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June 2018

IAL Chemistry WCH03 01

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Introduction

This paper proved accessible to most candidates and provided them the opportunity to demonstrate their knowledge and understanding of the practical skills they have developed during the IAS course. There was very little evidence of candidates having insufficient time to complete the paper.

Successful candidates:

- read the questions carefully and answered the questions as they were set
- were familiar with standard practical techniques used in a laboratory and understood the reasons for using those techniques
- were able to use observations from tests to identify inorganic and organic substances
- were able to draw apparatus
- were able to describe experiments
- were able to interpret results of experiments and evaluate them.

Some answers were of a lower standard. Less successful candidates:

- did not read the questions carefully and did not use the information they were given
- repeated information from the questions unnecessarily
- were not familiar with school laboratory apparatus and standard practical techniques.

Question 1 (a)

The majority of candidates made a good attempt at this question and many responses with full marks were seen. Common errors included: identifying magnesium as one of the cations as they did not appreciate that magnesium sulfate is soluble in water, giving incorrect charges on one or more of the ions (usually giving a 2 minus charge on the nitrate ion) and identifying the anion as an oxide. The majority of candidates could identify gas D as oxygen but fewer recognised the brown gas as nitrogen dioxide. The question asked candidates to name a test to distinguish between the cations so just 'flame test' was sufficient. Many candidates ignored this instruction and spent time describing how to carry out a flame test. The majority of candidates knew the flame test colours for the Group 2 cations but a few who included magnesium wrote that it gave a white flame. A few candidates did not read the question and suggested one or two Group 1 cations. Only a very small minority of candidates confused the terms anion and cation.

1 The inorganic compounds **A** and **B** contain the same Group 2 cation but different anions.

(a) Two tests were carried out on **A**. The observations made for each test are recorded in the table.

(i) Complete the statements in the inference column in the table by writing the names or formulae of the ions.

(3)

Test	Observation	Inference
Dilute sulfuric acid was added to an aqueous solution of **A**	A white precipitate formed	Two possible **cations** in **A** are Mg^{2+} Ba^{2+}
A sample of **A** was heated in a test tube A glowing splint was held in the mouth of the test tube	A brown gas was evolved The splint relit	The **anion** in **A** is O^{2-}

(ii) There were two gases evolved when **A** was heated; a brown gas **C**, and a gas **D** which relit the glowing splint.
Identify the gases **C** and **D** by giving their name or formula.

(2)

Gas **C** Nitrogen Oxide.

Gas **D** Oxygen.

(iii) Name a test that could be used to distinguish between the two cations identified in (a)(i).
Include the expected result of the test for **both** cations.

(3)

- We can use flame test to distinguish the both cations.
- Magnesium ~~flame~~ would give colourless flame.
- Barium would give apple-green flame.

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Examiner Comments

(i) This scored 1 mark for barium. Mg^{2+} is incorrect as magnesium sulfate is soluble in water so would not give a white precipitate. The oxide ion is incorrect as a metal oxide would not give a brown gas when heated.

(ii) 1 mark was awarded for oxygen. The brown gas is nitrogen dioxide so no mark is awarded for nitrogen oxide.

(iii) This scored 3 marks. The magnesium ion was penalised in (i) so a mark was given here for the idea that magnesium does not give a coloured flame in a flame test.

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Examiner Tip

Learn the trend in solubility of Group 2 sulfates.

1 The inorganic compounds **A** and **B** contain the same Group 2 cation but different anions.

(a) Two tests were carried out on **A**. The observations made for each test are recorded in the table.

(i) Complete the statements in the inference column in the table by writing the names or formulae of the ions.

(3)

Test	Observation	Inference
Dilute sulfuric acid was added to an aqueous solution of **A**	A white precipitate formed	Two possible **cations** in **A** are Na^+ [redacted] K^+
A sample of **A** was heated in a test tube A glowing splint was held in the mouth of the test tube	A brown gas was evolved The splint relit	The **anion** in **A** is [redacted] NO_3^-

(ii) There were two gases evolved when **A** was heated; a brown gas **C**, and a gas **D** which relit the glowing splint.
Identify the gases **C** and **D** by giving their name or formula.

(2)

Gas **C** [redacted] Nitrogen dioxide

Gas **D** Oxygen

(iii) Name a test that could be used to distinguish between the two cations identified in (a)(i).
Include the expected result of the test for **both** cations.

(3)

Flame test:

[redacted]

Result with Na^+: Yellow flame

Result with [redacted] K^+: Lilac flame

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Examiner Comments

(i) This scored 1 mark for the correct formula of a nitrate ion. Sodium and potassium are not in Group 2 so no marks are awarded for the cations.

(ii) Both gases are correct so 2 marks were awarded.

(iii) 1 mark was awarded for the flame test. No marks can be awarded for cations from the wrong group in the Periodic Table.

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Examiner Tip

Read the question carefully. The first line states clearly that the cations are in Group 2 so you will not receive any credit if you give cations from any other group.

Question 1 (b)

Many candidates were familiar with the reaction between a metal bromide and concentrated sulfuric acid and many answers with full marks were seen. A few candidates gave the name instead of the formula for bromide ions. Some candidates thought that the orange-brown gas was nitrogen dioxide. A few candidates confused the halides and even if they identified a bromide in (i), they wrote hydrogen chloride as one of the other gases. Hydrogen sulfide was sometimes given as the other acidic gas in (iv) but candidates should know that this is only produced when an iodide reacts with concentrated sulfuric acid.

(b) A test was carried out on **B**. The observations made for the test are recorded in the table.

(i) Complete the statement in the inference column in the table by writing the **formula** of the anion.

(1)

Test	Observation	Inference
Concentrated sulfuric acid was added to a sample of solid **B** in a test tube	An orange-brown gas **E** was evolved	The **formula** of the anion in **B** is Bromide

(ii) Identify the orange-brown gas **E** by giving its name or formula.

(1)

Gas **E** is Bromine.

(iii) Two colourless acidic gases were also evolved in the test in (b)(i).

These gases were dissolved in water.
Aqueous silver nitrate and dilute nitric acid were added to the solution and a cream precipitate formed.

Give the name or formula of the gas identified by this method.

(1)

Silver bromide.

(iv) Suggest the identity of the other acidic gas by giving its name or formula.

(1)

SO_2

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Examiner Comments

(i) A bromide is present in **B** but the question asks for the formula of the anion so no mark was awarded.

(ii) Bromine is correct for 1 mark.

(iii) Silver bromide is the cream precipitate that formed so this scored 0.

(iv) Sulfur dioxide is correct for 1 mark.

ResultsPlus
Examiner Tip

Read the question carefully when you are identifying species. Sometimes you are asked for a name, sometimes a formula and sometimes you can give either name or formula.

(b) A test was carried out on **B**. The observations made for the test are recorded in the table.

(i) Complete the statement in the inference column in the table by writing the **formula** of the anion.

(1)

Test	Observation	Inference
Concentrated sulfuric acid was added to a sample of solid **B** in a test tube	An orange-brown gas **E** was evolved	The **formula** of the anion in **B** is Br^-

(ii) Identify the orange-brown gas **E** by giving its name or formula.

(1)

Gas **E** is Br_2

(iii) Two colourless acidic gases were also evolved in the test in (b)(i).

These gases were dissolved in water.
Aqueous silver nitrate and dilute nitric acid were added to the solution and a cream precipitate formed.

Give the name or formula of the gas identified by this method.

(1)

$HBr_{(g)}$

(iv) Suggest the identity of the other acidic gas by giving its name or formula.

(1)

~~SO_2~~ $H_2S_{(g)}$

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Examiner Comments

(i), (ii) and (iii) are all correct and scored 1 mark each.

(iv) Hydrogen sulfide is formed when concentrated sulfuric acid is added to an iodide so this scored 0. Sulfur dioxide is the other acidic gas formed when concentrated sulfuric acid is added to a bromide.

ResultsPlus
Examiner Tip

Revise the reactions between concentrated sulfuric acid and metal halides.

Question 2 (a) (i)

The majority of candidates were able to identify the functional group as an alcohol using one of the acceptable answers in the mark scheme. A small minority lost the mark as they thought it was an ion. Some students incorrectly identified the functional group as a carboxylic acid as they missed the information in the question that showed there was only one oxygen atom in a molecule.

2 This question is about an organic compound **X**.

Information about compound X

Molecular formula: $C_4H_{10}O$

Test 1

Phosphorus(V) chloride was added to **X**.
Steamy fumes were formed.

(a) (i) Use all the information about **X** to identify the type of functional group present in **X**.

(1)

OH⁻ group

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Examiner Comments

This response scored 0 as the candidate has given the formula of a hydroxide **ion**.

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Examiner Tip

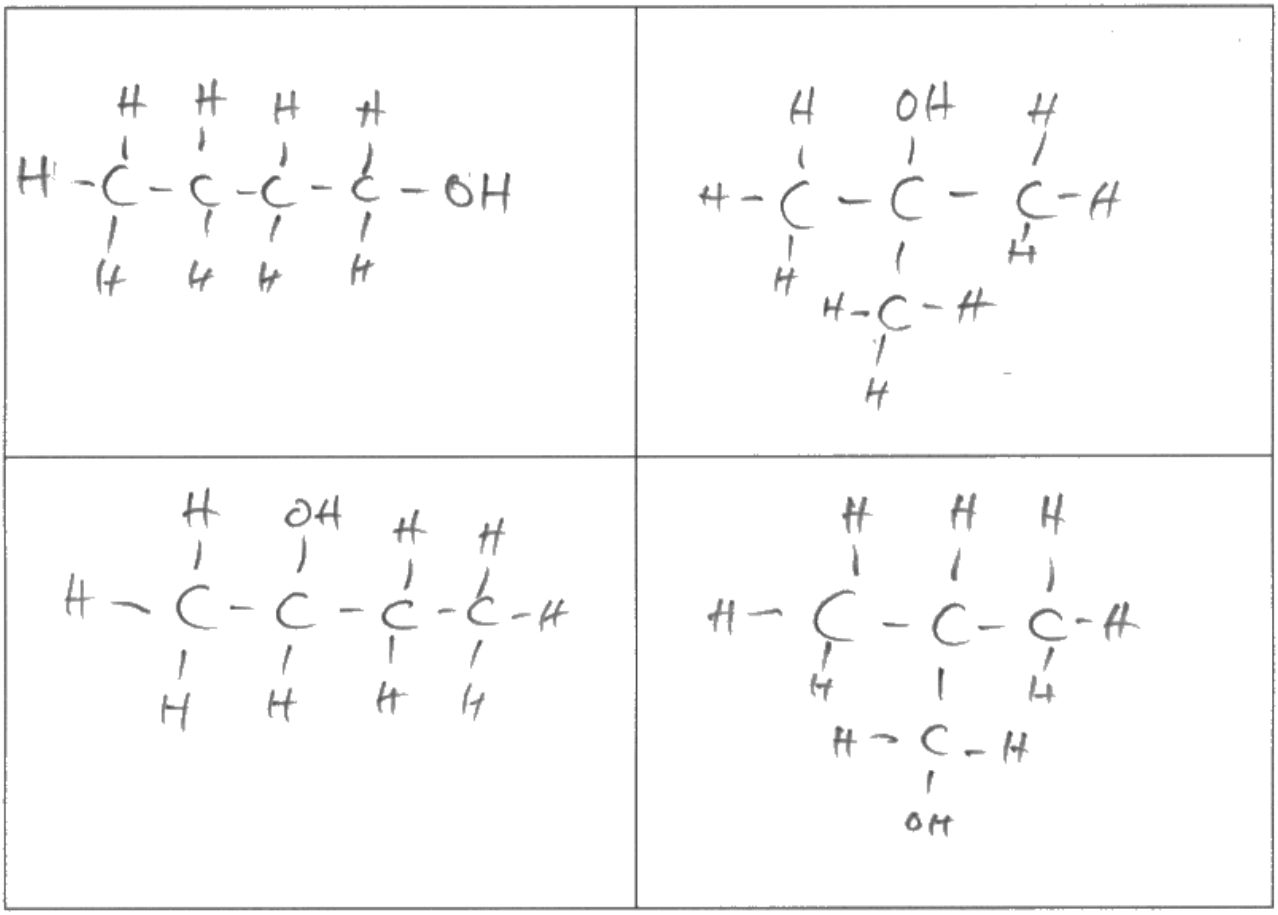
Be careful how you identify functional groups. It may be safer to write the name alcohol here as showing a charge on OH.

Question 2 (a) (ii) - (d) (i)

Many candidates made a good attempt at these questions. Some candidates lost a mark in (a)(ii) because they wrote the same alcohol down more than once as they forgot that the single C-C bond can be rotated. A small number used incorrect numbers of carbon atoms. It was acceptable to give structural, displayed or skeletal formulae but candidates using displayed formulae made fewer errors. Some candidates were showing that they did not understand the bonding in the alcohols by writing OH-C, with the hydrogen linked to the carbon instead of oxygen linked to carbon. The majority of candidates realised that X was a tertiary alcohol, although a few ketones and carboxylic acids were seen. A few candidates thought that 2-methylpropan-1-ol was a tertiary alcohol. Candidates found writing the equation for the reaction between X and phosphorus (V) chloride to be challenging and many incorrect products and unbalanced equations were seen. $C_4H_{10}Cl$ was a common incorrect formula of the organic product.

(ii) Draw the four possible structural isomers of **X**.
Use your answer to (a)(i) and the molecular formula of **X**.

(4)



(b) Another test was carried out on **X**.

Test 2

A few drops of acidified potassium dichromate(VI) solution were added to **X** and the mixture was heated.
The mixture stayed orange.

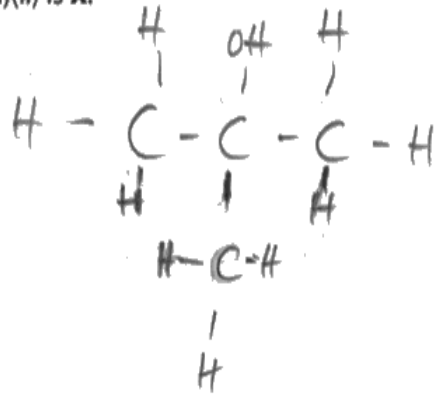
Use the result of **Test 2** to further classify the functional group present in **X**.

(1)

Tertiary Alcohol

(c) Use your answer to (b) to identify which of the four isomers of $C_4H_{10}O$ you have drawn in (a)(ii) is **X**.

(1)



2methylbuten-2-ol

(d) (i) Write the equation for the reaction between **X** and phosphorus(V) chloride. State symbols are not required.

(1)

$C_4H_9OH + PCl_5 \rightarrow POCl_3 + HCl + C_4H_9Cl$

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Examiner Comments

(a)(ii) Correct for 4 marks.

(b) Correct for 1 mark.

(c) The displayed formula of the tertiary alcohol is correct but the candidate has given an incorrect name, so no mark awarded.

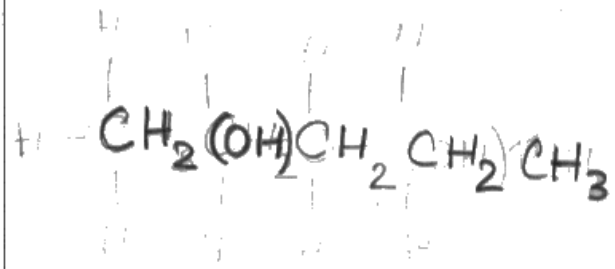
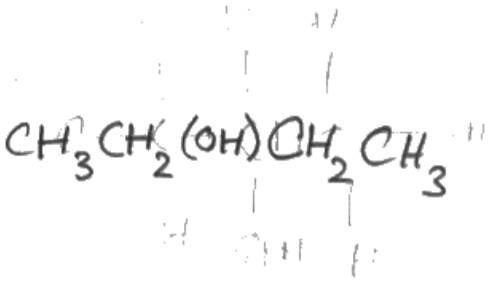
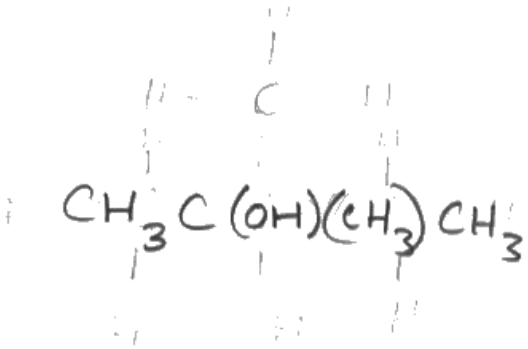
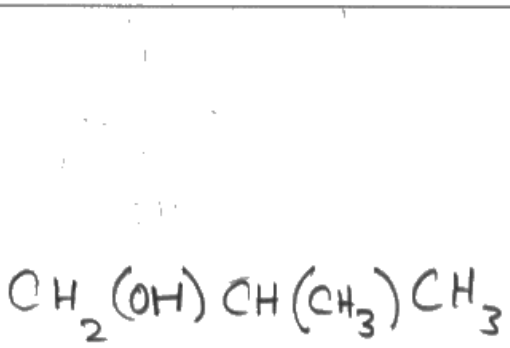
(d)(i) Correct equation for 1 mark.

ResultsPlus
Examiner Tip

If you give a name and formula, both must be correct to score the mark.

(ii) Draw the four possible structural isomers of **X**.
Use your answer to (a)(i) and the molecular formula of **X**.

(4)

(b) Another test was carried out on **X**.

Test 2

A few drops of acidified potassium dichromate(VI) solution were added to **X** and the mixture was heated.
The mixture stayed orange.

Use the result of **Test 2** to further classify the functional group present in **X**.

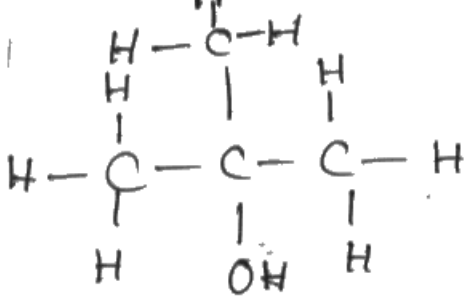
(1)

It is a tertiary alcohol

(c) Use your answer to (b) to identify which of the four isomers of $C_4H_{10}O$ you have drawn in (a)(ii) is **X**.

(1)

~~$CH_3C(OH)CH_2CH_3$~~



(d) (i) Write the equation for the reaction between **X** and phosphorus(V) chloride. State symbols are not required.

(1)

$C_4H_{10}O + PCl_5 \longrightarrow C_4$

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Examiner Comments

(a)(ii) This candidate has chosen to give structural formulae for the four alcohols. This is acceptable, however, the structure in the top right box is incorrect so no mark is awarded for that alcohol and 3 marks awarded overall.

(b) Correct for 1 mark.

(c) Correct for 1 mark.

(d)(i) Incomplete equation so no mark awarded.

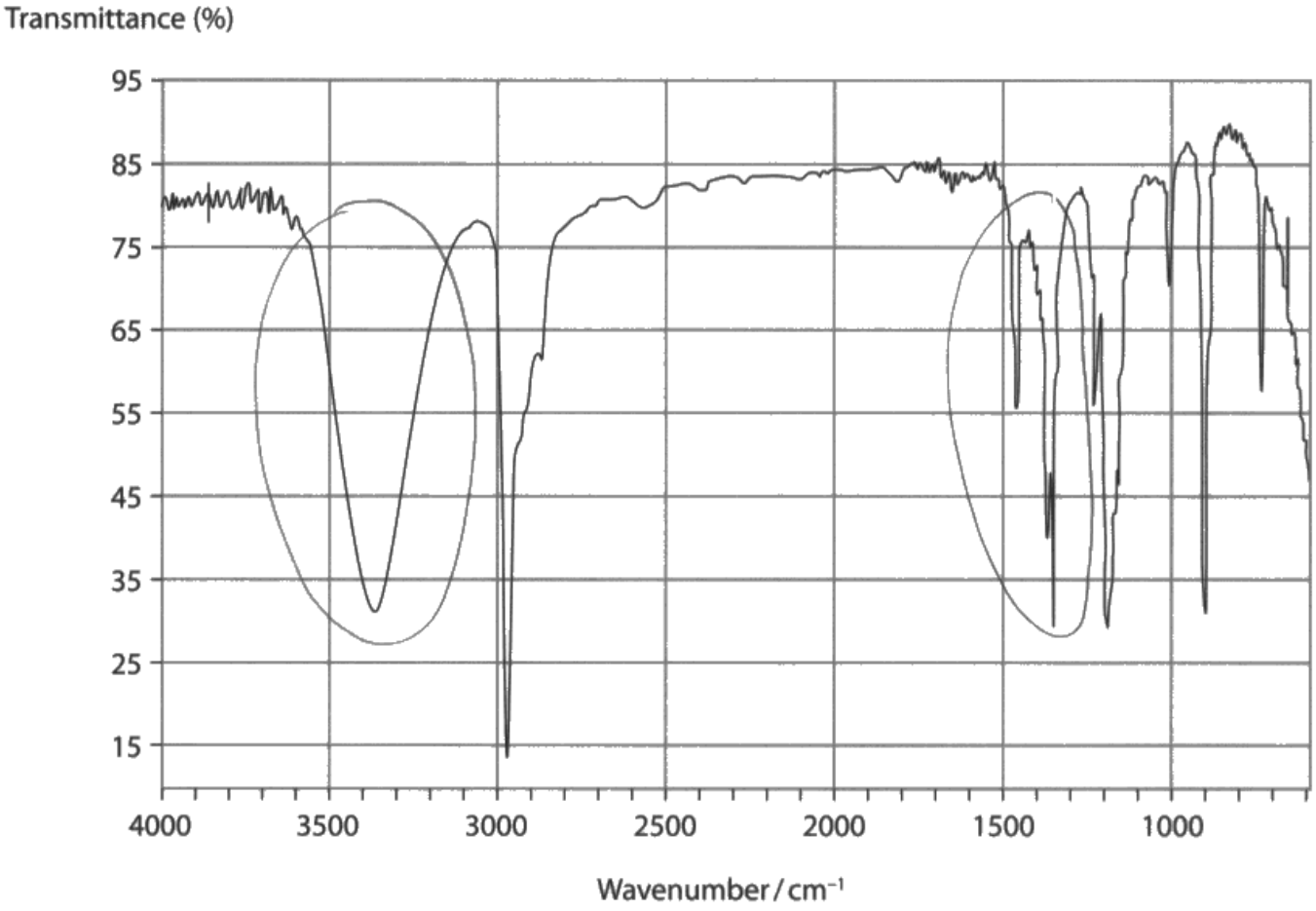
ResultsPlus
Examiner Tip

It is very easy to make a mistake by writing too many or too few hydrogen atoms in structural formulae. You are less likely to make a mistake if you use displayed formulae. However, be careful, if you give displayed and structural formulae, both must be correct.

Question 2 (d) (ii)

The majority of candidates were able to circle the absorbance corresponding to the O-H bond. A few candidates circled other absorbances instead of, or as well as, the correct answer and received no credit. A small minority of candidates seemed unfamiliar with infrared spectra and thought that the absorbances went up instead of down.

(ii) The infrared spectrum of **X** is shown.



Some data about infrared spectra are given in the table.

Group	Bond	Wavenumber / cm^{-1}
alkane	C–H stretch	2962–2853
alkane	C–H bend	1485–1365
alcohol	O–H stretch	3750–3200

Circle the peak on the spectrum that will **not** be present in the infrared spectrum of the **organic product** of the reaction between **X** and phosphorus(V) chloride.

(1)

haloalkane

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Examiner Comments

This candidate has circled the correct absorbance for an O-H bond, however, this response scored 0. The candidate has also circled another group of absorbances which is incorrect and this negated the mark.

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Examiner Tip

If you give additional incorrect answers you will not receive the mark for the correct answer.

Question 3 (a) (i)

Nearly all candidates were familiar with carrying out a titration. This question produced answers with the full range of marks but some gave a limited amount of detail in their answers. Common errors included: an incorrect colour change for the indicator; adding the indicator after the end point has been reached; not using a pipette to measure the sodium hydroxide; placing the sodium hydroxide in a volumetric flask instead of a conical flask or beaker; rinsing the flask with sodium hydroxide; not swirling the flask as the acid was added, and not adding the acid dropwise near the end point. There were four other technique points that could have scored a mark, such as using a white tile to make it easier to see the colour change of the indicator, but many candidates did not include any of these. Some candidates spent time describing how to rinse and fill the burette, even though the question told them that it was set up ready to use. Some candidates described how to make up a standard solution of sodium hydroxide, which was not necessary in this question. A small number of candidates used the wrong indicator and a few placed sodium hydroxide in the burette. Candidates should be encouraged to read all of the information in the question and to use it in their answer. They should be discouraged from repeating information given in the question. A few candidates described a thermometric titration, although they received credit for the points that overlapped with this question.

3 This question is about the preparation of crystals of hydrated sodium sulfate.

(a) You are provided with the following apparatus and materials to prepare a solution of sodium sulfate from sulfuric acid and aqueous sodium hydroxide:

- a burette, ready to use, filled with dilute sulfuric acid to the 0.00 cm^3 line
- an aqueous solution of sodium hydroxide
- methyl orange indicator
- access to other laboratory volumetric apparatus.

The equation for the reaction is

$$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

(i) A preliminary (rough) titration shows that about 18 cm^3 of sulfuric acid is required to react with 25.0 cm^3 of the aqueous sodium hydroxide.

Describe how you would carry out a second titration to find the accurate volume of sulfuric acid that reacts with 25.0 cm^3 of the aqueous sodium hydroxide.

In your answer, you should include the colour change of the indicator at the end-point.

(5)

- you would fill the burette with sulphuric acid
- and clamp it to a clamp stand
- fill the conical flask with 25.0 cm^3 of sodium hydroxide (aq)
- The add a few drops of methyl orange indicator.
- Add the sulphuric acid drop by drop, until the solution decolourises it.

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Examiner Comments

This candidate has the right idea about a titration experiment but only 1 mark was awarded for adding the acid drop by drop.

ResultsPlus
Examiner Tip

There is no need to repeat information given in the question.

The question stated that the burette was ready to use so the first three lines of the answer were not needed.

3 This question is about the preparation of crystals of hydrated sodium sulfate.

(a) You are provided with the following apparatus and materials to prepare a solution of sodium sulfate from sulfuric acid and aqueous sodium hydroxide:

- a burette, ready to use, filled with dilute sulfuric acid to the 0.00 cm^3 line
- an aqueous solution of sodium hydroxide
- methyl orange indicator
- access to other laboratory volumetric apparatus.

The equation for the reaction is

$$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

(i) A preliminary (rough) titration shows that about 18 cm^3 of sulfuric acid is required to react with 25.0 cm^3 of the aqueous sodium hydroxide.

Describe how you would carry out a second titration to find the accurate volume of sulfuric acid that reacts with 25.0 cm^3 of the aqueous sodium hydroxide.

In your answer, you should include the colour change of the indicator at the end-point.

(5)

Using the burette around 17 cm^3 of H_2SO_4 is added and drop by drop more H_2SO_4 is added until a colour change occurs, from yellow to ~~red~~ orange. The inital value must be recorded and must be subtracted from the new reading on the burette to get the second titre value.

ResultsPlus
Examiner Comments

This response has some correct techniques and scored 3 marks.

The candidate has scored marks for adding the sulfuric acid to the sodium hydroxide until about 17 cm^3 has been added, then adding the acid drop by drop and the correct colour change of the indicator.

ResultsPlus
Examiner Tip

Try to include all the practical details when you are describing an experiment.

3 This question is about the preparation of crystals of hydrated sodium sulfate.

(a) You are provided with the following apparatus and materials to prepare a solution of sodium sulfate from sulfuric acid and aqueous sodium hydroxide:

- a burette, ready to use, filled with dilute sulfuric acid to the 0.00 cm^3 line
- an aqueous solution of sodium hydroxide
- methyl orange indicator acid - yellow
- access to other laboratory volumetric apparatus.

The equation for the reaction is

$$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

(i) A preliminary (rough) titration shows that about 18 cm^3 of sulfuric acid is required to react with 25.0 cm^3 of the aqueous sodium hydroxide.

Describe how you would carry out a second titration to find the accurate volume of sulfuric acid that reacts with 25.0 cm^3 of the aqueous sodium hydroxide.

In your answer, you should include the colour change of the indicator at the end-point.

(5)

- Obtain the burette, filled with dilute sulfuric acid to the 0.00 cm^3 line.
- To a conical flask add 25cm^3 of aqueous sodium hydroxide using a pipette.
- ~~Place~~ Add 5 drops of methyl orange to the sodium hydroxide.
- Place the conical flask on a white tile and then place the burette attached to a clamp stand over the conical flask.
- Start titration by adding the dilute sulfuric acid dropwise. Keep swirling the conical flask to mix it's contents and observe any colourchange.
- When nearing 18cm^3 of sulfuric acid [eg: 16cm^3] start to add the sulfuric acid from the burette dropwise. This way a more accurate volume of sulfuric acid can be obtained [which ~~changes~~ changes the colour of NaOH]
- The ~~colour~~ change in the indicator at the end of the reaction will be from ~~Orange to~~ Red to Orange.

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Examiner Comments

This is an example of a very good description of the titration experiment that scored 4 marks. The only error is the colour change of the indicator at the end point.

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Examiner Tip

Learn the colour changes for methyl orange and phenolphthalein and always check whether the acid or the alkali is in the flask as this will affect the starting colour.

Question 3 (a) (ii) - (iii)

The majority of candidates were able to calculate the correct mean titre using the concordant results, however a significant minority included the result for Titration 1, even though it was more than 0.2 cm^3 from the results for Titrations 2 and 3. Many candidates could show the level of acid in the burette at the end of Titration 3 but a significant number showed that they did not know how to read a burette scale as they drew the level at 16.35 or 17.55 cm^3. Some did not read the question and drew the level at the mean titre value. Many candidates did not draw a curve to represent the meniscus of the acid solution and some, incorrectly, drew two curves or drew the meniscus upside down. A few candidates thought that the measurement is taken from the top of the curves either side of the meniscus.

(ii) The results of three further titrations are shown in the table.

Titration number	Rough	1	2	3
Final burette reading / cm^3	18.2	17.90	35.55	17.65
Initial burette reading / cm^3	0.00	0.00	18.00	0.00
Titre / cm^3	18.2	17.90	17.55	17.65
Used in mean (✓)		✓	✓	✓

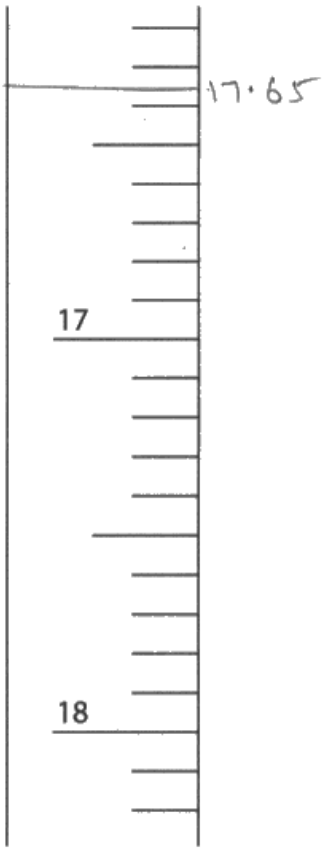
Calculate the mean titre.
Show which titres you have used in your calculation by putting a tick (✓) in the appropriate boxes in the table.

$$\text{mean} = \frac{17.90 + 17.55 + 17.65}{3}$$ (1)

mean titre 17.70 cm^3

(iii) On the diagram of part of a burette, show the level of dilute sulfuric acid when the final burette reading is recorded in **Titration 3**.

(2)



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Examiner Comments

(a)(ii) This candidate has used three titres to calculate the mean but the value of 17.90 cm^3 in Titration 1 is a lot higher than the values in Titrations 2 and 3 so should not be included. This answer scored 0.

(a)(iii) The candidate has realised that they need to show 17.65 cm^3 on the burette but they have read the burette the wrong way. 17.65 should be between 17 and 18 on the scale. They have also not shown the curved shape of the meniscus so this response scored 0.

ResultsPlus
Examiner Tip

Only use concordant results when working out the mean titre. Concordant results are within 0.2 cm^3 of each other.

Learn how to read a burette and draw a meniscus.

(ii) The results of three further titrations are shown in the table.

Titration number	Rough	1	2	3
Final burette reading / cm^3	18.2	17.90	35.55	17.65
Initial burette reading / cm^3	0.00	0.00	18.00	0.00
Titre / cm^3	18.2	17.90	17.55	17.65
Used in mean (✓)			✓	✓

Calculate the mean titre.
Show which titres you have used in your calculation by putting a tick (✓) in the appropriate boxes in the table.

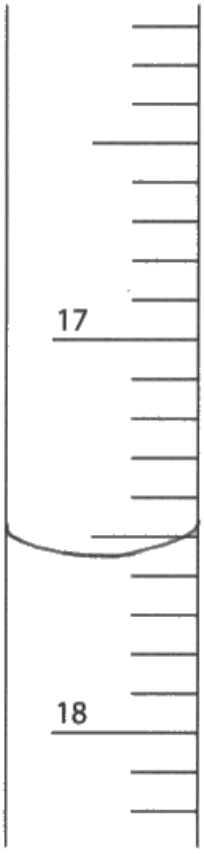
(1)

$$\frac{17.55 + 17.65}{2} = 17.60$$

mean titre 17.60 cm^3

(iii) On the diagram of part of a burette, show the level of dilute sulfuric acid when the final burette reading is recorded in **Titration 3**.

(2)



ResultsPlus
Examiner Comments

(a)(ii) Correct answer for 1 mark.

(a)(iii) The shape of the meniscus is correct but the candidate has shown the bottom of the meniscus at 17.55 cm^3 instead of 17.65 cm^3 so 1 mark was awarded.

ResultsPlus
Examiner Tip

Make sure you understand the scale on a burette.

Question 3 (b)

Many candidates found it difficult to describe how to obtain a sample of pure crystals of hydrated sodium sulfate. The majority missed the important point about 'pure' and forgot that there would be an indicator in the solution obtained from the titration, although some thought that it could be removed by filtration. Some did realise that they needed to repeat the titration without the indicator but did not specify using the mean titre of acid and the volume of sodium hydroxide needed. Some candidates also missed the point about hydrated crystals and they evaporated all of the water. A few candidates tried to remove the water by adding a drying agent and some thought sodium sulfate was insoluble and formed as a precipitate so they separated it using filtration.

(b) Using results from the table, briefly describe how to obtain a sample of pure crystals of hydrated sodium sulfate.

(2)

Heat the solution of sodium sulfate to remove excess water then dip a glass rod in it and remove. If crystals form on the glass rod then remove the solution from heating. Allow it to cool. Then decant ~~the solution~~ to remove the liquid, which leaves the crystals behind. Wash the crystals with cold water and dry between filter paper.

ResultsPlus
Examiner Comments

This is a good description of how to obtain crystals of sodium sulfate from a solution and it scored 1 mark. However, the candidate did not read the question carefully as it asks for a sample of pure crystals and there is an indicator in the solution from the titration.

ResultsPlus
Examiner Tip

Read the question carefully and try to answer it fully.

(b) Using results from the table, briefly describe how to obtain a sample of pure crystals of hydrated sodium sulfate.

(2)

Titrate exactly 17.60 cm^3 of dilute sulfuric acid with 25.0cm^3 NaOH in the absence of ~~Heat the solution~~ the indicator. Heat the solution formed to saturation. Allow the mixture to cool and crystallize. Filter off the crystals. Rinse the crystals with cold distilled water. Dry the crystals between e filter paper.

ResultsPlus
Examiner Comments

This is an example of an excellent answer that scored 2 marks.

ResultsPlus
Examiner Tip

Try to describe experiments in this amount of detail.

Question 4 (a) - (c)

Some candidates found it difficult to draw a labelled diagram of the apparatus set up for heating. Some crucibles looked more like beakers, evaporating basins or flasks. Some candidates did not show any crystals in the crucible and the experiment would not work without them. The best way to support a crucible over a Bunsen burner is to use a pipeclay triangle on top of a tripod. Only a very small minority of candidates showed this method of supporting the crucible, however examiners allowed the use of a gauze on this occasion. Many candidates did not even use a gauze and did not realise the crucible would fall down the hole at the top of the tripod. It is best to heat the crucible using a Bunsen burner, however in this experiment an electric heater was allowed. Many other experiments using a crucible need strong heating so an electric heater would not be suitable. Some candidates seemed confused about the meaning of 'hydrated' and thought that meant the crystals were dissolved in water to form a solution. A few candidates did not read the question and drew reflux or distillation apparatus. Candidates would benefit from much more practice in drawing diagrams of common laboratory apparatus. Two-dimensional diagrams showing a cross-section through the apparatus should be drawn, rather than attempts at three-dimensional pictures.

The majority of candidates could calculate the masses and complete the calculation correctly, although some were penalised for rounding the numbers in (c)(i) and/or (c)(ii) to 1 significant figure. Some candidates confused the masses of water lost and the contents after heating but they received credit for using these incorrect values in the calculation in (c).

4 An experiment is carried out to determine the value of n in the formula of hydrated zinc sulfate, $ZnSO_4.nH_2O$.

The following procedure is used.

Step **1** Weigh an empty crucible.

Step **2** Add two spatula measures of hydrated zinc sulfate to the crucible. Reweigh the crucible with the hydrated zinc sulfate.

Step **3** Heat the crucible and hydrated zinc sulfate to remove the water of crystallisation.

Step **4** Allow the crucible to cool. Reweigh the crucible and the anhydrous zinc sulfate.

The equation for the reaction is

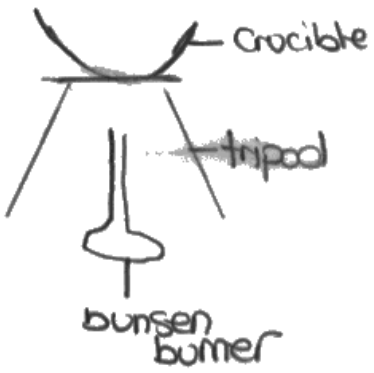
$$ZnSO_4.nH_2O(s) \rightarrow ZnSO_4(s) + nH_2O(g)$$

Results

Measurement	Value / g
Mass of empty crucible	13.26
Mass of crucible + contents before heating	16.71
Mass of crucible + contents after heating	15.30
Mass of contents before heating	3.45
Mass of contents after heating	1.41
Mass of water lost	2.04

(a) Draw a labelled diagram of the apparatus set up for heating in Step **3**.

(2)



(b) Complete the table of results.

(1)

(c) (i) Calculate the amount, in moles, of anhydrous zinc sulfate, $ZnSO_4$, left after heating.

(1)

1.41

Mr → 65.4 + 32.1 + (16 x 4) = 161.5

$\frac{1.41}{161.5} = 8.73 \times 10^{-3}$

8.73×10^{-3}

amount of anhydrous zinc sulfate left = 8.73×10^{-3} mol

(ii) Calculate the amount, in moles, of water lost during heating.

(1)

1.41g

Mr → 65.4 + 32.1 + (16 x 4) = 161.5

$\frac{2.04}{18} = 0.11$

amount of water lost = 0.11 mol

(iii) Calculate the value of n, using your answers to (c)(i) and (ii).

(1)

1 : n

$8.73 \times 10^{-3} : 0.113333$

n = 12.98 = 13

n = 13

ResultsPlus
Examiner Comments

(a) This diagram scored 1 mark for the Bunsen burner, tripod and gauze. The first mark was not awarded as no crystals were shown in the crucible.

(b) The masses are the wrong way around.

(c)(i) to (iii) These are correct answers from the masses in (b) so 1 mark was awarded for each part.

ResultsPlus
Examiner Tip

Make sure you include all details when drawing diagrams of apparatus.

4 An experiment is carried out to determine the value of n in the formula of hydrated zinc sulfate, $ZnSO_4.nH_2O$.

The following procedure is used.

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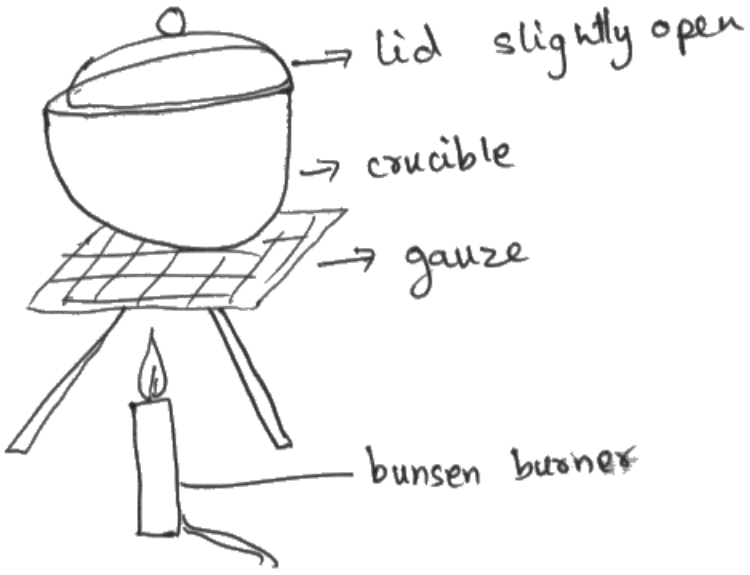
Mass of crucible + contents before heating	16.71
Mass of crucible + contents after heating	15.30
Mass of contents before heating	3.45
Mass of contents after heating	2·04
Mass of water lost	~~1·00~~ 1·41

(a) Draw a labelled diagram of the apparatus set up for heating in Step **3**.

(2)



(b) Complete the table of results.

(1)

(c) (i) Calculate the amount, in moles, of anhydrous zinc sulfate, $ZnSO_4$, left after heating.

(1)

mols = $\frac{2.04}{161.5} = 0.0126$

amount of anhydrous zinc sulfate left = 0.013 mol

(ii) Calculate the amount, in moles, of water lost during heating.

(1)

mols = $\frac{1}{16+2}$ $\frac{1.41}{18}$

amount of water lost = ~~0.06~~ 0.08 mol

(iii) Calculate the value of n, using your answers to (c)(i) and (ii).

(1)

$\frac{0.06}{0.013}$

n = ~~4.62~~ 6

~~0.08~~

$\frac{0.078}{0.013} = 6$

ResultsPlus
Examiner Comments

(a) This diagram scored 1 mark for the Bunsen burner, tripod and gauze. No crystals are shown in the crucible.

(b) The masses are correct for 1 mark.

(c)(i) Correct answer for 1 mark.

(c)(ii) Correct working but the candidate has rounded the answer to 1 significant figure so no mark awarded.

(c)(iii) Correct answer for 1 mark.

ResultsPlus
Examiner Tip

This candidate has attempted to draw a three-dimensional picture and has omitted the crystals from the crucible. In scientific work, it is better to draw a two-dimensional diagram showing a cross-section through the apparatus.

In calculations, do not round numbers to 1 significant figure, unless it is appropriate to do so. In this calculation, (c)(i) and (c)(ii) should be recorded to 2 or 3 significant figures as that is the accuracy of the masses or molar masses. It is appropriate to give the answer to (c)(iii) to 1 significant figure as that is the number of molecules of water of crystallisation, which is a whole number.

Question 4 (d) (i)

Many candidates worked out the correct effects of the two errors on the mass of water lost and the value of n. However, all combinations of increase and decrease were seen and many candidates would benefit from more practice at evaluating the effects of errors on their experiments.

(d) A data book gives the formula of hydrated zinc sulfate as $ZnSO_4.7H_2O$.

Two possible errors that might occur during the experiment are:

Error 1

Some of the hydrated zinc sulfate was lost from the crucible during heating in Step **3**.

Error 2

The crucible was not heated for long enough for all of the water of crystallisation to be lost.

(i) Predict the effect, if any, each error will have on the measured mass of water lost and hence the calculated value of n.

(2)

Error 1

Effect on measured mass of water lost would increase

Effect on calculated value of n Decrease

Error 2

Effect on measured mass of water lost would decrease

Effect on calculated value of n would increase

ResultsPlus
Examiner Comments

This response scored 1 mark for the correct effects on the measured masses of water lost.

ResultsPlus
Examiner Tip

It is acceptable to write short answers, such as this one, for this type of question.

Practise evaluating the results of your experiments to work out the effects of any errors.

Question 4 (d) (ii)

The majority of candidates suggested putting a lid on the crucible or heating more gently would prevent the crystals from 'jumping out' of the crucible. The most common incorrect answers were sealing the crucible, using a stopper or adding anti bumping granules, presumably because they thought the zinc sulfate was a solution. Some candidates suggested covering the crucible with cotton wool but did not think about the effect of heating this with a Bunsen burner.

(ii) Suggest how you could improve the experiment to stop the hydrated zinc sulfate from 'jumping out' of the crucible during heating.

(1)

add anti bumping granules and heat gradually and slowly

ResultsPlus
Examiner Comments

This candidate has correctly stated that heating the crystals gradually and slowly would prevent the crystals from 'jumping out' of the crucible. However, the use of anti bumping granules is incorrect when heating a solid and this negates the mark so no mark was awarded for this answer.

ResultsPlus
Examiner Tip

If you give more than one answer, make sure they are all correct. Any incorrect answer in a list of answers will lose the mark.

Question 4 (d) (iii)

It was pleasing to see that the majority of candidates were familiar with the technique of heating to constant mass, although some did not fully understand this technique and just mentioned constant mass without heating or confused it with crystallisation. A few candidates thought that they could add a drying agent, however, did not consider the effect this would have on the mass of crucible and contents after heating. Some candidates suggested testing for water vapour with cobalt chloride paper or anhydrous copper sulfate but that would not be very efficient.

(iii) Suggest how you could make sure that all the water of crystallisation is lost during heating.

(1)

Repeat the experiment by heating it till the point of saturation. If the mass of the content remains same then it can be stated that water of crystallisation is lost.

ResultsPlus
Examiner Comments

This candidate has the idea about heating to constant mass but seems to have confused it with heating to the point of saturation, which is used when obtaining crystals from a solution. This response scored 0.

ResultsPlus
Examiner Tip

Make sure you understand the meaning of 'heating to constant mass' and when it is used.

Question 5 (a)

Many candidates were able to score a mark for this item as there were many different acceptable answers. Some candidates just gave vague, general reasons, such as preventing the liquid splashing out, which was not enough to score the mark. Many candidates would benefit from thinking about the reasons for why each step is carried out when preparing and purifying an organic liquid. Candidates should understand that anti bumping granules do not prevent boiling but they promote the formation of small bubbles. A few candidates wrote about the reaction rather than the effect on the heating or boiling process.

5 Ethyl ethanoate is a colourless liquid with a boiling temperature of 77 °C.
It can be prepared by reacting ethanol with ethanoic acid.

$$C_2H_5OH(l) + CH_3COOH(l) \rightleftharpoons CH_3COOC_2H_5(l) + H_2O(l)$$

An outline procedure is given.

Step 1 Mix 20 cm^3 of ethanol and 20 cm^3 of ethanoic acid in a pear-shaped flask and add anti-bumping granules.

Step 2 Add 8 cm^3 of concentrated sulfuric acid slowly, and with cooling.

Step 3 Set up the apparatus for reflux, with the flask partially immersed in a water bath. Heat under reflux for 15 minutes.

Step 4 Allow the apparatus to cool, and then rearrange the apparatus for distillation. Collect all the distillate up to 80 °C.

(a) Give a reason why anti-bumping granules are used in Step **1**.

(1)

to avoid the ethanol and ethanoic acid from reacting vigorously.

ResultsPlus
Examiner Comments

This is an example of a weak answer that scored 0. The ethanol and ethanoic acid need to react to form the product and just adding 'vigorously' to the answer is not enough.

ResultsPlus
Examiner Tip

Try to give specific reasons for each technique.

5 Ethyl ethanoate is a colourless liquid with a boiling temperature of 77 °C.
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Step **3** Set up the apparatus for reflux, with the flask partially immersed in a water bath. Heat under reflux for 15 minutes.

Step **4** Allow the apparatus to cool, and then rearrange the apparatus for distillation. Collect all the distillate up to 80 °C.

(a) Give a reason why anti-bumping granules are used in Step **1**.

(1)

They are used to prevent the mixture from superheating by providing a rough surface and promoting small bubble formation.

ResultsPlus
Examiner Comments

This is an example of an excellent answer that scored 1 mark.

ResultsPlus
Examiner Tip

Make sure that you understand the reasons for all the techniques used in preparing and purifying an organic liquid.

Question 5 (b)

The majority of candidates knew that the mixture is cooled because the reaction with concentrated sulfuric acid is exothermic. Some candidates wrote generally about vigorous or violent reactions but these terms are too vague to be awarded a mark. Some candidates also mentioned the risk of an explosion, which is incorrect and lost them the mark, even if they also mentioned exothermic.

(b) Suggest a reason why the mixture is cooled as the concentrated sulfuric acid is added in Step **2**.

(1)

Highly corrosive

ResultsPlus
Examiner Comments

Concentrated sulfuric acid is corrosive but this does not explain why the mixture is cooled so this response scored 0.

ResultsPlus
Examiner Tip

Remember that all reactions involving concentrated sulfuric acid are exothermic.

(b) Suggest a reason why the mixture is cooled as the concentrated sulfuric acid is added in Step **2**.

(1)

Reaction is extremely exothermic ~~so to prevent~~ ~~shattering~~ to prevent explosion

ResultsPlus
Examiner Comments

The reaction is exothermic but this response scored 0 as the candidate has also stated that an explosion would occur and this negates the mark.

ResultsPlus
Examiner Tip

Take care not to write additional answers that lose the mark.

Question 5 (c)

Many candidates realised that this question was about flammability and could specify one or more of the organic compounds that are flammable. Some candidates referred generally to the mixture, the reactants or the products being flammable and forgot that water and concentrated sulfuric acid are present in the mixture and these are not flammable.

(c) Give a reason why the flask is heated in a water bath, rather than directly with a Bunsen flame, in Step **3**.

(1)

Because the reactant is flammable.

and the reaction is violet

ResultsPlus
Examiner Comments

This candidate has realised that the answer to this question is related to flammability but has not specified exactly what is flammable so this response scored 0.

ResultsPlus
Examiner Tip

Specify which substance or substances are flammable. Concentrated sulfuric acid is in the flask at the start of the reaction and that is not flammable.

Question 5 (d)

Many candidates could give an acceptable reason for why the mixture is heated under reflux. Some answers were vague and did not refer to preventing the **loss** of volatile components or the vapour being condensed. Common incorrect answers included: to prevent the mixture from evaporating or boiling, to reduce the rate of reaction, and to ensure complete oxidation.

(d) Give a reason why the mixture is heated under reflux in Step **3**.

$CH_3COOC_2H_5$ is volatile. (1)

ResultsPlus
Examiner Comments

Ethyl ethanoate is volatile but this is not enough to score a mark. The consequence of this property should be stated, for example, so it will not escape from the apparatus.

ResultsPlus
Examiner Tip

Give detailed reasons for your answers.

(d) Give a reason why the mixture is heated under reflux in Step **3**.

(1)

To make sure ~~all the reactants~~ the product has ~~been~~ been completely oxidised.

ResultsPlus
Examiner Comments

This is an example of a common incorrect answer that scored 0. In this experiment, ethanol and ethanoic acid are reacting to form ethyl ethanoate and water. Complete oxidation would refer to an experiment to produce ethanoic acid from ethanol.

ResultsPlus
Examiner Tip

Read the question carefully and make sure you understand which reaction is being asked about.

(d) Give a reason why the mixture is heated under reflux in Step **3**.

(1)

To prevent escape of volatile vapours of ethyl ethanoate as it has a low boiling point, the cold water flowing will condense the vapours, condensed vapours will return back to flask for complete reaction to occur.

ResultsPlus
Examiner Comments

This is an example of an excellent answer that scored 1 mark.

ResultsPlus
Examiner Tip

Try to give detailed answers, such as the one in this example.

Question 5 (e) (i)

The majority of candidates knew that carbon dioxide is produced in this reaction, although a significant minority thought hydrogen would be formed.

Question 5 (e) (ii)

Some candidates were familiar with the use of a separating funnel and could describe a suitable technique for releasing the gas pressure. Some candidates were less familiar with this technique and suggested opening the tap (without inverting the funnel) or inverting the funnel and then opening the stopper. In both of these cases the liquid would run out of the funnel. Some candidates referred to removing their finger or thumb from the top of the funnel. This did not score a mark as it would not be safe to shake a separating funnel by just sealing it with a finger or thumb.

(ii) Describe how to release the pressure in the separating funnel in Step **5**.

(1)

open the tap.

ResultsPlus
Examiner Comments

This was a common incorrect answer that scored 0.

ResultsPlus
Examiner Tip

Think about your answer. If the tap of a separating funnel is opened all of the liquid would pour out.

(ii) Describe how to release the pressure in the separating funnel in Step **5**.

(1)

by turning it upside down and opening it at regular intervals for a few seconds then turning it upright again

ResultsPlus
Examiner Comments

This candidate displayed right idea about turning the separating funnel upside down and opening it but they have not specified which end they will open - the stopper or the tap. This response scored 0.

ResultsPlus
Examiner Tip

Be precise about how to perform an experimental technique. Imagine that you are describing the technique to someone who has never carried out this technique before.

(ii) Describe how to release the pressure in the separating funnel in Step **5**.

(1)

By ~~oppe~~ ~~op~~ inverting the funnel and opening the ~~tap~~ tap at regular intervals.

ResultsPlus
Examiner Comments

This is a very good answer that scored 1 mark.

ResultsPlus
Examiner Tip

Inverting the funnel and opening the tap is the most effective technique for releasing the gas pressure.

Question 5 (f) (i)

The majority of candidates realised that anhydrous calcium chloride is a drying agent. Some candidates confused a drying agent with a dehydrating agent. A few students wrote an observation, for example, so the solution becomes clear, but did not receive credit for this as it does not explain what the calcium chloride is doing.

(f) (i) **Give a reason why anhydrous calcium chloride is added to the ethyl ethanoate in Step 6.**

(1)

To ensure there is no water present as calciumchloride is a ~~dehydrating~~ dehydrating agent

ResultsPlus
Examiner Comments

This is an example of a common answer that scored 0.

ResultsPlus
Examiner Tip

Make sure you understand the difference between a drying agent and a dehydrating agent as they have different, specific meanings in chemistry. A drying agent just removes water from something that is damp. A dehydrating agent chemically removes two hydrogen atoms and one oxygen atom from a molecule of a compound and produces water.

Question 5 (f) (ii)

Many candidates were able to suggest an alternative drying agent, yet all the incorrect answers shown in the mark scheme were also seen. Candidates should learn the few suitable drying agents used in purifying an organic liquid.

(ii) Suggest a reagent that could be used as an alternative to anhydrous calcium chloride in Step **6**.

(1)

H_2SO_4 , ~~Sodium~~ NaCl , $CaSO_4$.

ResultsPlus
Examiner Comments

This candidate has written the correct formula for calcium sulfate, which would be an acceptable drying agent. However, they have also included sulfuric acid and sodium chloride, which are incorrect, so this response scored 0.

ResultsPlus
Examiner Tip

Learn the common drying agents used in purifying organic liquids and do not add additional incorrect substances.

Question 5 (g)

Many candidates were able to suggest a suitable range of temperatures to collect a sample of pure ethyl ethanoate. The boiling temperature is 77°C so it is best to use a range within three degrees either side of that temperature. Some candidates suggested too narrow of a range, for example just 0.1 or 0.2°C either side of the boiling temperature and it would not be possible to collect the liquid over such a narrow range. Other candidates suggested a much wider range of temperatures, which were not acceptable as the liquid could contain impurities. Some even suggested a range that did not include the boiling temperature of the liquid. A number of candidates included 77 as their upper or lower temperature and this is also not acceptable. A few candidates ignored the instruction to give a temperature range and only stated one temperature.

(g) Give a suitable temperature **range** over which to collect the pure ethyl ethanoate during the final distillation in Step **7**.

(1)

77 – 79 C

ResultsPlus
Examiner Comments

This answer scored 0 as the lower temperature in the range is the boiling temperature of ethyl ethanoate.

ResultsPlus
Examiner Tip

When you collect an organic liquid, you should suggest a temperature range 2 or 3 degrees below its boiling temperature to 2 or 3 degrees above its boiling temperature.

(g) Give a suitable temperature **range** over which to collect the pure ethyl ethanoate during the final distillation in Step **7**.

(1)

~~49.8 – 50.2~~ 76.8 – 77.2

ResultsPlus
Examiner Comments

This candidate has the right idea and has suggested a range, with the actual boiling temperature in the middle of the range. However, this range is too small and it would not be possible to control the temperature with this degree of accuracy.

ResultsPlus
Examiner Tip

Select a range that is 1, 2 or 3 degrees above and below the boiling temperature of the organic liquid.

(g) Give a suitable temperature **range** over which to collect the pure ethyl ethanoate during the final distillation in Step **7**.

(1)

74°C ~~78°C~~ to 76°C AND 79°C to 81°C

77°C to 79°C AND 81°C to 83°C

ResultsPlus
Examiner Comments

This candidate has given two temperature ranges, neither of which is correct, so no mark was awarded.

ResultsPlus
Examiner Tip

Remember that the temperature range must include the boiling temperature of the liquid and only give one range.

Paper Summary

Based on their performance on this paper, candidates are offered the following advice:

- read all of the information in the questions and use it to help them to answer the questions
- practise drawing scientific diagrams of apparatus used in laboratory experiments
- revise how to interpret infrared spectra
- practise writing detailed descriptions of how to carry out experiments
- learn how to read a burette scale
- learn the meaning of the term 'hydrated'
- make sure that you understand the reasons for carrying out the steps involved in preparing and purifying an organic liquid.

Grade Boundaries

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

http://www.edexcel.com/iwantto/Pages/grade-boundaries.aspx

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