates to write a balanced equation, with state symbols, showing all the products formed by the fermentation of carbohydrates. The expected response was $C_6H_{12}O_6\,(s/aq) \rightarrow 2C_2H_5OH\,(aq) + 2CO_2(g)$.

Candidates' performance on this part was generally weak. While many candidates recognized that ethanol is produced during fermentation, relatively few of them were able to write the correct balanced chemical equation with appropriate state symbols. As a result, many candidates lost marks for incorrect formulas, balancing errors, or omission of products.

Common Errors and Misconceptions

Many candidates had trouble writing the balanced chemical equation for fermentation. Common errors included omitting carbon dioxide as a product, incorrectly including water or oxygen in the equation or identifying carbon dioxide as a reactant. Some candidates also used incorrect formulas, making it impossible to balance the equation correctly. In addition, many responses included incorrect or missing state symbols, particularly writing ethanol as (l) instead of the expected (aq).

Recommendations for Teachers

Teachers should reinforce to students that every chemical reaction should be represented by a balanced chemical equation with correct state symbols. Students should be given regular practice in writing the equation for fermentation, ensuring that they can correctly identify the reactant (glucose), the products (ethanol and carbon dioxide) and balance the equation accurately. Emphasis should also be placed on the appropriate use of state symbols, as these form an essential part of chemical equations and are frequently assessed in examinations.

Part (b) (i)

This part required candidates to state the name of the sweet-smelling product formed when ethanol reacts with ethanoic acid. The expected response was *ethyl ethanoate*.

Candidates' performance on this part was generally weak. Although many candidates recognized that the product formed from the reaction between ethanol and ethanoic acid is an ester, relatively few correctly named the specific compound, *ethyl ethanoate*.

Common Errors and Misconceptions

A common misconception was confusing the class of compound with the name of the compound. Many candidates responded with ester or perfume, rather than the specific ester formed. Others demonstrated uncertainty in ester nomenclature by confusing the names of the reactants, the functional group and the product.

Recommendations for Teachers

Teachers should place greater emphasis on the systematic naming of esters. Students should understand that ester names are derived from the alkyl group of the alcohol followed by the alkanoate name of the carboxylic acid. Regular practice in naming esters from their parent alcohols and carboxylic acids, together with writing the corresponding structural formulas, will improve students' understanding of esterification reactions and strengthen their performance in the examination.

Part (b) (ii)

This part required candidates to state the homologous series to which the product named in Part (b) (i) belongs. The expected response was *ester*.

This part was generally well answered. Most candidates correctly identified that the product formed belongs to the ester homologous series, even when they were unable to correctly name the compound in Part (b) (i).

Common Errors and Misconceptions

Some candidates who incorrectly identified the product in Part (b) (i) subsequently stated that the homologous series was alcohol or carboxylic acid. This indicated that some candidates confused the reactants and the product of the esterification reaction. This suggests that some candidates were unable to distinguish between the functional groups present before and after the reaction.

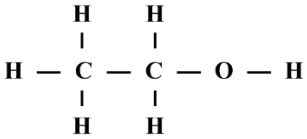
Recommendations for Teachers

Teachers should reinforce the relationship between functional groups and homologous series, emphasizing that the product of the reaction between an alcohol and a carboxylic acid is an ester. Students should be provided with opportunities to identify functional groups in reactants and products, and to relate these to their corresponding homologous series. This will strengthen their understanding of organic reaction pathways and improve accuracy in examination responses.

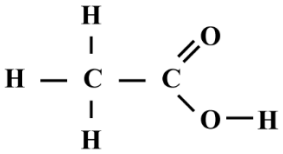
Part (b) (iii)

This part required candidates to draw the fully displayed structural formulas of the hydrolysis products of the sweet-smelling product (ethyl ethanoate). The expected response was as follows.

Product 1(Ethanol)

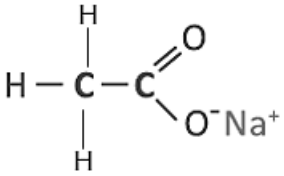


Product 2 (Ethanoic acid)

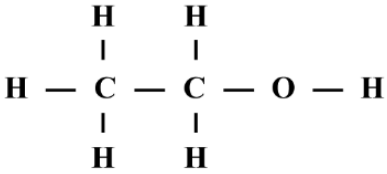


OR

Product 1 (sodium ethanoate)



Product 2 (ethanol)



In May-June 2026, candidates performed better on this part than candidates in previous years. Many candidates correctly drew the fully displayed structural formula of ethanol and those with a sound understanding of ester hydrolysis were able to identify and draw both hydrolysis products correctly. However, fewer candidates were able to accurately draw the structure of ethanoic acid (or sodium ethanoate in alkaline hydrolysis).

Common Errors and Misconceptions

Many candidates correctly identified the alcohol product but were unable to draw the corresponding carboxylic acid (or carboxylate salt). Some candidates drew structures in which carbon atoms formed five bonds, thereby violating the tetravalency of carbon. Others incorrectly attached the hydrogen atom of the hydroxyl (–OH) group directly to the carbon atom rather than to the oxygen atom. These errors indicate weaknesses in candidates' understanding of functional group structures, bonding and the molecular changes that occur during ester hydrolysis.

Recommendations for Teachers

Teachers should provide regular practice in drawing fully displayed structural formulas, emphasizing correct covalency, bonding and the arrangement of functional groups. Students should be taught to identify the products of both acidic and alkaline hydrolysis of esters by conceptually splitting the ester into its parent alcohol and carboxylic acid (or carboxylate salt). Greater emphasis should also be placed on the structure of the hydroxyl and carboxyl functional groups to ensure that atoms are connected correctly and that carbon always forms four covalent bonds.

Question 6

This question tested the following specific objectives from Section C (Inorganic Chemistry) of the syllabus: C:1.1, 4.2 and 4.3.

Part (a) (i)

Candidates performed fairly well. Most candidates scored partial marks. One notable observation is that many candidates used truncated responses not involving the relevant jargon. For example, instead of saying metals have a high density, many candidates stated 'dense' or 'they are dense'. Similarly, instead of stating good conductors of heat/electricity, many responses simply stated 'conductors.' Candidates should be taught to use the appropriate descriptors and that except in the case of providing certain jargon (for example, malleable, sonorous etc.) that these key descriptors are necessary. Some candidates listed traits that are peculiar and confined to certain metals only. For example, several candidates listed 'mercury is liquid at room temperature' which is an accurate statement but not a property of most metals and relates to a state of matter, not a physical property. Alternatively, when candidates state that metals are solid or metallic they are not awarded marks. Some candidates confused chemical and physical properties. These candidates listed bonding properties, oxidation tendencies and reactivity with acids. It is recommended that while some nouns are acceptable, teachers should emphasize describing the properties instead of blanketing one-word responses.

Part (b) (i)

Most candidates were able to earn at least one mark. Candidates appeared to be slightly more familiar with chlorophyll and its central metal, magnesium, than with haemoglobin. This suggests a lack of understanding of the human biology importance of organometallic chemistry. Candidates who may have been studying biology also listed zinc and calcium as metals in chlorophyll. This is likely because of the overlap in the importance of these metals for the overall plant function; however, it is magnesium that sits directly within the chlorophyll and this should be emphasized by chemistry teachers. It should be stressed that while candidates can give the metal or its ion, failing to state the correct charge on the metal ion would result in them gaining no marks. A few candidates incorrectly stated Fe^{3+}.

Part (b) (ii)

As in Part (b) (i), candidates were generally successful in identifying the role of chlorophyll in the absorption of sunlight for photosynthesis. A few candidates stated that it is a pigment and gives plants their green colour; however, candidates did not receive marks for stating such. The expected function is that *chlorophyll makes plants autotrophic* (able to produce their own food).

Many candidates could not state the function of haemoglobin. This was related to fact that some candidates were unable to identify iron as the metal that is present in haemoglobin in Part (b) (i); therefore, these candidates were unable to state the role of haemoglobin which is mediated by the Fe^{2+} ion. Many candidates stated that haemoglobin is important for transporting nutrients, clotting blood, providing energy, giving blood its red colour

or existing in red blood cells. None of these responses were correct because they did not express the primary function of the iron within haemoglobin, which are *to bind oxygen* and *to transport it about the body*.

Part (c) (i)

In this part, the general quality of responses was poor. Few candidates achieved full marks. Most candidates received one mark out of three, while fewer received two marks. The most common response for which candidates earned a mark was *mercury is toxic/poisonous*. This recognition of the toxicity of mercury by candidates was good; however, many candidates failed to express the sequence of how contamination led to the toxic effects on the fishes. Only a few candidates mentioned the leaching of mercury into the water source from the broken thermometers and its subsequent ingestion. An even lesser portion of candidates mentioned and explained the phenomenon of bioaccumulation occurring within the food chain. Candidates largely focused on the fish directly consuming the mercury and dying as a result of doing so. Some candidates focused on the glass from the thermometers being consumed by fish, completely ignoring the toxic chemical. In some cases, candidates referred to mercury as 'containing harmful substances' or 'highly reactive' suggesting ambiguity in the understanding of the toxicity of the metal itself. It is recommended that candidates emphasize cause-and-effect reasoning in environmental chemistry situations. Candidates showed a tendency to mention the result only, rather than articulating the steps that led to it. In many instances, candidates gave the vague phrase 'causing death' and they were not awarded marks for stating such. Candidates should also be taught to differentiate between coming into direct contact with the toxic agent and biomagnification/bioaccumulation, as these concepts are assessed differently.

Part (c) (ii)

Candidates' performance in this part was very poor. They appeared to lack understanding of the protocols used to deal with hazardous chemical waste, according to laboratory safety regulations. Most candidates failed to earn marks because they suggested disposal methods that were biologically and environmentally unsafe, such as placing the substances in regular waste bins or landfills, or attempting to remove them from water by filtration before burying them in soil. Other responses included recycling the mercury and switching to digital or alcohol thermometers, which while plausible, ignore the premise of the question — how to dispose of the waste products of mercury to avoid contamination. Several candidates gave responses that were relevant to personal laboratory mercury spill procedures, which were assessed in Part (c) (iii) and were not relevant in this part. Examples of appropriate responses include the following.

- Cease and desist from dumping mercury into water sources.
- Contract a hazardous waste disposal company for safe removal of the waste.
- Placing mercury waste into double-bagged, airtight or sealed bags/containers.
- Labelling these containers as hazardous.

Part (c) (iii)

Many candidates were able to score at least one point in this part by identifying an appropriate safety response to the broken mercury thermometer. The most common correct response involved wearing appropriate personal protective equipment, PPE, (such as gloves and masks). Candidates should be advised that in such questions, multiple PPE items are treated as one response, thus, some candidates who listed two different PPE items received

one mark. Other appropriate responses included *notifying a teacher/lab technician*, *advising peers to evacuate/stay away from the area*, *avoiding touching the mercury* and *washing hands thoroughly*. A few concerning responses were noted with candidates suggesting wiping it up with tissue and throwing it away in the garbage without specifying if the bin used was separate from normal thrash. Additionally, in some responses candidates stated that it should be washed down the laboratory sink/drains. It is not expected that candidates would give these responses even if they are struggling to suggest appropriate measures. This presents a concern for proper laboratory safety competence among budding chemists and should be addressed with deliberate emphasis.

PAPER 031 — SCHOOL-BASED ASSESSMENT (SBA)

The School-Based Assessment (SBA) evaluates candidates' experimental, analysis and interpretation skills with respect to the laboratory and fieldwork. SBAs are marked out of a total of 40 marks.

The maximum score obtained on Paper 031 was 40 out of 40 marks. The mean score was 34.64 (86.60 per cent) and the standard deviation 5.48.

PAPER 032 — ALTERNATIVE TO SCHOOL-BASED ASSESSMENT (SBA)

Paper 032, the Alternative to School-Based Assessment, is written by private candidates. This paper examines the same skills as those tested in Paper 031. The focus, therefore, is on candidates' experimental skills and their use of knowledge (Analysis and Interpretation).

Paper 032 consists of one practical question (conducted in a laboratory), one structured question and one planning and design question.

In May–June 2026, the maximum score obtained by any candidate was 36 out of 40. The mean score was 15.71 (39.28 per cent) and the standard deviation 8.08.

Question 1

This question tested the following specific objectives from Section A (Principles of Chemistry) of the syllabus: A: 6.2, 6.6, 10.2, 10.3 and 10.4. It consisted of a practical component that candidates were expected to carry out in a laboratory setting.

Part (a)

Most candidates did not obtain time measurements within the range submitted by the Lab Supervisors. The modal score was one out of six as a significant number of candidates gained a mark for converting all time to seconds.

Part (b)

Most candidates were unable to calculate and report the reaction rate correctly to three decimal places, indicating weaknesses in both data processing and mathematical skills. Common errors were as follows.

- Failure to convert time into a single unit before calculation. Many candidates used the recorded time expressed in hours and minutes directly in the calculation of the rate (1/t), rather than first converting the entire time to a single unit (for example, minutes or seconds). In some instances, candidates treated a time of 1 h 58 min as 1.58, resulting in an incorrect calculation of (1/t = 1/1.58 = 0.633). Some candidates also incorrectly interpreted the notation 1/t, writing values such as 0.158. This suggested that candidates misunderstood that (1/t) involves shifting the decimal place rather than calculating the reciprocal of the measured time.
- Incorrect rounding to three decimal places. A significant number of candidates demonstrated weak numerical skills when rounding calculated values. For example, for (1/42 = 0.0238095238), several candidates reported 0.023 instead of the correct value of 0.024. This indicates that many candidates do not consistently apply the standard rules for rounding decimal numbers.

Part (c)

The overall standard of graph plotting was weak. Many candidates experienced difficulty in selecting appropriate scales, accurately plotting data points and constructing a suitable line of best fit. These errors suggest limited proficiency in graphing experimental data and interpreting quantitative results.

Common Errors Observed

- Inappropriate choice of scale. Many candidates selected scales that were unsuitable for the range of data provided, making accurate plotting difficult. For example, several candidates used a scale of 2 cm = 0.03 units on the *y*-axis, which resulted in impractical intervals and reduced the accuracy of the graph. Candidates should select scales that make effective use of at least half of the graph paper and allow data points to be plotted with ease and precision.
- Incorrect plotting of data. Some candidates simply wrote the calculated rate values along the *y*-axis instead of plotting them as coordinates against the corresponding independent variable. This indicates a fundamental misunderstanding of the principles of Cartesian graph plotting.
- Unsatisfactory line of best fit. Many candidates were unable to draw an appropriate line of best fit. In several instances, lines were drawn by joining points sequentially rather than constructing a smooth best-fit line or curve that represented the overall trend in the data.

Recommendations for Teachers

Teachers should provide students with regular opportunities to

- select appropriate scales for graphical representation of experimental data
- plot coordinates accurately on Cartesian axes
- distinguish between plotting individual data points and labelling axis values
- draw appropriate lines or curves of best fit that reflect the overall trend in the data
- interpret graphs by relating graphical trends to the underlying scientific principles investigated during practical activities.

Greater emphasis should be placed on graphing skills during laboratory exercises so that students become proficient in presenting and analysing experimental data.

Part (d)

Most candidates correctly identified that the rate of reaction increases as the concentration of the reactants increases. However, a significant proportion of candidates explained the results in terms of adding more water, stating that this caused the reaction to take longer, without explicitly relating the observation to the decrease in reactant concentration.

Many candidates therefore described the procedural change rather than the underlying scientific principle. Candidates should recognize that adding water dilutes the reactant solution, resulting in a lower concentration of reactant particles per unit volume. This reduces the frequency of effective collisions between reacting particles, thereby decreasing the rate of reaction.

Part (e)

A common error was that candidates used 100 cm^3 instead of the specified volume when calculating the number of moles of sodium thiosulphate. This resulted in an incorrect value for the number of moles and, consequently, errors in all subsequent stoichiometric calculations.

Part (f)

A significant proportion of candidates incorrectly doubled the relative atomic mass of sulfur from 32 to 64 before calculating the required mass. This indicates that candidates confused the relative atomic mass of sulfur (S) with the relative molecular/formula mass of a sulfur-containing species such as S_2 or another compound.

Part (g)

Most candidates indicated incorrect measurement or human error as the source of error. These responses are very vague and do not convey what may have affected the experimental results.

Question 2

This question was based on Section C, Inorganic Chemistry of the syllabus, specific objectives C 6.1 and 6.2.

Part (a)

This part was generally well answered as most candidates scored at least one mark and many obtained full marks. Most candidates correctly identified that the addition of aqueous sodium hydroxide to Solution R produced a white precipitate. A high proportion of candidates also recognized that the precipitate dissolved when sodium hydroxide was added in excess, demonstrating sound knowledge of the characteristic reactions of Al^{3+}, Pb^{2+} and Zn^{2+} ions.

Common Errors and Misconceptions

Although candidates' performance was generally good, several common errors were observed.

- Some candidates correctly identified the formation of a white precipitate but incorrectly stated that it was insoluble in excess sodium hydroxide.
- Several candidates omitted the important phrase *in excess*, stating only that the precipitate dissolved. This resulted in the loss of one mark because the observation specifically relates to the addition of excess sodium hydroxide.
- Some candidates gave incorrect precipitate colours or provided no response.
- A few candidates used the term *clear* to describe the observation when the precipitate dissolved. In qualitative analysis, candidates should state that the precipitate dissolved or was soluble in excess sodium hydroxide, rather than describing the solution as clear.

Recommendations for Teachers

Teachers should continue to reinforce the importance of systematic qualitative analysis and ensure that students do the following.

- Distinguish between the initial observation (formation and colour of the precipitate) and the subsequent observation after the reagent is added in excess.
- Learn and practise the characteristic reactions of common cations, particularly the formation of white precipitates with aqueous sodium hydroxide and those that dissolve in excess.
- Understand that Al^{3+}, Pb^{2+} and Zn^{2+} ions form amphoteric hydroxides, which dissolve in excess sodium hydroxide.
- Use precise scientific language, stating that the precipitate dissolves or is soluble in excess sodium hydroxide and avoid using vague terms such as *clear*.
- Participate in regular practical and laboratory experience so they can confidently recognize precipitate colours and changes in solubility during qualitative analysis.

Part (b)

Candidates' performance on this part was satisfactory. A significant number of candidates earned the available mark. Many candidates correctly recognized that, since the inference stated Pb^{2+} ions were absent, the expected observation was no visible reaction when aqueous potassium iodide was added. Acceptable responses included *no visible reaction*, *no precipitate formed* and *no yellow precipitate observed*. These responses demonstrated that candidates understood that the absence of an expected reaction can provide important evidence in qualitative analysis.

Common Errors and Misconceptions

Several common errors were identified. These included the following.

- Many candidates misread or overlooked the given inference that Pb^{2+} ions were absent and instead described the observation for the presence of lead (II) ions.
- A common incorrect response was 'a yellow precipitate was formed'. This indicated that candidates recalled the characteristic test for lead (II) ions but failed to relate it to the inference provided.
- Some candidates expected every qualitative analysis test to produce a visible change and therefore described colour changes or precipitates even when no reaction was expected.
- A small number of candidates provided no response.

Recommendations for Teachers

Teachers should emphasize to students that they must carefully interpret the information provided in the question before recalling qualitative analysis tests. In particular, students should be taught to do the following.

- Read the stated inference carefully and ensure that their observations are consistent with it.
- Recognize that the absence of a visible reaction is itself a valid and important observation in qualitative analysis.
- Understand that aqueous potassium iodide is used to test for Pb^{2+} ions, which produce a bright yellow precipitate of lead (II) iodide when present. If Pb^{2+} ions are absent, the correct observation is no visible reaction or no precipitate formed.
- Become familiar with both the positive and negative outcomes of common qualitative analysis tests rather than memorizing only the characteristic precipitates.
- Use accurate scientific terminology such as *no visible reaction*, *no precipitate formed*, or *no yellow precipitate observed* where appropriate.

Part (c)

This part was answered well by most candidates, with many of them earning full marks. Most candidates correctly identified that the addition of aqueous ammonia to Solution R produced a white precipitate, which dissolved when ammonia was added in excess.

Common Errors and Misconceptions

Although candidates' performance was generally strong, a few misconceptions were evident.

- Some candidates correctly stated that a white precipitate was formed but failed to indicate that it dissolved in excess aqueous ammonia, resulting in the loss of one mark.

- A small number of candidates incorrectly stated that the precipitate was insoluble in excess ammonia, suggesting confusion between the reactions of zinc ions and other metal ions that also produce white precipitates.
- Some candidates omitted a response altogether.

Recommendations for Teachers

Teachers should continue to reinforce the sequence of observations required in qualitative analysis and to ensure that students do the following.

- Record both the initial observation (formation and colour of the precipitate) and the subsequent observation when the reagent is added in excess.
- Recognize that Zn^{2+} ions are distinguished by the formation of a white precipitate that dissolves in excess aqueous ammonia.
- Compare the behaviour of zinc ions with other common metal ions that produce white precipitates, emphasizing that zinc hydroxide is the only common white precipitate that dissolves in excess aqueous ammonia, whereas the white precipitates of ions such as Al^{3+}, Ca^{2+}, Mg^{2+} and Pb^{2+} remain insoluble.
- Use accurate terminology such as *white precipitate formed* followed by *precipitate dissolved* or *precipitate was soluble in excess aqueous ammonia*.
- Participate in practicals in which they perform qualitative analysis tests. In doing so, they can confidently distinguish between ions with similar initial observations based on their behaviour in excess reagent.

Part (d)

This part was generally well answered. Most candidates scored at least one mark and many obtained full marks. Most candidates correctly identified that the addition of aqueous silver nitrate to Solution R produced a white precipitate, indicating the presence of chloride ions (Cl^-). A large proportion of candidates also recognized that the precipitate dissolved upon the addition of aqueous ammonia, demonstrating a sound understanding of the confirmatory test for chloride ions.

Common Errors and Misconceptions

Despite the overall good performance, several common errors were observed.

- Many candidates correctly identified the formation of a white precipitate but failed to state that it dissolved in aqueous ammonia, losing one of the two available marks.
- Some candidates incorrectly stated that the white precipitate remained insoluble after the addition of aqueous ammonia. This suggested that such candidates confused the differing behaviour of the silver halides in aqueous ammonia.
- A few candidates gave responses unrelated to the expected observations, such as stating that the solution ‘bleached’, possibly associating chloride ions with bleaching agents rather than the silver nitrate test.
- Some candidates did not provide a response.

Recommendations for Teachers

Teachers should reinforce the use of confirmatory tests in qualitative analysis and ensure that students.

- Record the sequence of observations, beginning with the formation and colour of the precipitate, followed by its behaviour after the second reagent is added.

- Understand that the reaction of chloride ions with aqueous silver nitrate produces a white precipitate of silver chloride, which dissolves in aqueous ammonia.
- Differentiate the behaviour of the silver halides in aqueous ammonia.
    - — Silver chloride (AgCl) — white precipitate, soluble in aqueous ammonia.
    - — Silver bromide (AgBr) — cream precipitate, only slightly soluble in concentrated ammonia.
    - — Silver iodide (AgI) — yellow precipitate, insoluble in aqueous ammonia.
- Avoid confusing the chemistry of chloride ions with the bleaching properties of chlorine-containing compounds.
- Participate in practicals in which they perform confirmatory tests for halide ions so they can confidently distinguish between chloride, bromide and iodide based on both precipitate colour and solubility in aqueous ammonia.

Part (e)

This part was generally well answered, as most candidates obtained full marks or at least one of the two available marks. Many candidates correctly identified that the addition of aqueous sodium hydroxide to Solution S produced a green (dirty green) precipitate, consistent with the presence of Fe^{2+} ions. A large proportion of these candidates also correctly stated that the precipitate was insoluble in excess sodium hydroxide.

Common Errors and Misconceptions

Although the overall performance of candidates' was satisfactory, several common errors were evident.

- Many candidates correctly identified the formation of a green precipitate but incorrectly stated that it dissolved in excess sodium hydroxide.
- Some candidates confused Fe^{2+} and Fe^{3+} ions, either by naming the incorrect ion or by describing the characteristic observations for iron (III) instead of iron (II).
- A wide range of incorrect precipitate colours was given by some candidates, indicating uncertainty about the characteristic colour of the iron (II) hydroxide precipitate.

A considerable number of candidates did not attempt the question.

Recommendations for Teachers

Teachers should reinforce the characteristic reactions of transition metal ions and ensure that students

- recognize that Fe^{2+} ions produce a green (dirty green) precipitate of iron (II) hydroxide when aqueous sodium hydroxide is added
- understand that this precipitate is insoluble in excess sodium hydroxide, as iron (II) hydroxide is not amphoteric
- distinguish clearly between the characteristic observations for Fe^{2+} and Fe^{3+} ions
    - — Fe^{2+}: Green (dirty green) precipitate, insoluble in excess sodium hydroxide
    - — Fe^{3+}: Reddish-brown precipitate, insoluble in excess sodium hydroxide
- differentiate between amphoteric hydroxides (such as those of Al^{3+}, Zn^{2+} and Pb^{2+}), which dissolve in excess sodium hydroxide and non-amphoteric hydroxides such as those of iron(II) and iron(III), which remain insoluble
- gain laboratory experience and undertake revision exercises that focus on recognizing precipitate colours and distinguishing between ions with similar reactions.

Part (f)

Overall, candidates performed well on this part, with the majority of them earning the available mark. Most candidates correctly identified that the addition of acidified aqueous barium chloride to Solution S produced a white precipitate, indicating the presence of sulphate ions (SO_4^{2-}). This demonstrated that these candidates had a sound understanding of the confirmatory test for sulphate ions.

Common Errors and Misconceptions

Despite the generally good performance of candidates, several common errors were observed.

- Some candidates described precipitates of various colours, indicating uncertainty about the characteristic appearance of barium sulphate.
- A few candidates wrote 'white solution' instead of *white precipitate*, showing a lack of precision in using scientific terminology.
- Some candidates did not provide a response.
- A small number of candidates appeared unfamiliar with the purpose of acidifying the barium chloride solution before testing for sulphate ions.

Recommendations for Teachers

Teachers should continue to strengthen students' understanding of anion tests by ensuring that they

- recognize that the addition of acidified aqueous barium chloride to a solution containing SO_4^{2-} ions produces a white precipitate of barium sulphate
- understand that barium sulphate is insoluble and remains unaffected by dilute hydrochloric acid, making it a reliable confirmatory test for sulphate ions
- use accurate scientific terminology when giving observations by stating a *white precipitate* was produced rather than a 'white solution'
- become familiar with the colours and appearances of precipitates formed during common qualitative analysis tests
- participate in regular practical exercises during which they carry out tests for anions so they can confidently recognize the expected observations and relate them to the corresponding inference.

Question 3

This question was based on Section A of the syllabus, Principles of Chemistry, specific objective: A 2.5.

Part (a)

Overall, this part was done well. This indicated that candidates could extrapolate an appropriate aim given the scenario. In very few circumstances candidates did not use action words leading to a targeted outcome. For example, it is insufficient to state the following as an aim: 'to separate oil and seawater'. While part of the aim suggests separation, the target, based on information given in the question, is to achieve pure water. Hence, the aim should more accurately incorporate separation of oil from sea water and the separation of salt from the seawater to obtain pure water. A more accurate aim would be *to obtain a pure sample of water from the contaminated seawater and petroleum mixture*.

Part (b)

Overall, candidates' performance on this part was poor. Some candidates used one method of separation only. This showed that candidates did not understand how to separate mixtures with multiple components as doing so requires a sequential approach. In this part, candidates were expected to separate the petroleum (immiscible with water) from saltwater using a separating funnel followed by simple/fractional distillation to recover the pure water. Many candidates provided an incomplete response, either omitting the initial use of the separatory funnel or using the separatory funnel alone and not following with distillation. Some candidates suggested that basic paper filtration could be used to separate the oil and water. Other candidates described evaporation, which can be used to separate the water from salt but cannot be used to recover the pure water. Therefore, describing a method which involved evaporation would be flawed. Additionally, some candidates who identified at least one method could not articulate a logical stepwise procedure as they missed some critical points such as opening the tap of the separating funnel to release the denser liquid or heating the saltwater to boil in the distillation method.

Recommendations for Teachers

It is recommended that in addition to teaching individual separation methods, teachers should integrate laboratory exercises that involve mixtures requiring multiple separation processes to be used to obtain a final product. This can help students be able to apply the underlying scientific basis for separation and understand how to string these together into a logical sequence when separating a complex mixture. Students should also be encouraged to focus on the following.

- The procedural steps that involve transfer of reagents from one apparatus to another, for example, pour petroleum and sea water mixtures into a separating funnel.
- The key observations needed to initiate a subsequent step, for example, leave mixture to settle.
- When external inputs are needed to initiate a step, for example, heat/increase the temperature of the sea water to boiling.
- How to collect the end-product, for example, collect the distillate/pure water in a conical flask.

Part (c)

Stemming from the partial responses in Part (b), several candidates could not score maximum points, as they only gave apparatus and material information for one method. For full marks, candidates were required to list seven to nine pieces of relevant apparatus; however, many candidates could only list three to six. This suggests a lack of familiarity with laboratory equipment relevant to the techniques in question (separatory funnel and simple/fractional distillation). This may possibly be due to limited hands-on interaction with physical laboratory apparatus.

Candidates should be encouraged to review their procedure and attempt to pinpoint the apparatus and materials required to perform these steps as a useful way of ensuring that appropriate apparatus are listed. Candidates should also be taught to list priority apparatus and materials. For example, candidates are not awarded marks for listing water for the condenser in simple distillation but the petroleum contaminated sea water is essential to carrying out the procedure. Likewise, both the round-bottom flask and a conical flask are necessary in distillation, the former for heating and the latter for collecting the product based on the procedural requirements. It is normal practice to place the conical flask on a tile in some laboratories; however, the tile is not essential to a distillation setup and so candidates will not be awarded marks if it is listed.

Part (d)

Candidates' performance on this part was very weak. Many candidates were unable to achieve full marks. Of note is that the question asked for the diagram of the apparatus required to obtain pure water. Candidates who did not read the question carefully drew the apparatus for the separatory funnel. While this is part of the method, it is not appropriate for answering this part. Of the attempts to draw distillation apparatus, several candidates drew open (not airtight) diagrams which had detached pieces. In attempting to draw the condenser, several candidates did not show the water inlet and outlets surrounding the central channel and a further few added these inlet/outlets to the channel itself incorrectly. Many candidates either did not use a thermometer at all in their diagram or drew the thermometer without the rubber bong seal atop the distillation column. Candidates should be encouraged to label all parts of their diagram. For distillation, candidates must accurately draw and label the round bottom flask, heat source, thermometer, condenser and receiving flask. These must also all be placed appropriately as in a real set up.

In general, candidates should produce cleaner representations when drawing diagrams. It is evident that candidates lacked practice in drawing diagrams for different methods, as some candidates who gave appropriate methods and apparatus struggled to draw them. The difficulties in drawing may have exacerbated the difficulty of this part and caused candidates to ignore other subtleties, including the airtight nature of the setup and labelling.

Part (e)

Candidates generally demonstrated an awareness of safety precautions, with most of them scoring at least one of the two possible marks. By far the most frequently used correct response involved the use of personal protective equipment (gloves and goggles were the most common). Only a few candidates mentioned precautions related to the technical aspect of the experiment. These could have included ensuring the airtightness of the system, using boiling chips to reduce splashing in the round bottom flask when heating or releasing pressure

buildup in the separatory funnel while mixing. Many candidates stated standard housekeeping procedures (for example, starting with clean apparatus) which are not credited as precautions. Unique hazards or risks associated with particular procedures should be emphasized. Teachers should categorize precautions so that candidates can begin to think outside of simple PPE and consider the equipment validity and/or controls that impact the procedure.