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# Examiners' Report
# June 2023

## International Advanced Level Chemistry WCH13 01

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## Introduction

The paper had an emphasis on experimental techniques and there were good opportunities for all candidates to demonstrate their chemical understanding. Many candidates had clearly prepared well for this paper and were able to apply their knowledge of practical work successfully to familiar and novel situations. Conversely, it appeared that a significant number of candidates did not seem to have an understanding of how some basic organic apparatus was used nor a good grasp of using simple qualitative tests for identification. However, the calculation questions were done with impressive accuracy by the majority of candidates and there was no evidence of candidates running out of time.

## Question 1 (a)

Q01(a)(i) was answered well by the majority of candidates and most were able to correctly identify barium from the flame test. However, a number of candidates gave Ba with no charge so did not score, as the cation ($Ba^{2+}$) was asked for in the question. Very occasionally, wrong ions such $Cu^{2+}$ or $Ba^{+}$ were seen too, which did not score but allowed access to Q01(a)(iii) via transferred error.

In Q01(a)(ii), many candidates recognised the yellow precipitate being due to the iodide ion, but as in Q01(a)(i) a number of candidates did not give the charge of the anion and there was clearly some confusion between iodine and iodide. If wrong ions were given, they were usually other halides.

Q01(a)(iii) was answered particularly well and even those candidates who made a mistake in Q01(a)(i) or Q01(a)(ii) were able to score a transfer error mark here. However, a few candidates just wrote the name instead of the formula and so did not score.

Of those candidates who answered Q01(a)(iv) successfully, the large majority used concentrated sulfuric acid as the reagent and went on to give a correct observation. Unfortunately, a number of candidates did not state that the acid was concentrated so did not score the test mark but they were able to score the result mark. However, it appeared that most candidates were unable to recall the reactions of halides with concentrated sulfuric acid. The majority of candidates did not give a different test but suggested using ammonia solution, which is just an extension of the silver nitrate test.

Identify, by name or formula, the cation present in **A**.

**(1)**

$Ba^{2+}$ / Barium ion

(ii) Aqueous silver nitrate, acidified with dilute nitric acid, was added to a sample of solid **A** dissolved in distilled water.

A yellow precipitate formed.

Identify, by name or formula, the anion present in **A**.

**(1)**

$I^-$ / Iodide

(iii) Give the **formula** of **A**.

**(1)**

~~Ba²I~~ $BaI_2$

(iv) The **anion** present in **A** can be shown by a **different** test on solid **A**.

Give a suitable different test with the expected result to show the identity of this **anion**.

**(2)**

| Test | Expected result |
|---|---|
| Addition of concentrated $H_2SO_4$ | Purple fumes |

**ResultsPlus**
**Examiner Comments**

This is an excellent answer. Although either would do, the candidate gives both the correct name and formulae of the ions. They also use concentrated sulfuric acid and give a positive result of the test so full marks are scored.

Identify, by name or formula, the cation present in **A**.

**(1)**

~~[illegible]~~ $Ba^{+}$

(ii) Aqueous silver nitrate, acidified with dilute nitric acid, was added to a sample of solid **A** dissolved in distilled water.

A yellow precipitate formed.

Identify, by name or formula, the anion present in **A**.

**(1)**

$I^{-}$

(iii) Give the **formula** of **A**.

**(1)**

$BaI$

**ResultsPlus**
**Examiner Comments**

Here the candidate appreciated that the ion was barium but gave the incorrect charge so they could not score the mark in Q01(a)(i). However, they did get a transfer error mark by giving BaI as the formula in Q01(a)(iii).

**ResultsPlus**
**Examiner Tip**

Make use of the periodic table to ensure ions have correct charges.

(iv) The **anion** present in **A** can be shown by a **different** test on solid **A**.

Give a suitable different test with the expected result to show the identity of this **anion**.

**(2)**

| Test | Expected result |
|---|---|
| Add concentrated ammonia to the solid A. | The yellow precipitate that was formed previously will not dissolve. |

**ResultsPlus**
**Examiner Comments**

Despite the question asking for a different test, many candidates opted to test the solubility of the precipitate formed in the first test by adding ammonia. This use of ammonia was frequently seen and did not score.

**ResultsPlus**
**Examiner Tip**

Candidates should read the question carefully, paying particular attention to the words in bold as they are there to guide the response required.

## Question 1 (b)(i)

The test for the ammonium ion by the formation of ammonia gas was well known, but many candidates did not warm the mixture or explain it was the vapours that had to be tested with indicator paper. The use of HCl instead of NaOH as the test reagent was a common wrong answer.

(b) Solid **B** is ammonium sulfate.

(i) Give a test, with the expected result, to confirm the presence of the ammonium ion in **B**.

**(2)**

| Test | Expected result |
| --- | --- |
| Add sodium hydroxide and apply heat | ammonia gas is produced, which turns damp red ~~lit ma~~ litmus paper blue |

**ResultsPlus**
**Examiner Comments**

This is an excellent answer. The candidate has explained clearly how to carry out the test and confirm the identity of ammonia gas so both marks were scored.

(b) Solid **B** is ammonium sulfate.

(i) Give a test, with the expected result, to confirm the presence of the ammonium ion in **B**.

**(2)**

| Test | Expected result |
|---|---|
| warm with NaOH | turns damp red litmus paper blue |

ResultsPlus
Examiner Comments

The test answer is correct. However, the result should have mentioned that it was the evolved ammonia gas that was tested with damp red litmus.

ResultsPlus
Examiner Tip

Although this response was awarded both marks as an allow on the mark scheme, candidates should be encouraged to include full details when describing the observations from practical work.

## Question 1 (b)(ii-iii)

In Q01(b)(ii) the test for the sulfate ion had been learned by the majority of candidates and most were able to identify a suitable barium compound, suitable acid and give the correct result of the test. However, despite the question being worth 3 marks a number of candidates only gave two pieces of information. Many candidates missed out the acid or simply said that the solution was acidified, so lost a mark.

In Q01(b)(iii) the ionic equation was often well done but surprisingly some candidates missed out state symbols despite it being asked for in the question. Others wrote a full equation instead of an ionic one and some responses gave the wrong state symbols.

(ii) Give a test, with the expected result, to confirm the presence of the sulfate ion in **B**.

**(3)**

| Test | Expected result |
|---|---|
| Add nitric acid and barium nitrate to B. | A white precipitate formed if sulfate ion present. |

(iii) Write the **ionic** equation for the reaction taking place in (b)(ii). Include state symbols.

**(1)**

$$Ba^{2+}(aq) + SO_4^{2-}(aq) \longrightarrow BaSO_4(s).$$

**ResultsPlus**
**Examiner Comments**

This is an excellent answer that scored full marks.

(ii) Give a test, with the expected result, to confirm the presence of the sulfate ion in **B**.

**(3)**

| Test | Expected result |
|---|---|
| Add Hcl. followed by Bacl. | white solid appear. |

**ResultsPlus**
**Examiner Comments**

In this example the candidate has given the wrong formula for barium chloride so a mark is lost. This is unfortunate as if they had simply written barium chloride instead of giving BaCl, they would have scored full marks.

**ResultsPlus**
**Examiner Tip**

Candidates should use the Periodic Table to help them when writing formulae.

(ii) Give a test, with the expected result, to confirm the presence of the sulfate ion in **B**.

**(3)**

| Test | Expected result |
|---|---|
| Add $BaCl_2$ | white precipitate forms. |

ResultsPlus
Examiner Comments

The candidate has omitted the acid so only scored two marks.

## Question 2 (a)

The result of this simple test to identify an OH group was known by almost all candidates.

## Question 2 (b)

The identification of carbon dioxide from the limewater test was known by almost all candidates.

## Question 2 (c)

The Benedict's or Fehling's tests were well understood by most candidates, however a lack of precision often cost marks. Almost all candidates appreciated the solution was blue to start and most knew it was brick red at the end but many candidates omitted the word precipitate or solid and so lost a mark. Occasionally, candidates got confused with Tollen's reagent and gave the wrong result of a silver mirror, which also did not score.

(c) 2 $cm^3$ of Benedict's or Fehling's solution is added to separate 2 $cm^3$ samples of each compound. The test tubes are placed in a warm water bath.

| Observations | |
|---|---|
| **C** | **D** |
| No change | Positive result |

Give the expected observation for the positive result produced by liquid **D**.
Include the initial and final appearance of the contents of the test tube.

**(2)**

Brick red precipitate.

Initially it was a blue solution which then turns into brick red precipitate.

**ResultsPlus**
**Examiner Comments**

This is an excellent answer and scored both marks.

(c) 2 $cm^3$ of Benedict's or Fehling's solution is added to separate 2 $cm^3$ samples of each compound. The test tubes are placed in a warm water bath.

| Observations | |
|---|---|
| **C** | **D** |
| No change | Positive result |

Give the expected observation for the positive result produced by liquid **D**.
Include the initial and final appearance of the contents of the test tube.

**(2)**

The blue Fehling's Solution turns red forming a precipitate of $CU_2O_2$ this is the red precipitate formed.

**ResultsPlus**
**Examiner Comments**

The candidate has got both scoring points, the blue starting solution forming the red precipitate. Unfortunately, although not required, they have given the incorrect formula of the red precipitate so the mark is lost.

**ResultsPlus**
**Examiner Tip**

Any additional information given in an answer is usually just ignored. However, if it is incorrect a mark is often lost.

(c) 2 cm$^3$ of Benedict's or Fehling's solution is added to separate 2 cm$^3$ samples of each compound. The test tubes are placed in a warm water bath.

| Observations | |
|---|---|
| **C** | **D** |
| No change | Positive result |

Give the expected observation for the positive result produced by liquid **D**. Include the initial and final appearance of the contents of the test tube.

**(2)**

There is a ~~ct~~ Colour change from Blue to Brick red.

**ResultsPlus**
**Examiner Comments**

This illustrates a common error where the candidate has not mentioned the solid (precipitate) forming during the reaction.

**ResultsPlus**
**Examiner Tip**

Learn all the tests and expected results from the specification.

## Question 2 (d)

There were many good answers to this question with lots of candidates getting full marks or only missing out on Q02(d)(ii), which surprisingly, was the most challenging item.

In Q02(d)(i) the majority of candidates were able to draw the correct structure for C, but the two aldehydes in D proved to be more problematic. Common errors included ketones, alkenes and structures that had atoms with the wrong number of bonds.

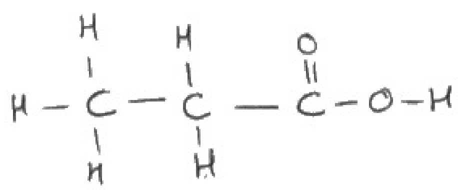
In Q02(d)(ii) very few candidates managed to correctly identify the wavenumber and peak that would be present in the infrared spectrums of both C and D. Most did not seem to understand that C=O peaks of aldehydes and carboxylic acids were different and so the only similarity had to be the C-H stretching in alkanes. Unfortunately, a few candidates who got this bond forgot to give the wavenumber.

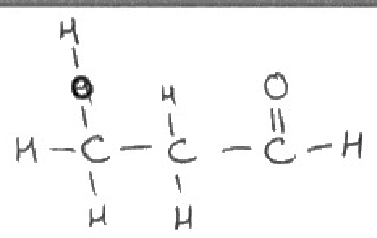
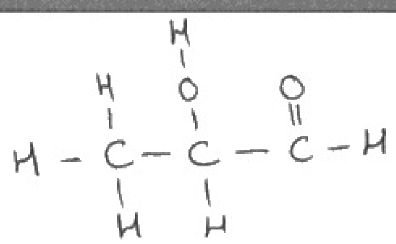
In Q02(d)(iii) a large majority of candidates were able to identify the peak being due to $CH_3^+$ but either did not mention which of their structures would give this peak or had two structures which both contained a $CH_3$.

(d) Both **C** and **D** have the molecular formula $C_3H_6O_2$.

(i) Deduce the structure of **C** and the **two** possible structures of **D**.
Use the molecular formula and the results from (a), (b) and (c).

**(3)**

| Structure of **C** |
|---|
|  |

| Possible structure of **D** | Possible structure of **D** |
|---|---|
|  |  |

(ii) Some infrared data are given in the table.

| Group | Wavenumber range / $cm^{-1}$ |
|---|---|
| O—H stretching in alcohols | 3750–3200 |
| O—H stretching in carboxylic acids | 3300–2500 |
| C═O stretching in aldehydes | 1740–1720 |
| C═O stretching in ketones | 1720–1700 |
| C═O stretching in carboxylic acids | 1725–1700 |
| C—H stretching in aldehydes | 2900–2820, 2775–2700 |
| C—H stretching in alkanes | 2962–2853 |

State the wavenumber range for one peak that would be present in the infrared spectra of **both C** and **D**, identifying the bond responsible for this peak.

**(1)**

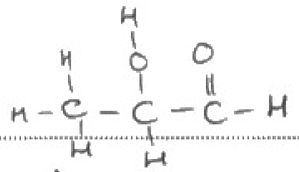
C-H stretching in alkanes 2962-2853

(iii) A student suggested that the structure of **D** could be identified using mass spectrometry because only one of the possible structures of **D** would have a peak at $m/z = 15$.

Identify which of the possible structures of **D** would be expected to give this peak. Justify your answer.

**(2)**

Structure of D -



As m/z = 15 is caused by $CH_3^+$ which can only be formed from this structure.

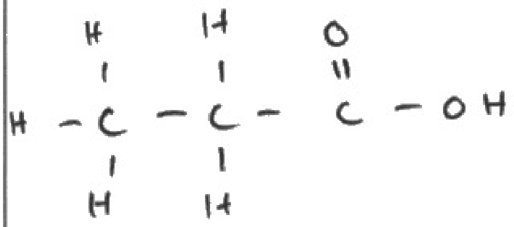
**ResultsPlus**
**Examiner Comments**

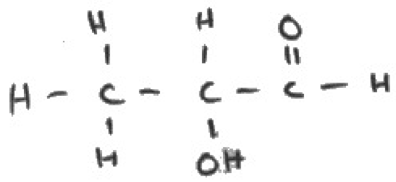
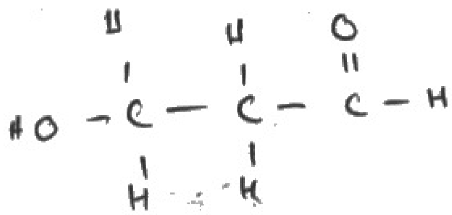
This is an excellent fully correct answer.

(d) Both **C** and **D** have the molecular formula $C_3H_6O_2$.

(i) Deduce the structure of **C** and the **two** possible structures of **D**. Use the molecular formula and the results from (a), (b) and (c).

**(3)**

| Structure of **C** |
|---|
|  |

| Possible structure of **D** | Possible structure of **D** |
|---|---|
|  |  |

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| C═O stretching in carboxylic acids | 1725–1700 |
| C—H stretching in aldehydes | 2900–2820, 2775–2700 |
| C—H stretching in alkanes | 2962–2853 |

State the wavenumber range for one peak that would be present in the infrared spectra of **both C** and **D**, identifying the bond responsible for this peak.

**(1)**

~~O-H stretching~~ ~~3300-2500~~ ~~3750-3200~~

stretching
O - H 3300 - 2500 .

**ResultsPlus**
**Examiner Comments**

The wrong peak and wavenumber has been identified and this was a common error.

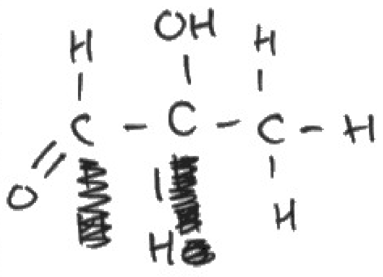
**ResultsPlus**
**Examiner Tip**

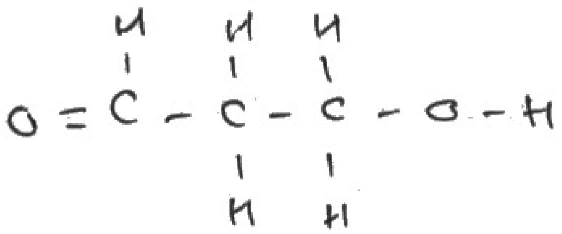
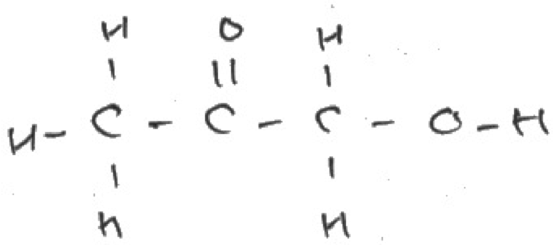
Become familiar with Infrared data tables, particularly the different environments of C=O and O-H groups.

(d) Both **C** and **D** have the molecular formula $C_3H_6O_2$.

(i) Deduce the structure of **C** and the **two** possible structures of **D**.
Use the molecular formula and the results from (a), (b) and (c).

**(3)**

| Structure of **C** |
|---|
|  |

| Possible structure of **D** | Possible structure of **D** |
|---|---|
|  |  |

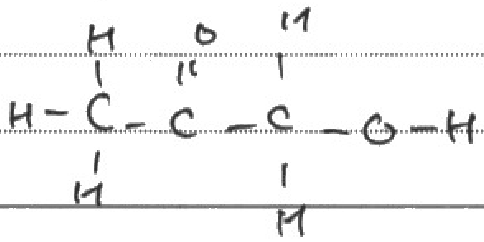
(iii) A student suggested that the structure of **D** could be identified using mass spectrometry because only one of the possible structures of **D** would have a peak at $m/z = 15$.

Identify which of the possible structures of **D** would be expected to give this peak. Justify your answer.

**(2)**

the Second one = 12 + 1+1+1 = 15

$(CH_3)^{+\cdot}$



we can add the mvs of CH3

**(Total for Question 2 = 10 marks)**

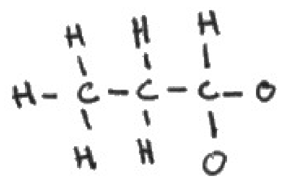
ResultsPlus
Examiner Comments

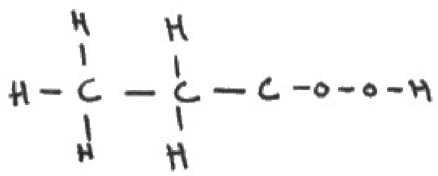
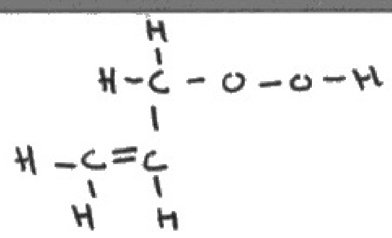
Here only one of the structures in Q02(d)(i) is correct, the aldehyde in D. However, in Q02(d)(iii) they correctly identify the $CH_3^+$ and despite the fact that one of their structures of D is incorrect, they successfully explain why it would give this peak and so both marks are scored.

(d) Both **C** and **D** have the molecular formula $C_3H_6O_2$.

(i) Deduce the structure of **C** and the **two** possible structures of **D**.
Use the molecular formula and the results from (a), (b) and (c).

**(3)**

| Structure of **C** |
|---|
|  |

| Possible structure of **D** | Possible structure of **D** |
|---|---|
|  |  |

**ResultsPlus**
**Examiner Comments**

Unfortunately, this type of response was seen quite regularly. Although there was no test for unsaturation in this question, a number of candidates inserted a carbon double bond into one or more of their structures. Of greater concern was that some candidates seemed unaware of simple rules of bonding and here the oxygen forms either one or two bonds and the carbon two or four bonds.

**ResultsPlus**
**Examiner Tip**

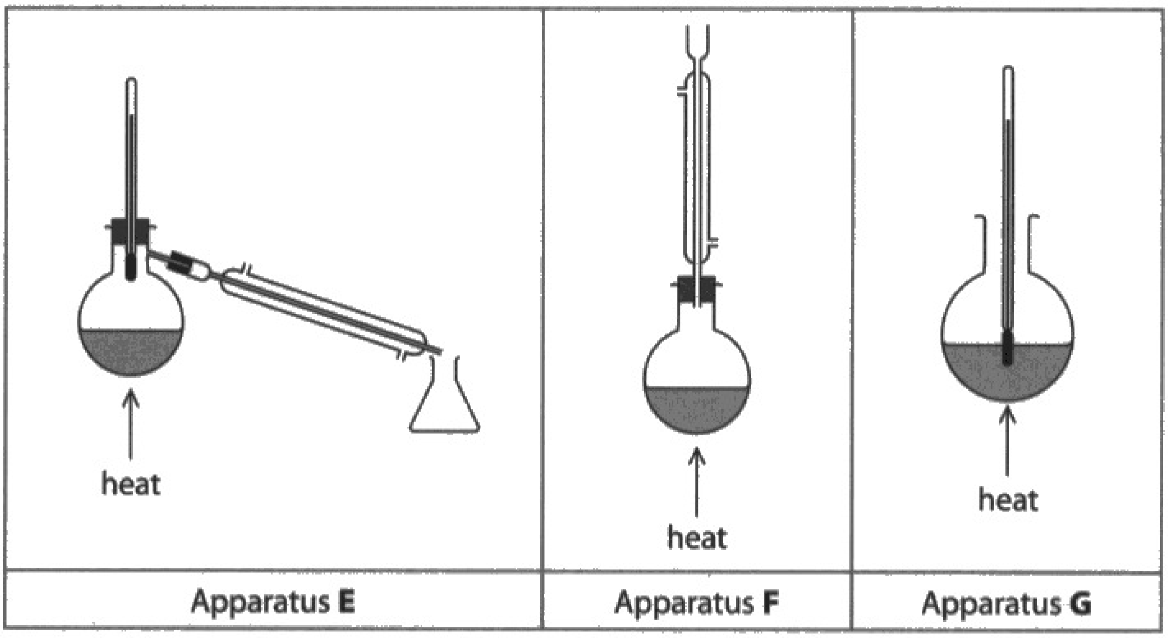
Candidates should learn the basic tests to identify functional groups in organic compounds. They should also practise drawing displayed structures, ensuring that simple bonding rules are applied in terms of the number of bonds each element will form.

## Question 3 (a)(i-ii)

In Q03(a)(i) the need to heat under reflux to ensure the complete oxidation of butan-1-ol to butanoic acid was well known by most of the candidates. However, many did not specify that the apparatus was distillation.

In Q03(a)(ii) the open apparatus and why it would not be suitable was well understood with the majority of candidates correctly recognising that the gases would evaporate and escape. However, many candidates just commented on the lack of a condenser and a number of candidates were concerned about the position of the thermometer.

(a) A group of students was required to oxidise butan-1-ol to butanoic acid.
The students suggested three different types of apparatus for this reaction.




Their teacher told them they should use apparatus **F**.

(i) Explain why apparatus **E** is **not** suitable for the oxidation of butan-1-ol to butanoic acid.
alcohol carboxylic

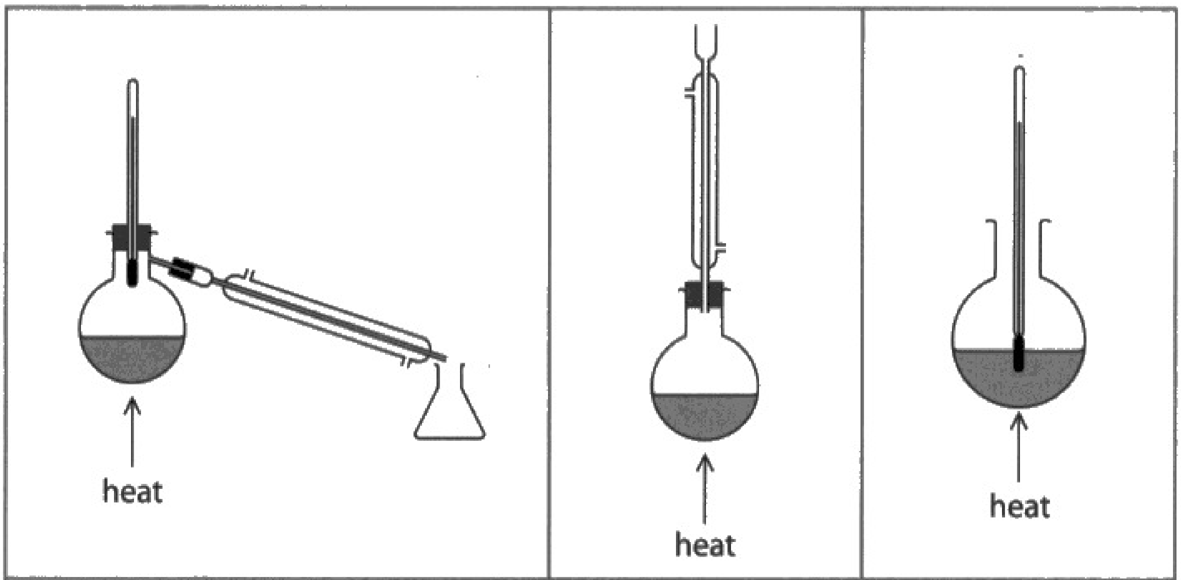
**(2)**

Apparatus E is set up for a distillation reaction which would produce an aldehyde, while to produce butanoic, which is a carboxylic acid, it required heating under reflux.

ResultsPlus
Examiner Comments

This is a good answer as the candidate understands the apparatus is for distillation and reflux is required to produce butanoic acid. Both marks are scored.

(a) A group of students was required to oxidise butan-1-ol to butanoic acid.
The students suggested three different types of apparatus for this reaction.




Apparatus **E** | Apparatus **F** | Apparatus **G**

Their teacher told them they should use apparatus **F**.

(i) Explain why apparatus **E** is **not** suitable for the oxidation of butan-1-ol to butanoic acid.

**(2)**

Apparatus E is used ~~two~~ to separate two liquids which have different boiling temperatures and for oxidation we do not require separating.

**ResultsPlus**
**Examiner Comments**

Here the candidate understands the apparatus can be used to separate liquids with different boiling points but they have not explained why it is not suitable for complete oxidation so no mark is scored.

(ii) Give a **different** reason why apparatus **G** is also **not** suitable for the oxidation of butan-1-ol to butanoic acid.

**(1)**

No liebig condensor so all the butan-1-ol will evaporate / be lost.

**ResultsPlus**
**Examiner Comments**

The candidate correctly explains that a lack of condenser means reactants would evaporate and be lost so scores the mark.

(ii) Give a **different** reason why apparatus **G** is also **not** suitable for the oxidation of butan-1-ol to butanoic acid.

**(1)**

It doesn't have a condensur

**ResultsPlus**
**Examiner Comments**

Many candidates noted the importance of the condenser but did not appreciate how it prevented the loss of reactants and products. Simply saying the condenser was missing was a common answer that did not score.

## Question 3 (a)(iii)

This question was found to be very challenging. Although most candidates clearly knew that the water has to flow in from the bottom of the condenser, very few were able to explain concisely why. Many candidates simply described how a condenser worked or said that the cold water needs to flow against gravity.

(iii) Explain why, in apparatus **F**, the water should flow in from the bottom of the condenser.

**(2)**

This ensures that the condenser is completely filled ~~with~~ water ~~for~~ in order to efficiently and effectively cool the organic vapour.

**ResultsPlus**
**Examiner Comments**

This is a very good answer. The candidate states why the water should flow in from the bottom of the condenser and then explains how this improves the efficiency of the cooling process. Both marks scored.

(iii) Explain why, in apparatus **F**, the water should flow in from the bottom of the condenser.

**(2)**

For efficient cooling. It will convert the hot vapour to liquid.

If water flows in from the top, inefficient cooling will lead to volatile substances escaping For example, butan-1-ol. is volatile.

condensed

**ResultsPlus**
**Examiner Comments**

The candidate understands the importance of efficient cooling but does not mention that water flowing from the bottom of the condenser would ensure the condenser was full. One mark scored.

(iii) Explain why, in apparatus **F**, the water should flow in from the bottom of the condenser.

**(2)**

So That It will be able to condense the liquid after evaporation and return It back again for reaction.

**ResultsPlus**
**Examiner Comments**

This was a very common wrong response where the candidate has not answered the question but simply explained the purpose of the condenser. No marks scored.

**ResultsPlus**
**Examiner Tip**

As well as learning the names of the apparatus used for organic reactions, it is important to be able to explain why they are used.

## Question 3 (a)(iv)

The large majority of candidates knew that potassium dichromate was the oxidising agent but fewer candidates mentioned the need for acidification with a suitable acid. Although the oxidation number of the chromium was not required, if it was given it had to be correct and a small number of candidates lost the mark by giving potassium dichromate (VII), instead of (VI) as their answer.

(iv) State the reaction **mixture** that can be used to oxidise the butan-1-ol to butanoic acid.

**(1)**

$K_2Cr_2O_7$ in dilute sulphuric acid

**ResultsPlus**
**Examiner Comments**

This is an excellent answer where the candidate has given the correct formula of potassium dichromate and mentioned sulfuric acid so the mark is scored.

• So that all condensed. evaporates by the time it reaches end of condenser.

(iv) State the reaction **mixture** that can be used to oxidise the butan-1-ol to butanoic acid.

**(1)**

potassium dichromate (VI)

**ResultsPlus**
**Examiner Comments**

The candidate has correctly identified the oxidising agent, but the question asks for the reaction mixture which includes sulfuric acid. Both are required and so no mark is scored. This was a common response.

**ResultsPlus**
**Examiner Tip**

Only a single compound was given as the answer here, despite the word mixture being in bold in the question. Emboldened words are to help candidates inform their answer, so look out for them.

(iv) State the reaction **mixture** that can be used to oxidise the butan-1-ol to butanoic acid.

$(H_2SO_4)$ **(1)**

~~K₂Cr₂O₇~~ (Potassium dichromate (VII)). Sulphuric acid is also ~~SO₄~~ needed to be added.

**ResultsPlus**
**Examiner Comments**

The candidate has correctly identified the oxidising agent and the acid required. However, they have included the wrong oxidation number of the chromium and so the mark is negated. Nothing scored.

**ResultsPlus**
**Examiner Tip**

Read the question carefully and do not include unnecessary details, such as oxidation numbers, unless requested.

## Question 3 (a)(v)

The majority of candidates knew this colour change.

## Question 3 (b)(i)

This question was quite poorly answered by candidates. Mistakes included failing to state the sulfuric was concentrated and wrong reagents such as $PCl_5$ were also noted. However, the most common incorrect answer was 'ethanolic potassium hydroxide' which indicated candidates had confused this elimination reaction with the elimination of halogenoalkanes.

(b) Butan-1-ol can also form the alkene but-1-ene in an elimination reaction.

(i) Name a suitable chemical reagent to carry out this elimination reaction.

**(1)**

Concentrated phosphoric acid

**ResultsPlus**
**Examiner Comments**

Concentrated phosphoric acid or concentrated sulfuric are suitable reagents for this reaction and both were seen in similar numbers. Here the candidate has given the name but the formula would have scored too.

(b) Butan-1-ol can also form the alkene but-1-ene in an elimination reaction.

(i) Name a suitable chemical reagent to carry out this elimination reaction.

**(1)**

~~$PCl_5$~~ ~~KOH~~ ~~K~~ $H_2SO_4$

dehydrating agent to remove water

**ResultsPlus**
**Examiner Comments**

Although the candidate has given the correct reagent, they have omitted that the acid must be concentrated so no mark is scored.

(b) Butan-1-ol can also form the alkene but-1-ene in an elimination reaction.

(i) Name a suitable chemical reagent to carry out this elimination reaction.

**(1)**

concentrated phosphoric acid
or alcholic potassium hydroxidic

**ResultsPlus**
**Examiner Comments**

Although the candidate has given the correct reagent, concentrated phosphoric acid, they have also written alcoholic potassium hydroxide. Unfortunately, this second reagent is incorrect so they have negated their correct answer, so no mark is scored.

**ResultsPlus**
**Examiner Tip**

Remember that if more than one answer is given, they will all be marked and incorrect ones may negate correct answers.

(b) Butan-1-ol can also form the alkene but-1-ene in an elimination reaction.

(i) Name a suitable chemical reagent to carry out this elimination reaction.

**(1)**

~~pot~~ ethanolic potassium hydroxide

**ResultsPlus**
**Examiner Comments**

This was an extremely common incorrect answer. This candidate has focussed on the word elimination and given the reagents to produce an alkene from a halogenoalkane, not from the alcohol as was asked in the question.

**ResultsPlus**
**Examiner Tip**

Read the question carefully and ensure that you answer it, rather than a question that you may be more familiar with.

## Question 3 (b)(ii)

The majority of candidates identified a suitable reagent and gave the correct observations so scored both marks. Almost all the answers used bromine water as the test reagent, but bromine and acidified potassium permanganate were also occasionally seen.

(ii) Give a chemical test, including the expected result, to confirm the presence of the C═C double bond in but-1-ene.

**(2)**

Test with Bromine water, brown colour will turn colourless.

**ResultsPlus**
**Examiner Comments**

The candidate has given the correct reagent and noted the colour change so both marks are scored.

(ii) Give a chemical test, including the expected result, to confirm the presence of the C═C double bond in but-1-ene.

**(2)**

Use bromine liquid/ $Br_2(l)$ and it will decolourise the ~~liq~~ bromine liquid from brown to colourless.

**ResultsPlus**
**Examiner Comments**

Although seen less frequently, the use of bromine is an alternative answer so the candidate scores both marks as they have the correct colour change too.

(ii) Give a chemical test, including the expected result, to confirm the presence of the C=C double bond in but-1-ene.

(2)

-Using bromine water, when you add but-1-ene in Bromine water it decolorises it.

**ResultsPlus**
**Examiner Comments**

The candidate has given the correct reagent and although they have not stated the starting colour of the bromine water, just 'decolourises' is sufficient, so both marks are scored.

## Question 4 (a)(i)

Almost all candidates scored at least one mark here, but many responses highlighted a weakness in understanding of what an observation is. A number of candidates thought that effervescence, bubbling and fizzing were different observations. Others tried to use the chemical equation to answer the question but gave inadequate or confused responses – for instance, many candidates appreciated that the calcium hydroxide solution formed is limewater but then wrote about limewater going cloudy with $CO_2$. Others, seeing $H_2$ in the equation just stated that hydrogen gas was evolved, which is not an observation and therefore not creditworthy. A very small minority of candidates understood that calcium hydroxide is not very soluble and correctly stated a white solid would be observed.

(a) (i) State **two** observations when this reaction takes place.

(2)

Bubbling , and a white precipitate forms .

**ResultsPlus**
**Examiner Comments**

This is a very good answer that makes two observations and each one scores a mark.

(a) (i) State **two** observations when this reaction takes place.

(2)

- Effervescence of a colourless gas seen.
- A colourless solution is seen, and the solid dissolves and dissapears.

**ResultsPlus**
**Examiner Comments**

The candidate has made three observations. Fortunately, the second observation about the colourless solution is ignored and so they score a mark for noting the effervescence and the solid disappearing. Two marks scored.

(a) (i) State **two** observations when this reaction takes place.

**(2)**

Fizzing forms.

Effervescence of colourless gas forms.

**ResultsPlus**
**Examiner Comments**

The candidate has made the same observation twice by mentioning fizzing and effervescence. Only one mark is scored.

**ResultsPlus**
**Examiner Tip**

Candidates need to understand what constitutes an observation. A colourless gas such as hydrogen being formed is not an observation but bubbles being produced in the solution is.

## Question 4 (a)(ii)

This calculation was well understood and large numbers of totally correct, well-presented answers were seen. However, a number of candidates used the molar volume of 24 $dm^3$ in their calculation which restricted their score. Likewise, some candidates got confused and divided the moles by the volume which gave a nonsensical answer. Despite all the data having three significant figures, a number of candidates gave their final answer to four significant figures and so lost a mark. However, overall, this calculation was particularly well done and most candidates scored well.

(ii) Calculate the value for the molar volume of hydrogen under these conditions, using the student's results.

Give your answer to an appropriate number of significant figures and include units.

**(4)**

mass of calcium = 1.783 − 1.657

= 0.126 g

no of moles of calcium = $\frac{0.126}{40.1}$

= $3.14 \times 10^{-3}$

Ca : $H_2$

1 : 1

$3.14 \times 10^{-3}$ : $3.14 \times 10^{-3}$

molar volume of $H_2$ = $\frac{0.072}{3.14 \times 10^{-3}}$

= 22.9 $dm^3\ mol^{-1}$

**ResultsPlus**
**Examiner Comments**

This is a very good answer. The calculation is set out clearly, the answer is to 3 significant figures and the units are correct. All four marks scored.

(ii) Calculate the value for the molar volume of hydrogen under these conditions, using the student's results.

$\frac{\text{Volume.}}{\text{mol.}}$

Give your answer to an appropriate number of significant figures and include units.

**(4)**

~~mol of Ca:~~ $1.783 - 1.657 = 0.126g.$

mole of Ca: $\frac{0.126g}{40.1} = 3.1421446 \times 10^{-3}$ mol

$$\text{Molar volume of } H_2 = \frac{\text{volume}}{\text{mole.}} = \frac{72\ cm^3}{3.1421446 \times 10^{-3}\ mol.} = \cancel{22914}\ 22900\ \cancel{23000\ cm^3mol^{-1}}$$

$$= 22900\ cm^3\ mol^{-1}$$

**ResultsPlus**
**Examiner Comments**

This is another very good answer. The calculation is set out clearly and the candidate has used $cm^3$ instead of $dm^3$ and given their final answer to 3 significant figures. All four marks scored.

(ii) Calculate the value for the molar volume of hydrogen under these conditions, using the student's results.

Give your answer to an appropriate number of significant figures and include units.

**(4)**

Mass of Ca = 1.783 − 1.657 = 0.126g

$nCa = \frac{0.126}{40.1} = 3.142 \times 10^{-3}$ mol

$nH = 3.142 \times 10^{-3}$ mol

$\frac{72}{3.142 \times 10^{-3}} = 22914.3\ cm^3 mol^{-1}$

**ResultsPlus**
**Examiner Comments**

The calculation and units are fully correct but unfortunately the final answer has 4 significant figures so a mark is lost. Three marks scored.

**ResultsPlus**
**Examiner Tip**

Candidates should be aware of the importance of using the correct number of significant figures in their final answer.

(ii) Calculate the value for the molar volume of hydrogen under these conditions, using the student's results.

Give your answer to an appropriate number of significant figures and include units.

**(4)**

Mass of Ca

= 1.783 − 1.657

= 0.126 g

mols = $\frac{0.126}{40.1}$

= 0.00314 mol

72 cm$^3$ → 72000 dm$^3$

72000 × 0.00314 = 226.08 ≈ 226 dm$^3$ mol$^{-1}$

ResultsPlus
Examiner Comments

The candidate makes a good start by calculating the mass and number of moles of calcium, but they are then confused with what to do with these numbers. Instead of dividing the volume by the moles to calculate the molar volume, they multiply them together. Two marks scored.

## Question 4 (b)(i)

This straightforward percentage error calculation scored quite well. The most common mistakes were using the wrong denominator or incorrectly rounding the final answer.

(b) A second student using this method obtained a value of 21.8 $dm^3 mol^{-1}$ for the molar volume of hydrogen.

(i) Calculate the percentage error in this student's value.
The data book value for the molar volume of hydrogen under these conditions is 23.9 $dm^3 mol^{-1}$.

**(1)**

percentage error $= \frac{23.9 - 21.8}{23.9} = 8.79\%$

**ResultsPlus**
**Examiner Comments**

This is the correct calculation and the answer has been rounded properly. The mark is scored.

(b) A second student using this method obtained a value of 21.8 $dm^3 mol^{-1}$ for the molar volume of hydrogen.

(i) Calculate the percentage error in this student's value.
The data book value for the molar volume of hydrogen under these conditions is 23.9 $dm^3 mol^{-1}$.

**(1)**

percentage error $= \frac{(23.9 - 21.8)}{23.9} \times 100$

$= 8.78\%$

**ResultsPlus**
**Examiner Comments**

This is a correct calculation but the candidate has rounded the answer wrongly and so the mark is not scored. This was quite a common mistake.

(b) A second student using this method obtained a value of 21.8 $dm^3 mol^{-1}$ for the molar volume of hydrogen.

(i) Calculate the percentage error in this student's value.
The data book value for the molar volume of hydrogen under these conditions is 23.9 $dm^3 mol^{-1}$.

**(1)**

$$= \frac{23.9 - 21.8}{21.8} \times 100$$

$$= 9.63\%$$

**ResultsPlus**
**Examiner Comments**

The calculation is incorrect as the denominator is wrong and this was another common error. No mark scored.

**ResultsPlus**
**Examiner Tip**

Practise percentage error calculations and pay attention to how the final answer is rounded.

## Question 4 (b)(ii)

This question proved to be very challenging for the majority of candidates. Despite the wording of the question many candidates suggested the difference was due to apparatus or operator errors or non-standard conditions. Likewise, a significant number of responses were too vague to score marks with answers such as gas escapes or reaction was incomplete. On the other hand, there were some excellent explanations of gas loss before the bung was placed on the flask and a few candidates understood that as calcium is a reactive metal, it may have already slightly reacted before being used. Other candidates suggested that not all the calcium had reacted which also scored a mark.

(ii) Give **two** possible reasons why this student obtained a value below the data book value.
Assume the method was followed correctly and there were no measurement errors.

(2)

Calcium ~~hydroxide~~ may contain impurities and ~~may~~
~~& calcium~~ & calcium may not be fully reacted

**ResultsPlus**
**Examiner Comments**

This candidate scored the same scoring point twice by observing that the calcium may be impure and it may not all react. One mark scored.

(ii) Give **two** possible reasons why this student obtained a value below the data book value.
Assume the method was followed correctly and there were no measurement errors.

(2)

calcium and water didn't react completely.

there was a delay in connecting the gas syringe.

gas escaped from the bung if its was not properly fixed to the conical flask.

ResultsPlus
Examiner Comments

A mark is scored for the comment about the calcium not reacting with the water completely and a second mark for noting the delay when connecting the gas syringe. The point about the bung not fitting properly was ignored. Two marks scored.

(ii) Give **two** possible reasons why this student obtained a value below the data book value.
Assume the method was followed correctly and there were no measurement errors.

**(2)**

They might have not perfomed the experiment under standard conditions (100KPa, 298K). The equipment might (gas syringe, or weighing boat) ~~had~~ have a manufactural errors.

ResultsPlus
Examiner Comments

This illustrates a common error where, despite the information in the question, the candidate has mentioned non-standard conditions and equipment errors. No marks scored.

ResultsPlus
Examiner Tip

When commenting on why an experiment does not give expected results avoid generic statements. Instead read the question carefully and make suggestions specific to the practical being carried out.

## Question 4 (c)(i)

The colour change was correctly known by the majority of candidates. However, a few reversed the colours and some candidates did not understand the end point colour was orange, not red.

## Question 4 (c)(ii-iii)

Calculation errors were extremely rare in Q04(c)(ii) and most candidates were able to correctly identify the concordant results and so scored both marks. However, it was quite common to see a third or occasionally all four titrations used to calculate the mean, resulting in only one mark being awarded.

The standard titration question in Q04(c)(iii) was very well done and the majority of candidates demonstrated clear working for each step of the calculation with many scoring full marks. However, a number of candidates failed to score the last mark as they left their answer in mol $dm^{-3}$ instead of g $dm^{-3}$. Rather surprisingly, a small minority of candidates did not appreciate they had to use the mean titration from Q04(c)(ii) and used 25 $cm^3$ instead. Fortunately, this mistake allowed access to the rest of the calculation marks.

(c) A third student carried out an experiment to determine the concentration of a saturated solution of calcium hydroxide, $Ca(OH)_2$, in water at room temperature.

$25.0\,cm^3$ of a saturated solution of calcium hydroxide was pipetted into a conical flask. Three drops of methyl orange indicator were added and the solution was titrated with $0.0400\,mol\,dm^{-3}$ hydrochloric acid.

The procedure was repeated until concordant titres were obtained.

The results are shown in the table.

| Titration | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Final burette reading / $cm^3$ | 26.85 | 31.25 | 34.55 | 27.15 |
| Initial burette reading / $cm^3$ | 0.00 | 5.00 | 8.00 | 1.00 |
| Titre / $cm^3$ | 26.85 | 26.25 | 26.55 | 26.15 |
| Concordant results (✓) | ✓ | ✓ | ✓ | ✓ |

(i) State the colour change observed in the conical flask at the end-point of the titration.

**(2)**

From orange to yellow

(ii) Complete the table and use the concordant results to calculate the mean titre.

**(2)**

$$\frac{26.85 + 26.25 + 26.55 + 26.15}{4} = \boxed{26.45}$$

ResultsPlus
Examiner Comments

The candidate has filled in the titre results correctly, but wrongly chosen all 4 as being concordant. Their mean titre calculation is correct so one mark is scored.

(c) A third student carried out an experiment to determine the concentration of a saturated solution of calcium hydroxide, $Ca(OH)_2$, in water at room temperature.

$25.0\,cm^3$ of a saturated solution of calcium hydroxide was pipetted into a conical flask. Three drops of methyl orange indicator were added and the solution was titrated with $0.0400\,mol\,dm^{-3}$ hydrochloric acid.

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| Initial burette reading / $cm^3$ | 0.00 | 5.00 | 8.00 | 1.00 |
| Titre / $cm^3$ | 26.85 | 26.25 | 26.55 | 26.15 |
| Concordant results (✓) | | ✓ | | ✓ |

(i) State the colour change observed in the conical flask at the end-point of the titration.

**(2)**

From Yellow to Orange

(ii) Complete the table and use the concordant results to calculate the mean titre.

**(2)**

$$\frac{26.25 + 26.15}{2} = 26.20\ cm^3$$

(iii) The reaction taking place in this titration is

$$Ca(OH)_2(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$$

Calculate the concentration of the calcium hydroxide solution in $g\,dm^{-3}$.

**(4)**

Moles of HCl = 0.0262 × 0.04 = 0.001048 mol

Moles of $Ca(OH)_2$ = $\frac{0.001048}{2}$ = 0.000524 mol

Mass of $Ca(OH)_2$ = 0.000524 × 74.1

= 0.0388 g

Concentration of $Ca(OH)_2$ = $\frac{0.0388}{0.025}$ = 1.55 g/dm$^{-3}$

**ResultsPlus**
**Examiner Comments**

This is a very good answer. The correct concordant results are identified and the mean calculated in Q04 (c)(ii) so both marks are scored. In Q04 (c)(iii) the calculation is clearly set out and correct so four marks are awarded.

(iii) The reaction taking place in this titration is

$$Ca(OH)_2(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$$

Calculate the concentration of the calcium hydroxide solution in g dm$^{-3}$.

**(4)**

$\frac{n}{c \mid v}$ $\quad V = 26.2$

$\text{conc}_{HCl} = 0.400 \text{ mol dm}^{-3}$

$c = \frac{n}{v}$ $\quad V_{Ca(OH)_2} = 25$

$n_{(HCl)} = (0.400)(26.2 \times 10^{-3}) = \cancel{0.01} \; 0.01048 \text{ mol}$

1 : 2

x $\quad$ 0.01048

$x = 5.24 \times 10^{-3}$

$\frac{n}{c \mid v}$ $\quad c = \frac{5.24 \times 10^{-3}}{25 \times 10^{-3}} = 0.2096$

$\approx 0.210 \text{ mol dm}^{-3}$

**ResultsPlus**
**Examiner Comments**

The candidate has correctly calculated the moles of hydrochloric acid, the moles of sodium hydroxide and the concentration of sodium hydroxide in mol dm$^{-3}$.

However, they have omitted the last step and not converted the concentration to g dm$^{-3}$. This was quite a common error and so three marks are scored.

## Question 4 (d)

Rather fittingly, this last question was the most challenging on the paper and proved to be a good discriminator. Many candidates clearly understood the effect of temperature on equilibrium but often failed to gain any marks by not relating this to the precipitation of calcium hydroxide. Common wrong ideas included the formation of calcium oxide by thermal decomposition and references to water evaporating as the temperature increased. Despite being told dissolving was an exothermic reaction, a number of candidates also thought that solubility would increase with increasing temperature.

(d) Dissolving calcium hydroxide in water is an exothermic process.

Describe what you would see if the saturated solution of calcium hydroxide was heated from room temperature to 50 °C.
Justify your answer.

**(2)**

There are white precipitate appear, because its forward reactions is ~~a~~ exothermic, so as temperature high, the equilibrium shift to left, so more solid $Ca(OH)_2$ produced.

**ResultsPlus**
**Examiner Comments**

In this excellent answer the candidate explains why the equilibrium shifts to the left-hand side resulting in more white calcium hydroxide coming out of solution. Both marks awarded.

(d) Dissolving calcium hydroxide in water is an exothermic process.

Describe what you would see if the saturated solution of calcium hydroxide was heated from room temperature to 50 °C.
Justify your answer.

**(2)**

Some of the solution would evaporate and ~~a little~~ ~~amount of~~ ~~cry~~ ~~solid Na would be~~ small amount of a white solid will begin to form at the bottom. This is because heating may cause decomposition to take ~~place~~ place

ResultsPlus
Examiner Comments

Despite the temperature only being raised to 50$^{o}$ C, this candidate thought the water would evaporate resulting in a white solid being formed. There was no reference to the movement of the equilibrium so no marks were scored. This was a common wrong answer.

## Paper Summary

Based on their performance on this paper, candidates should:

- Always read the information in the question carefully, noting any instructions in bold type.
- Make sure they learn and understand the procedures in the core practicals.
- Understand the reason for choosing and using a particular piece of apparatus and understand how it works.
- Not give a generic response to practical questions.
- Learn the qualitative tests to identify organic groups and inorganic ions.
- Show working when carrying out calculations and think carefully about units, significant figures and rounding.

## Grade boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:

https://qualifications.pearson.com/en/support/support-topics/results-certification/grade-boundaries.html

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