



**CARIBBEAN
EXAMINATIONS
COUNCIL**

CAPE[®] CHEMISTRY UNIT 2



Subject Report

May–June 2025

CARIBBEAN EXAMINATIONS COUNCIL

**REPORT ON CANDIDATES' WORK IN THE
CARIBBEAN ADVANCED PROFICIENCY EXAMINATION[®]**

MAY–JUNE 2025

**CHEMISTRY
UNIT 2**

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Table of Contents

INTRODUCTION	1
PAPER 01 — MULTIPLE CHOICE	2
PAPER 02 — STRUCTURED ESSAY	3
Question 1.....	3
Question 2.....	7
Question 3.....	10
PAPER 032 — ALTERNATIVE TO THE SCHOOL BASED ASSESSMENT	14
Question 1.....	14
Question 2.....	16
Question 3.....	18

INTRODUCTION

This guide was compiled using candidates' responses from the May–June 2025 CAPE Unit 2 Chemistry examination. In 2025, a total of 2830 candidates sat the CAPE Chemistry Unit 2 examination. This number represented a decrease of 49 candidates when compared with 2024. In 2025, the percentage of candidates earning Grades I–V was 93.10 per cent which is slightly below the 95.15 per cent achieved in 2024 and the 94.22 per cent achieved in 2023.

Unit 2: Chemical Principles and Applications II is divided into three modules. These modules are as follows.

- Module 1: The Chemistry of Carbon Compounds
- Module 2: Analytical Methods and Separation Techniques
- Module 3: Industry and the Environment

The examination comprised the following papers.

- Paper 01 — Multiple Choice
- Paper 02 — Structured Essay Questions
- Paper 031 — School-Based Assessment (SBA)
- Paper 032 — Alternative to School-Based Assessment (Private Candidates)

Across all modules, the mean performance of candidates declined when compared with 2024 and 2023. Consequently, candidates' overall performance on both Paper 01 and Paper 02 was lower. The topics assessed in Unit 2 appeared to present challenges for several candidates.

PAPER 01 — MULTIPLE CHOICE

This paper comprised 45 multiple-choice items designed to assess the syllabus content comprehensively. The mean score was 62.45 out of a possible 90 marks and the standard deviation was 15.99.

- Functional Group Isomerism — Isomers that have different groups located on the same carbon skeleton and belong to different homologous series.

Example



Part (b)

In Part (b) (i), candidates were required to complete a table by providing appropriate observations and inferences for the tests carried out on oxidation products R and S. These tests included reactions with PCl_3 , litmus, 2,4-DNPH, and Benedict's solution. Candidates generally demonstrated sound knowledge of the expected experimental observations and corresponding inferences related to the oxidation products of the given hydrocarbon.

The completed table is shown below.

Test	Observation	Inference
Product R		
(i) PCl_3 was added.	Dense white fumes were observed	Hydroxyl, carboxylic group possibly present.
(ii) Blue litmus was placed in the product R.	Blue litmus turns red.	Solution is also acidic.
Product S		
Product S was divided into two portions.		
(iii) To the first portion, 2,4-DNPH was added	Orange or yellow orange ppt present	Ketone or aldehyde is present
(iv) To the second portion from above a small amount of Benedict's solution was added.	No observable change was seen or a blue colour remains	No aldehyde present

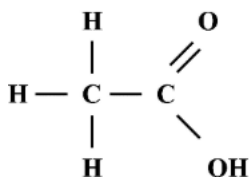
In Part (b) (ii), candidates were asked to deduce the functional groups present in Product R and Product S, based on the observations recorded in the table.

Many candidates responded correctly, identifying the following.

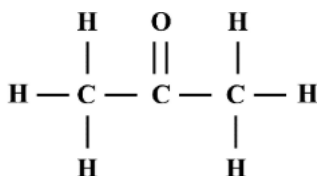
- Product R — Carboxylic acid functional group (–COOH) or carboxyl
- Product S — Ketone functional group (R₂C=O)

For Part (b) (iii), candidates were required to draw the displayed structure of either Product R or Product S formed from the oxidation of the specified hydrocarbon. Candidates who drew any one of the expected structures earned full marks. Most candidates demonstrated accurate understanding when drawing the structure of Product S. The following are the expected structures.

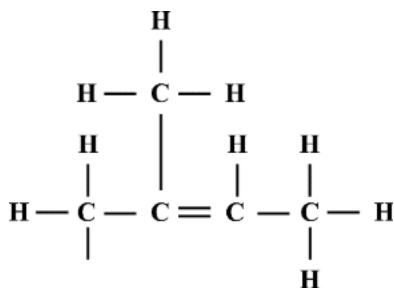
- Product R



- Product S

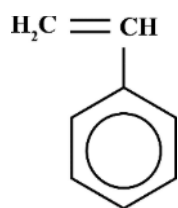


For Part (b) (iv), candidates were asked to name and draw the displayed structure of the C₅H₁₀ hydrocarbon that was oxidized to form Product R and Product S. Most candidates correctly identified and drew the structure of *2-methylbut-2-ene*. The expected structure was as follows.



Part (c)

In Part (c) (i), candidates were provided with a diagram of a polymer and were required to deduce the monomer used to form it. Most candidates displayed the required understanding by correctly drawing the structure of the monomer. Candidates who identified the monomer as *phenylethene* or who provided the expected structure received full marks. The expected structure is shown below.



For Part (c) (ii), candidates were asked to explain how addition polymers form, using both the polymer diagram and the monomer identified in Part (c) (i). Several candidates responded well, explaining that *addition polymers are formed when unsaturated organic molecules such as phenyl ethene join together to form a long chain polymer polyphenyl ethene.*

In Part (c) (iii), candidates were required to identify suitable reagents and describe the colour changes that would distinguish the polymer from its monomer. Most candidates demonstrated good experimental knowledge by clearly stating the reagents and the expected observations.

Candidates who provided either of the following tests with the correct observations were awarded full mark.

- Using Bromine water. Br_2 (aq) — the monomer would decolourise the bromine, whereas the colour remains the same with the polymer.
- Using acidified potassium manganate (VII) solution — the monomer would decolourise the potassium manganate (VII) solution, whereas the colour remains the same with the polymer.

For Part (c) (iv), candidates were asked to state two characteristics of condensation polymers. Many candidates provided comprehensive responses.

Expected characteristics included any two of the following.

- Two different monomers are joined by condensation.
- The polymer as well as a small molecule are formed.
- The small molecules are HCl or H_2O .

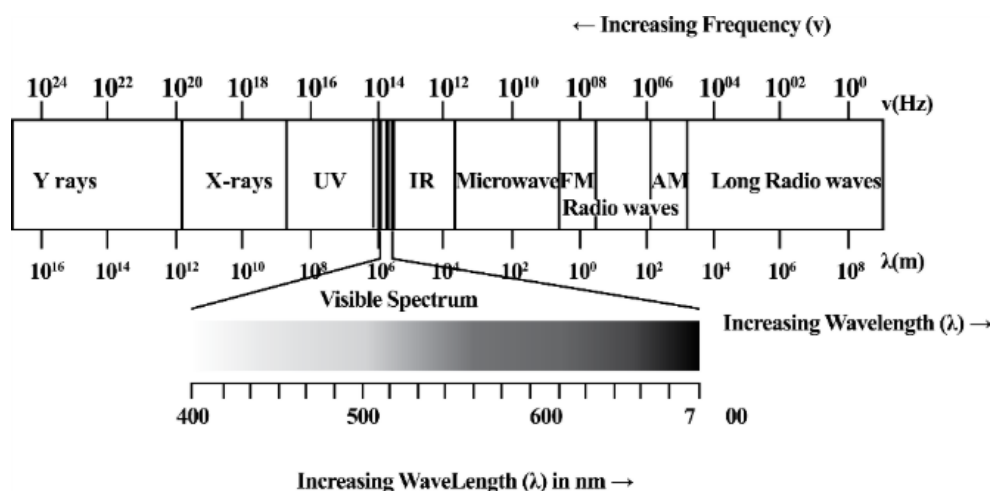
In Part (c) (v), candidates were required to list three examples of condensation polymers based on their linkage types. Many candidates responded accurately. Examples of condensation polymers include *polyamides, polyesters and polysaccharides.*

Question 2

This question assessed specific objectives 4.1, 4.2, 4.3, 5.2, 5.3, 5.4, 5.5, 6.1, 6.2, 6.3 and 6.4 from Module 2: Analytical Methods and Separation Techniques. The mean score was 45.66 and the standard deviation 10.39.

Part (a)

Candidates were required to draw a diagram showing the approximate wavelength ranges for any three types of electromagnetic radiation. Candidates were awarded marks for correctly identifying three forms of radiation along with their corresponding wavelength ranges, as illustrated in the following provided diagram.



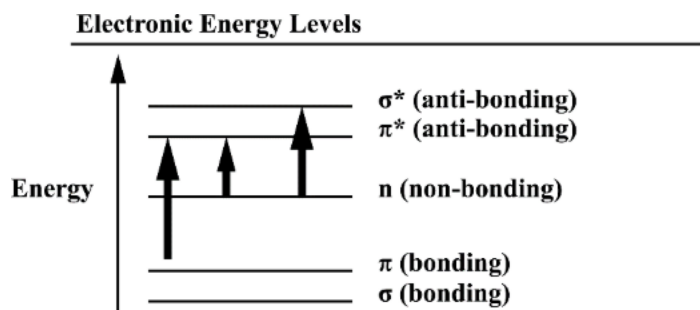
Part (b)

This part required candidates to calculate the energy of radiation given its frequency, using the appropriate formula. Most candidates were able to apply the relationship $E = hf$ and correctly calculate the energy of the radiation. The expected working was as follows.

$$E = (1.01 \times 10^{16} \text{ s}^{-1}) \times (6.63 \times 10^{-34} \text{ J}\cdot\text{s}) = 6.696 \times 10^{-18} \text{ J}$$

Part (c)

Candidates were required to draw the correct electronic transitions on the diagram provided, corresponding to UV/VIS absorptions. Most candidates successfully illustrated the three expected transitions between the specified energy levels. Only the three transitions shown in the following diagram were accepted based on the UV/VIS energy range.



Part (d)

For Part (d) (i), candidates were required to state the observable change when ammonia is added to a solution containing Cu^{2+} ions. It was expected that candidates would indicate the intensity of the blue solution formed. Some candidates correctly stated that *a dark blue solution is produced*.

In Part (d) (ii), candidates were asked to explain why 615 nm was selected as the wavelength for analysis in the spectrophotometer. Candidates who stated either of the following responses were awarded full marks.

- 615 nm is the optimal wavelength for absorption by Cu^{2+} ions.
- 615 nm corresponds to the complementary colour of the blue solution.

For Part (d) (iii) candidates were required to describe how a calibration curve is prepared and how it is used to determine unknown concentrations. The following is an example of an expected description.

- Prepare standard solutions of Cu^{2+} ions.
- Measure the absorbance of each standard solution.
- Plot a calibration curve of absorbance versus concentration
- Determine the concentration of the unknown solution by extrapolating from the graph.

Part (e)

For Part (e) (i), candidates were required to calculate the molar concentration of a Cu^{2+} solution from a given mass concentration. Candidates who carried out the following calculation were awarded full marks.

$$\frac{2.5 \times 10^{-3} \text{ g dm}^{-3}}{63.5 \text{ g mol}^{-1}} = 3.9 \times 10^{-5} \text{ mol dm}^{-3}$$

In Part (e) (ii), candidates were required to calculate the molar absorptivity using Beer–Lambert’s Law and the absorbance provided. The expected calculation was as follows.

$$A = Ecl$$

$$E = \frac{A}{cl} = \frac{0.524}{(3.9 \times 10^{-5}) \times (1)} = 1.3 \times 10^4 \text{ dm}^3 \text{ mol}^{-1} \text{ cm}^{-1}$$

For Part (e) (iii), candidates were required to determine the concentration of Cu^{2+} ions in a well-water sample from its absorbance. The expected response is shown below.

$$c = \frac{A}{\epsilon l} = \frac{0.350}{(1.3 \times 10^4) \times (1)} = 2.7 \times 10^{-5} \text{ mol dm}^{-3}$$

Part (f)

This part required candidates to outline the steps involved in analysing a sample using UV/VIS spectroscopy. A few candidates experienced difficulty describing the procedure clearly. Candidates are reminded that syllabus objectives involving experimental techniques should be reviewed carefully, especially when these activities are not performed as hands-on practicals.

The expected steps were as follows.

Step 1: Weigh accurately a mass of sample using an electronic balance.

Step 2: Dissolve sample in an appropriate solvent and make up to a fixed volume.

Step 3: Filter sample and place in cuvette.

Step 4: Blank spectrophotometer and check absorbance of the sample at a particular wavelength.

Step 5: If absorbance is greater than 1.0, make serial dilutions.

Step 6: Place sample in cuvette.

Part (g)

Candidates were required to explain the principles of infrared (IR) spectroscopy, including how molecules absorb IR radiation. Most candidates answered correctly, stating that *covalent molecules have modes of vibration. When these vibrations cause a change in the dipole moment of the molecule, absorption occurs. The energy of the absorption corresponds to frequencies of IR light.*

Part (h)

In Part (h) (i), candidates were asked to identify the functional groups responsible for the IR absorptions shown in the diagram for Compound D. Many candidates correctly identified

- 1695 cm^{-1} — carbonyl group (C=O)
- 1619 cm^{-1} — C=C double bond.

Candidates who identified either or both functional group assignments in their responses were awarded marks.

For Part (h) (ii), candidates were required to state two types of molecular vibrations that Compound D may exhibit. Many candidates answered correctly by identifying *stretching* and *bending*.

Question 3

This question assessed specific objectives 1.1, 7.1, 7.2, 7.3, 2.1, 2.3, 9.6 and 8.5 from Module 3: Industry and the Environment. The mean was 41.39 and the standard deviation 9.55.

Part (a)

Candidates were required to list four factors that influence the location of industrial plants. Most candidates demonstrated the required knowledge and correctly identified several relevant factors. Appropriate responses included the following.

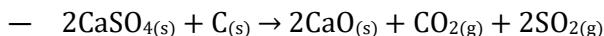
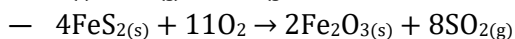
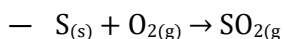
- Access to raw materials and water
- Cost of transportation and storage
- Cost of energy supply
- Access to labour
- Ability to expand the facility
- Safety of workers and surrounding communities
- Waste disposal options

Part (b)

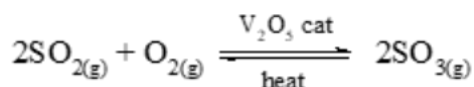
For Part (b) (i), candidates were required to outline the first two steps of the contact process, using balanced equations where appropriate.

Most candidates performed well and correctly outlined the following reactions.

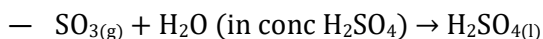
- Oxidation of S containing species to produce SO_2 . Any one of the following equations could have been used.



- Oxidation of SO_2 to SO_3



- Formation of H_2SO_4



Although many candidates included the correct chemical equations, some omitted the vanadium(V) oxide catalyst (V_2O_5) in the second reaction (oxidation of SO_2 to SO_3).

For Part (b) (ii), candidates were required to state one use of sulfur oxide in the food industry. Candidates generally showed good understanding and many of them correctly identified the use of sulfur dioxide (SO₂) as a preservative. Examples of acceptable responses included *preservation of wines, dried fruits and fruit juices*.

In Part (b) (iii), candidates were required to state two environmental concerns associated with sulfur dioxide (SO₂). Most candidates accurately stated concerns such as the following.

- Contribution to acid rain
- Acidification of rivers and lakes
- Acidification of soils
- Irritation of eyes and throat

Part (c)

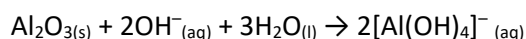
Part (c) (i) required candidates to explain how aluminium oxide is separated from bauxite using the Bayer process. Candidates were also required to support their answer using balanced chemical equations. Many candidates accurately described the separation process and they wrote the appropriate balanced chemical equations. However, only a few candidates were able to obtain full marks.

Candidates could have given one of the following responses to explain how aluminium oxide is separated from bauxite using the Bayer process.

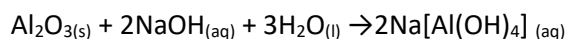
- Al₂O₃ is amphoteric and SiO₂ is acidic.
- Heating bauxite ore in concentrated NaOH dissolves both Al₂O₃ and SiO₂.

The expected supporting balanced chemical equations are shown below.

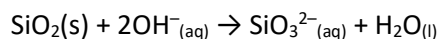
Step 1: Dissolution of aluminium oxide



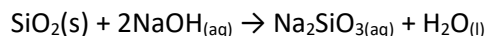
Or



Step 2: Dissolution of silicon dioxide

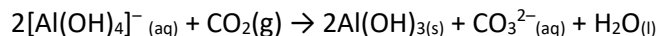


Or

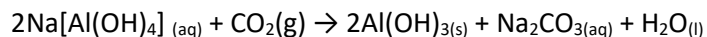


Step 3: Precipitation of aluminium hydroxide

Al(OH)₃ is obtained by precipitating the [Al(OH)₄]⁻ with CO₂.



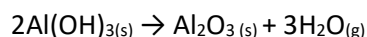
Or



Step 4: Conversion to alumina

The Al(OH)₃ is separated by filtration, washed and thermally decomposed to form alumina, Al₂O₃.

Or



For Part (c) (ii) candidates were required to write the main anode and cathode reactions involved in the electrolysis of aluminium oxide. Most candidates displayed that they had good understanding of what was required by providing the correct balanced equations at the anode and cathode, using the appropriate physical states.

Candidates were expected to state the following.

- Cathode reaction: $\text{Al}^{3+}_{(\text{l})} + 3\text{e}^- \rightarrow \text{Al}_{(\text{s})}$
- Anode reaction: $2\text{O}^{2-}_{(\text{l})} \rightarrow \text{O}_{2(\text{g})} + 4\text{e}^-$

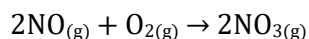
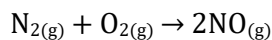
In Part (c) (iii), candidates were asked to describe one environmental impact of alumina production. Many candidates responded well, often explaining the negative impact of red mud on animals and humans.

Candidates who listed any one of the following impacts were awarded full marks.

- Caustic waste from the red mud (mud lake) must be stored which consumes valuable land space.
- Caustic waste contaminates ground and surface water.
- Mining destroys ecosystems.
- Dust pollution increases respiratory illnesses.
- Noise pollution can disturb residents in surrounding areas or cause animals to migrate from their habitat.

Part (d)

Candidates were required to write equations showing how nitrogen oxides (NO_x) is formed during the combustion of fossil fuels. Most candidates correctly provided balanced chemical equations that represent the reaction of the oxides of nitrogen. These reactions are shown below.



Part (e)

This part addressed experimental techniques and was generally well answered by candidates.

In Part (e) (i), candidates were asked to describe a qualitative test that can be used in a school laboratory to detect the presence of aqueous nitrate ions. Many candidates displayed their experimental knowledge and understanding required by writing the appropriate chemical test to detect the presence of aqueous nitrate ions.

The following are examples of acceptable responses.

- Add Al(s) or Zn(s) followed by NaOH (aq) and warm the mixture. If nitrate ions are present, ammonia gas is produced.
- Add Cu(s) followed by slow addition of concentrated H₂SO₄. If nitrate ions are present a brown ring is produced.

In Part (e) (ii), candidates were asked to compare the school laboratory test with the cadmium reduction method and state whether the school test is suitable for water quality analysis. Many candidates correctly stated that the school-based test is not suitable but did not give a reason.

Candidates who provided responses which included any of the following points were awarded full marks.

- The school test is not suitable because pollutants are often present in trace (small) quantities.
- Qualitative tests done in a school laboratory are not as sensitive as the cadmium reduction method to trace quantities of NO₃⁻.

For Part (e) (iii), candidates were asked to name a reagent used to detect phosphate ions. Many candidates were able to correctly identify the reagent as *ammonium molybdate*.

Paper 032 comprises three compulsory questions designed to assess candidates' laboratory skills. Overall, candidates' performance on Paper 032 was poor. The maximum mark available was 35. The mean score was 18.34 and the standard deviation was 6.86.

Across the three modules, candidates' performance declined. When compared with the previous year, there were slight declines in Modules 1 and 2, while the greatest decline in performance occurred in Module 3.

Question 1

This question required candidates to carry out a series of qualitative tests on an unknown organic liquid, X. Candidates were expected to carefully observe and record colour changes, precipitate formation and any gases produced. They were then required to make accurate chemical inferences for each test. Using the reagents provided, candidates needed to interpret the results and ultimately deduce the structure of the unknown organic compound based on the combined observations.

For Part (a) (i) to (iv) candidates appropriately recorded the required observations and inferences for the reactions of X. The following table shows how the table should have been completed to show the expected results.

	Test	Observation	Inference
(a) (i)	<ul style="list-style-type: none"> Add 1 cm³ of water to 1 cm³ of X. Add blue and red litmus paper to the mixture above. 	<ul style="list-style-type: none"> X dissolved to form a colourless solution. Blue remains the same and red remains the same. 	
(ii)	Add acidified Potassium dichromate, K ₂ Cr ₂ O ₇ to 1 cm ³ of X.	There was a change from orange to green.	Primary or secondary alcohol or aldehyde.
(iii)	Add aq. NaOH followed by iodine solution to 1 cm ³ of X then warm.	Yellow precipitate.	Ethanol or secondary alcohol bearing the methyl group, or ethanal or methyl ketone.
(iv)	Add 1 cm ³ concentrated H ₂ SO ₄ followed by ethanoic acid to 1 cm ³ of X.	Sweet smelling liquid formed.	Ester formed ethanol or secondary alcohol present.
(v)	Add 4 drops of 2,4-DNPH to 1 cm ³ of X.	No precipitate/orange colour remain the same.	No carbonyl groups present.
(vi)	Add magnesium to 2 cm ³ of X. Test for any gas produced.	<ul style="list-style-type: none"> Bubbles of colourless gas. A pop sound with lighted splint. 	

Part (b) required candidates to deduce the structure of the unknown organic liquid, X, using the observations and inferences recorded in Table 1. Based on the results of the qualitative tests, candidates correctly identified the unknown compound (X) as *ethanol*, with the structural formula C_2H_5OH .

Question 2

Part (a)

Candidates were required to construct a properly formatted titration results table that included burette readings 1, 2 and 3, as well as the initial volume, final volume and volume used. Many candidates constructed an appropriate table, recording values to two decimal places and using the correct units in the appropriate order. The expected table is shown below.

VOLUME OF POTASSIUM MANGANATE (VII) cm³	1	2	3
Final Reading	24.10	41.10	28.50
Initial Reading	0.00	17.60	4.80
Volume used	24.10	23.50	23.70

Part (b)

For Part (b) (i), candidates were required to mark with an asterisk (*) the titration values that were concordant, that is, values falling within 0.10 cm³ of each other and should therefore be used to calculate the average titre. The candidate correctly placed the asterisks beside the appropriate volumes. The expected positions of the asterisks are shown below.

VOLUME OF POTASSIUM MANGANATE (VII) cm³	1	2	3
Final Reading	24.10	41.10	28.50
Initial Reading	0.00	17.60	4.80
Volume used	24.10	23.50	23.70
Asterisk to indicate titration volume to be used.		*	*

In Part (b) (ii), candidates were required to calculate the average volume of potassium manganate (VII) used in the experiment. Candidates correctly the average volume. Candidates who used the following calculations were awarded full marks.

$$23.50 \text{ cm}^3 + 23.70 \text{ cm}^3 = 47.20 \text{ cm}^3$$

$$\frac{47.20}{2} = 23.60 \text{ cm}^3$$

In Part (b) (iii), candidates were asked to name the apparatus used to measure the sulfuric acid and distilled water. Candidates demonstrated the required experimental knowledge and correctly identified the *measuring cylinder* as the appropriate apparatus.

Part (c)

The candidate demonstrated the required knowledge and correctly calculated the number of moles of potassium manganate (VII). The correct calculations are shown below

$$M_r \text{ of } \text{KMnO}_4 = 158$$

$$\text{Molar concentration of } \text{KMnO}_4 = \frac{2.37}{158} = 0.015 \text{ mol dm}^{-3}$$

$$\text{Moles of } \text{KMnO}_4 = \frac{0.015 \times 23.60}{1000} = 3.54 \times 10^{-4}$$

Part (d)

Candidates were required to calculate the number of moles of $\text{H}_2\text{C}_2\text{O}_4$ that reacted with the KMnO_4 used. Most candidates correctly applied the mole ratio. The following is the expected response.

Mole ratio of $\text{MnO}_4^- : \text{C}_2\text{O}_4^{2-}$ is 2:5

$$\text{No. of moles of } \text{C}_2\text{O}_4^{2-} = \frac{3.54 \times 10^{-4} \times 5}{2} = 8.85 \times 10^{-2} \text{ moles}$$

Part (e)

Candidates were required to calculate the mass concentration of $\text{H}_2\text{C}_2\text{O}_4$. Many candidates correctly calculated the molar mass and applied the correct steps, but the final numerical answer was incorrect. The correct mass concentration of $\text{H}_2\text{C}_2\text{O}_4$ is $90 \times 3.54 \times 10^{-2} = 3.19 \text{ g dm}^{-3}$. The correct working is shown below.

25 cm^3 of $\text{H}_2\text{C}_2\text{O}_4$ contains $8.85 \times 10^{-4} \text{ mol}$

$$1000 \text{ cm}^3 \text{ contains} = \frac{8.85 \times 10^{-4} \times 1000}{25} = 3.54 \times 10^{-2} \text{ moles}$$

$$M_r \text{ of } \text{H}_2\text{C}_2\text{O}_4 = 90$$

$$\text{Mass concentration} = (3.54 \times 10^{-2}) \times 90 = 3.19 \text{ g dm}^{-3}$$

Question 3

This question required candidates to plan and design a laboratory experiment to determine whether a suspected water sample contained nitrate (NO_3^-) and lead (II) (Pb^{2+}) ions. Candidates were expected to outline a hypothesis, aim, list of materials, procedure, variables, expected results for each ion, and one possible source of error.

Part (a)

Most candidates wrote an appropriate hypothesis, for example *contamination of the water at the storage company is due to NO_3^- and Pb^{2+} ions.*

Part (b)

Many candidates wrote an acceptable aim such as *to identify the presence of NO_3^- and Pb^{2+} ions in water at a storage company.*

Part (c)

Candidates exhibited experimental knowledge and understanding. Most of them listed the required reagents and apparatus. These include the following.

- Test tubes
- Bunsen burner
- Water from storage company
- Aqueous potassium iodide
- Copper turnings, concentrated sulfuric acid (or aqueous sodium hydroxide, zinc or aluminium powder)

Part (d)

Many candidates demonstrated good experimental knowledge and understanding, and they described an acceptable experimental method.

Experimental Method

Step 1: Test for NO_3^- ions

- Add copper turnings and concentrated sulfuric acid, warm the mixture.

Or

- Add aqueous sodium hydroxide and zinc or aluminium powder, warm the mixture.

Step 2: Test for Pb^{2+} ions

- Add aqueous potassium iodide.

Part (e)

Most candidates only got one or two variables correct.

Variables

- Controlled — Volume of water
- Responding — Observations made
- Manipulated — Reagents used for test

Part (f)

The description of the experimental results was in line with the experimental method described.

Expected Results

- Presence of the NO_3^- ions: Candidates who stated one of the following responses earned marks.
 - It is expected that a blue solution and red-brown gas (if copper turnings and concentrated sulfuric acid is used) will be observed.
 - It is expected that a pungent odour and red litmus changes to blue (if aqueous sodium hydroxide and zinc or aluminium powder is used) will be observed.
- Presence of the Pb^{2+} ions: the expected response was it is expected that a bright yellow precipitate will be observed.

Part (g)

Many candidates did not provide an acceptable possible source of error. An acceptable source of error *is the concentration of contaminants in water is too low to be detected.*