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Examiners' Report
June 2022

GCE Chemistry 9CH0 03

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Introduction

This paper provided candidates with the opportunity to demonstrate their knowledge and understanding of topics throughout the whole GCE specification. Many of the questions are synoptic in nature as they draw on two or more different topics. The paper covers the indirect assessment of practical skills and questions: in this context assess conceptual and theoretical understanding of experimental methods that draw on candidates' experiences of the Core Practicals.

Examiners reported that some answers were almost illegible. Candidates should be encouraged to write their answers clearly so that the examiners can read them easily and award the correct marks.

Successful candidates:

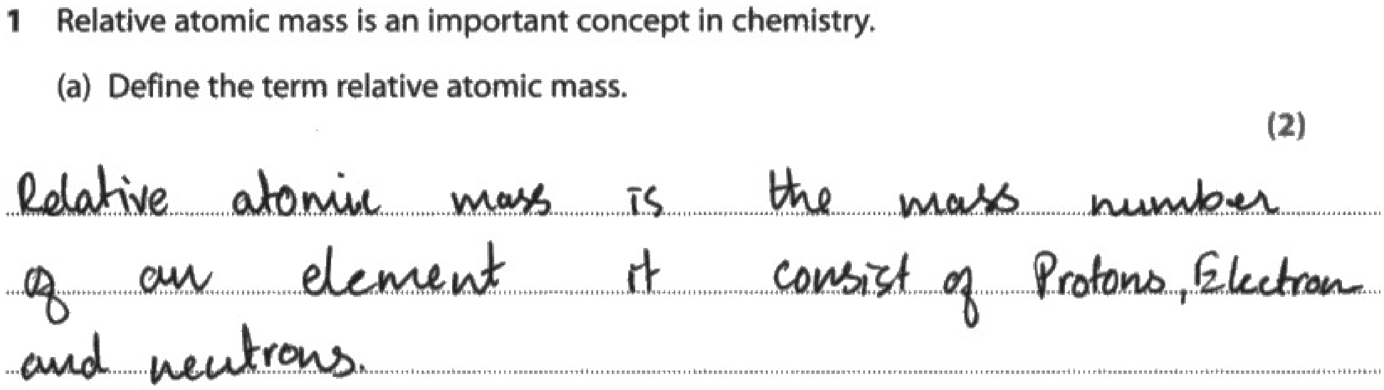
- read the questions carefully and answered the questions as they were set
- understood and used correct scientific terminology
- had used or seen a wide-range of practical techniques, could describe them accurately and had understood what was happening at each stage
- could carry out unstructured calculations.

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

- did not read the questions carefully, and gave answers that were related to the topic being tested, but did not answer the question
- did not use correct scientific terminology, for example, they interchanged atoms, molecules, ions, elements and compounds without understanding what the correct word should be
- were unfamiliar with some practical techniques, such as distillation and recrystallisation
- could not progress beyond the first mark or two in unstructured calculations.

Question 1 (a)

The majority of candidates scored 1 mark for this question as they knew that the mass of an atom was compared with 1/12 of the mass of a carbon-12 atom. Many candidates did not state that it is the **weighted** mean mass of an atom of an element. A small number of candidates confused mass number with relative atomic mass. Candidates are advised to learn the definitions in the specification.



1 Relative atomic mass is an important concept in chemistry.

(a) Define the term relative atomic mass.

(2)

Relative atomic mass is the mass number of an element it consist of Protons, Electron and neutrons.

ResultsPlus
Examiner Comments

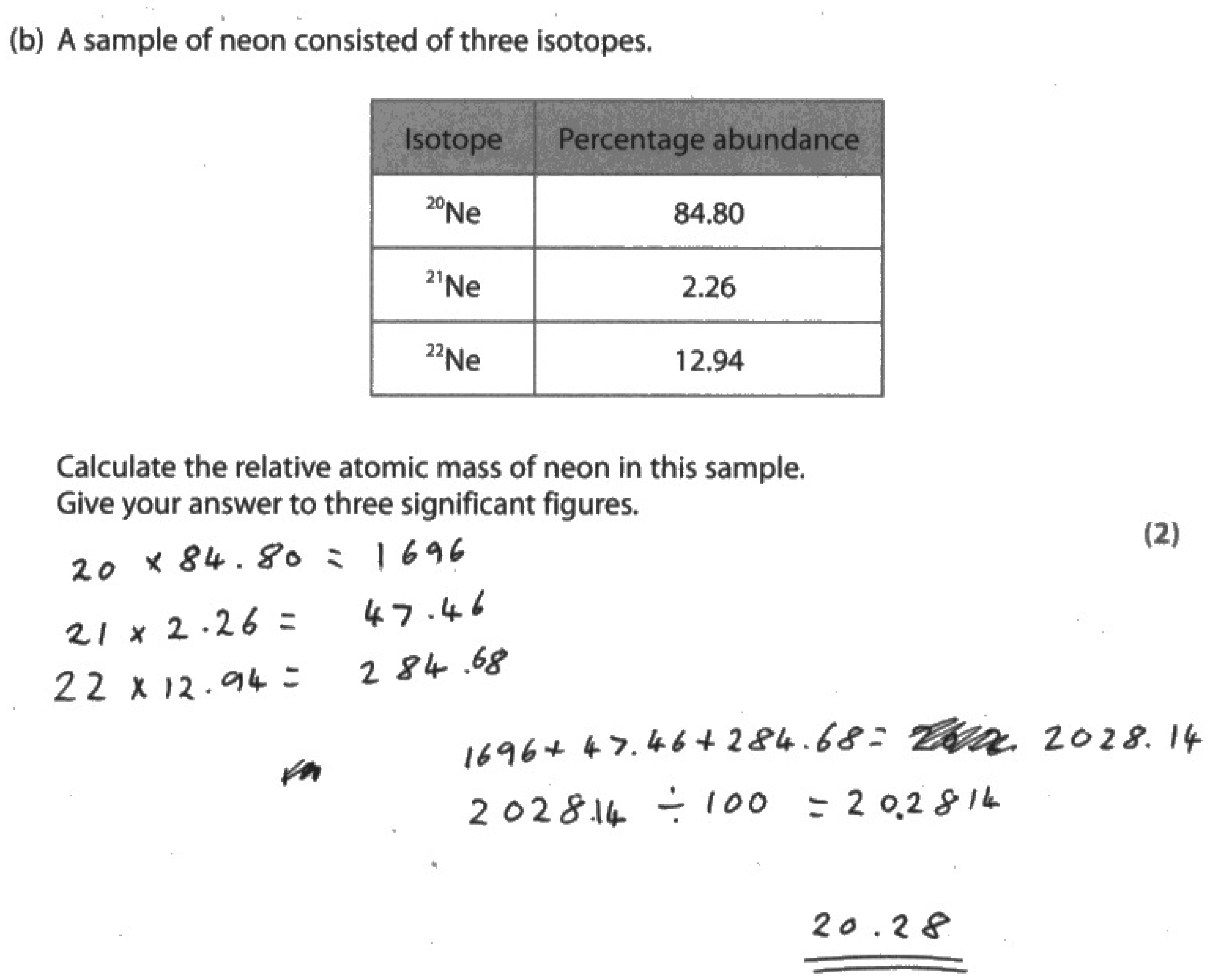
This response scored 0 as the candidate has confused mass number with relative atomic mass. However, even if the question had asked for the meaning of mass number, this candidate would not have scored a mark as they included electrons.

ResultsPlus
Examiner Tip

Learn the definitions in the specification so that you can recall them accurately.

Question 1 (b)

The vast majority of candidates scored full marks for this question. Many of those who were not awarded 2 marks did not read the question and gave their answer to 4 significant figures instead of the required three.



(b) A sample of neon consisted of three isotopes.

Isotope	Percentage abundance
^{20}Ne	84.80
^{21}Ne	2.26
^{22}Ne	12.94

Calculate the relative atomic mass of neon in this sample.
Give your answer to three significant figures.

(2)

$20 \times 84.80 = 1696$

$21 \times 2.26 = 47.46$

$22 \times 12.94 = 284.68$

$1696 + 47.46 + 284.68 = 2028.14$

$2028.14 \div 100 = 20.2814$

$\underline{\underline{20.28}}$

ResultsPlus
Examiner Comments

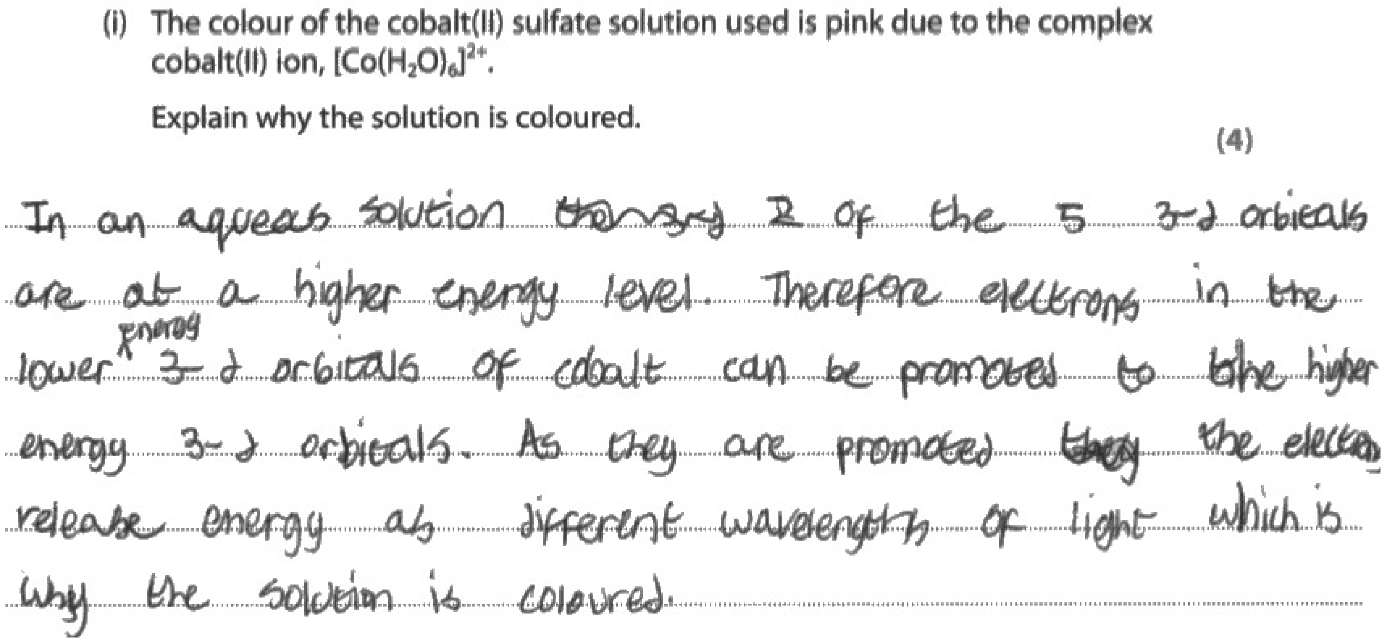
This response scored 1 mark for the correct working. They have not rounded their answer to 3 significant figures.

Examiner Tip

Read the question carefully to see if you have been asked to give your answer to a calculation to a specified number of decimal places or significant figures or if you have to judge an appropriate number of significant figures from the data in the question.

Question 2 (a)(i)

There were a significant number of candidates who were confused about why the cobalt(II) sulfate solution is coloured. Many were confused between a d subshell and a d orbital so thought that a d orbital could split into two different energies. Some just referred to electrons moving between energy levels and did not specify that electrons are promoted when they absorb energy. There was a lot of confusion then with flame tests as many candidates referred to the electrons dropping down and emitting energy. Many candidates would benefit from a review of colour in transition metal ions and flame tests to ensure that they understand the difference.



(i) The colour of the cobalt(II) sulfate solution used is pink due to the complex cobalt(II) ion, $[Co(H_2O)_6]^{2+}$.

Explain why the solution is coloured.

(4)

In an aqueous solution 2 of the 5 3-d orbitals are at a higher energy level. Therefore electrons in the lower energy 3-d orbitals of cobalt can be promoted to the higher energy 3-d orbitals. As they are promoted ~~they~~ the electron release energy as different wavelengths of light which is why the solution is coloured.

ResultsPlus
Examiner Comments

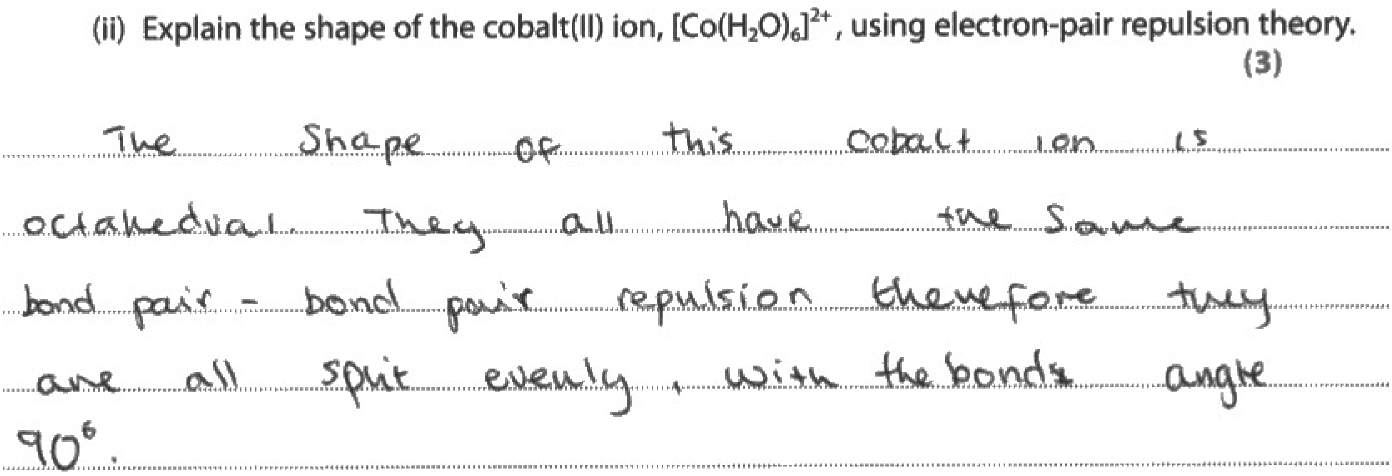
This response scored 2 marks. The candidate has shown that the d orbitals are split into two energy levels and that electrons in the lower level are promoted to a higher level. However, they have not stated that electrons absorb energy for this promotion to take place. The release of energy takes place in flame tests when electrons drop down from higher energy levels to their ground state.

ResultsPlus
Examiner Tip

Make sure you understand the difference in how colour arises in transition metal aqueous ions and in flame tests.

Question 2 (a)(ii)

The majority of candidates knew that complex ions with six ligands are octahedral, although incorrect terms such as octagonal, hexagonal and hexahedral were seen. Fewer candidates were able to explain the shape in terms of the number of pairs of electrons and the idea of minimising repulsion between them. Some candidates just wrote about six ligands or bonds and did not refer to the bond pairs and some wrote about lone pair-lone pair repulsion being greater than bond pair-bond pair repulsion, even though that was not relevant here. A few candidates were confused and wrote about minimum separation and maximum repulsion. Candidates should revise the names of the basic shapes of molecules and ions and the reasons why they are these shapes.



(ii) Explain the shape of the cobalt(II) ion, $[Co(H_2O)_6]^{2+}$, using electron-pair repulsion theory.

(3)

The Shape of this cobalt ion is octahedral. They all have the Same bond pair - bond pair repulsion therefore they are all split evenly, with the bonds angle 90°.

ResultsPlus
Examiner Comments

This response scored 1 mark for the correct shape. They have not specified how many bond pairs there are and 'the same bond pair-bond pair repulsion' is not acceptable for the bond pairs being arranged to minimise repulsion.

ResultsPlus
Examiner Tip

Make sure you understand the reasons why molecules and ions have particular shapes.

Question 2 (a)(iii)

Many candidates gave clear reasons for carrying out Steps 3 and 4 of the procedure, showing that they had carried out practical work to obtain pure, dry crystals. The most observant candidates realised that cobalt(II) sulfate solution was present in excess so the crystals are rinsed to remove this excess solution. A significant number of candidates did not comment on the use of ice-cold water, even though it was printed in bold. Some thought the ice-cold water would quench the reaction. The majority of candidates realised that the warm oven was used to dry the crystals, although some lost the mark if they stated that the water of crystallisation would be removed, the crystals would be dehydrated or an anhydrous salt is obtained.

(iii) Give the reasons for carrying out Steps **3** and **4** of the procedure, referring particularly to the words in bold.

(3)

rinsed with ice cold water to remove any soluble impurities - rinsed to remove solutes, ice cold so that none of the desired crystals dissolve and are removed. (if hot may ~~remov~~ dissolve crystals)

Warm oven to completely dry the crystals ~~or~~ by removing all water - to dehydrate crystals. Heating causes water to be lost by evaporation.

ResultsPlus
Examiner Comments

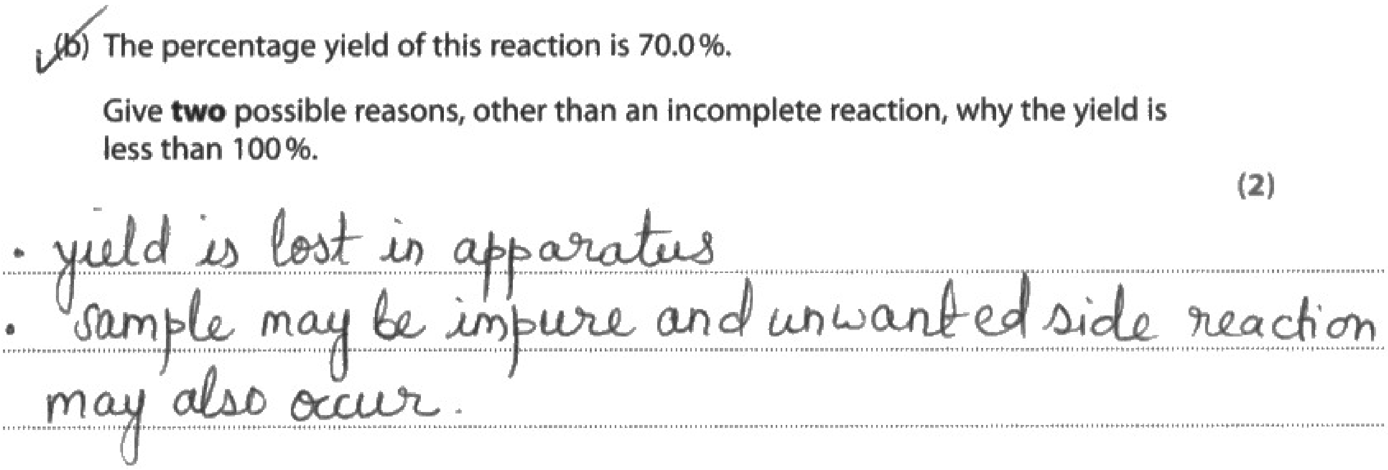
This response scored 2 marks for the reasons for rinsing and using ice-cold water. The candidate correctly states that the warm oven is used to dry the crystals but this mark is negated by stating 'to dehydrate crystals'.

ResultsPlus
Examiner Tip

Learn the difference between dry and dehydrate.

Question 2 (b)

There were many possible reasons why the yield is less than 100% and most candidates were able to write about at least one of them. General answers, such as 'transfer losses', are not acceptable. The candidates should write about one specific transfer loss that is relevant to the question. Credit was not given to reasons such as the crystals would get washed away, unless dissolving was also mentioned. Other general reasons, that might be applicable in other experiments, were not relevant here so did not score, for example, the reaction is reversible or by-products are formed. Some candidates suggested reasons that would give an increase in yield, such as the crystals were not dry when weighed or impurities are present.



(b) The percentage yield of this reaction is 70.0%.

Give **two** possible reasons, other than an incomplete reaction, why the yield is less than 100%.

(2)

- yield is lost in apparatus
- sample may be impure and unwanted side reaction may also occur.

ResultsPlus
Examiner Comments

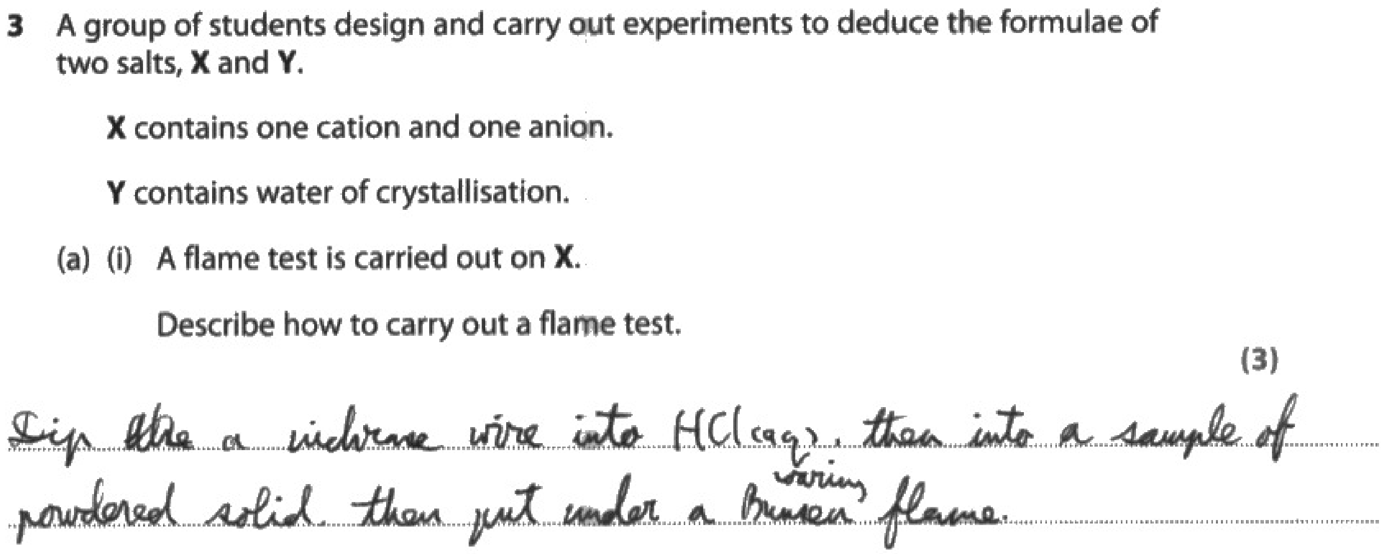
This response scored 0 as there is too little specific detail in the answer. The candidate could have scored a mark if they had mentioned specific apparatus where the yield is lost, such as transferring from the evaporating basin to the filter funnel in Step 2. If the sample was impure, the impurities would increase the yield.

ResultsPlus
Examiner Tip

When you are asked for reasons for a lower yield than expected in an experiment, give specific details that are relevant to the experiment in the question.

Question 3 (a)(i)

The majority of candidates understood the method of carrying out a flame test using a nichrome wire and concentrated hydrochloric acid. However, a significant number of candidates lost the third mark by stating that the wire with the solid sample should be held under, above or near the flame, rather than **in** the flame. A small number of candidates suggested using the safety flame on the Bunsen. Some candidates demonstrated knowledge beyond the question by describing how the concentrated hydrochloric acid is used to form a volatile chloride.



3 A group of students design and carry out experiments to deduce the formulae of two salts, **X** and **Y**.

X contains one cation and one anion.

Y contains water of crystallisation.

(a) (i) A flame test is carried out on **X**.

Describe how to carry out a flame test.

(3)

Dip ~~the~~ a nichrome wire into HCl(aq), then into a sample of powdered solid. then put under a roaring Bunsen flame.

ResultsPlus
Examiner Comments

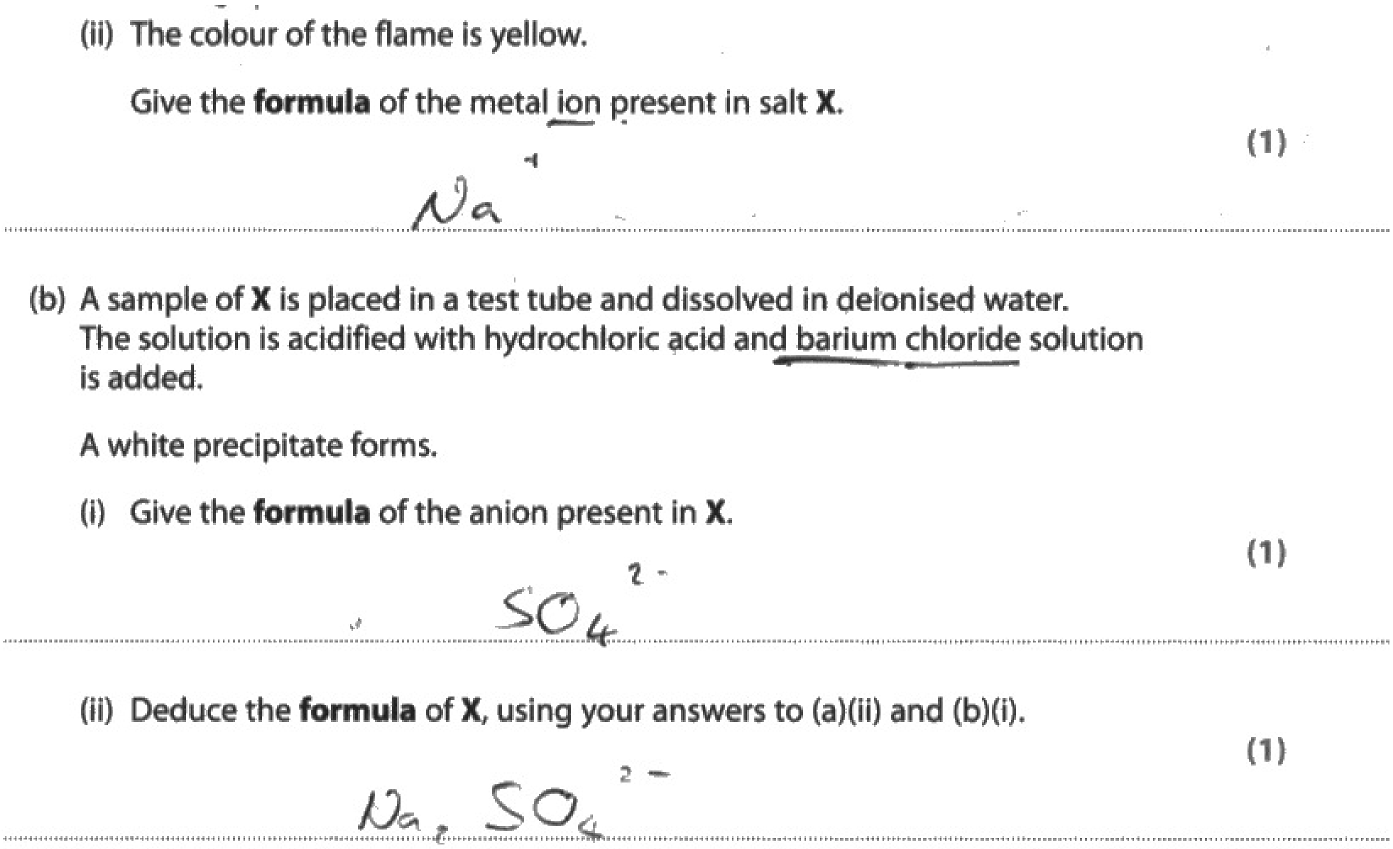
This is a common response that scored 2 marks. A flame test only works if the sample being tested is **in** the Bunsen flame.

ResultsPlus
Examiner Tip

Revise all the details of carrying out a flame test. Try to imagine yourself carrying this out and think about how you would get the sample under the flame, as stated here.

Question 3 (a)(ii)-(b)(ii)

The majority of candidates were familiar with the results of the tests and could identify the ions present. Some candidates did not read the question so wrote the names of the ions instead of the formulae and some did not include charges on the ions. Some candidates were confused between the sulfate test using barium chloride solution and the chloride test using silver nitrate solution. A small number of candidates were unable to balance the charges on the ions to write the overall formula.



(ii) The colour of the flame is yellow.

Give the **formula** of the metal ion present in salt **X**.

(1)

Na^{+}

(b) A sample of **X** is placed in a test tube and dissolved in deionised water. The solution is acidified with hydrochloric acid and barium chloride solution is added.

A white precipitate forms.

(i) Give the **formula** of the anion present in **X**.

(1)

SO_4^{2-}

(ii) Deduce the **formula** of **X**, using your answers to (a)(ii) and (b)(i).

(1)

$Na_2SO_4^{2-}$

ResultsPlus
Examiner Comments

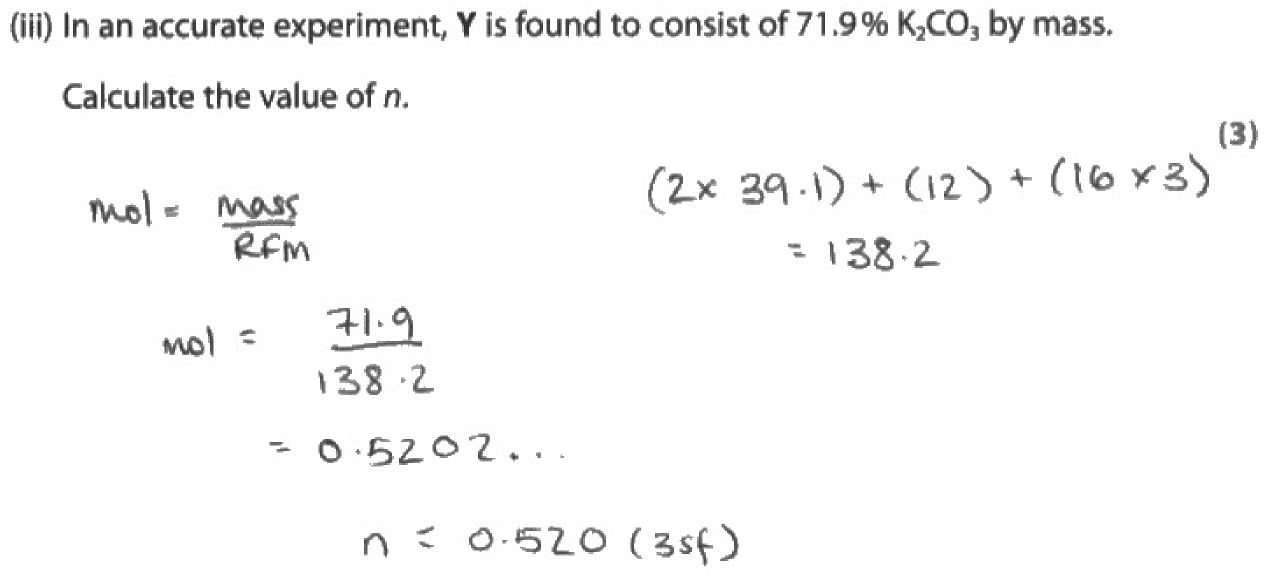
The first two parts of the answer are correct and scored 2 marks. However, the candidate has shown an overall charge of 2 – on the formula of **X**, which is incorrect.

ResultsPlus
Examiner Tip

Revise how to write an overall formula from its constituent ions.

Question 3 (c)(iii)

There were several ways of calculating the value of *n* and the majority of candidates scored full marks by using one of them. A few candidates were able to work out the percentage of water in the crystals but were unable to proceed any further. A few candidates calculated an incorrect relative formula mass for potassium carbonate, for example, by omitting one of the potassium ions, and they should check their work carefully as the correct formula was given in the question.



(iii) In an accurate experiment, **Y** is found to consist of 71.9 % K_2CO_3 by mass.

Calculate the value of *n*.

(3)

$\text{mol} = \frac{\text{mass}}{\text{RFM}}$

$(2 \times 39.1) + (12) + (16 \times 3)$

$= 138.2$

$\text{mol} = \frac{71.9}{138.2}$

$= 0.5202\ldots$

$n = 0.520$ (3sf)

ResultsPlus
Examiner Comments

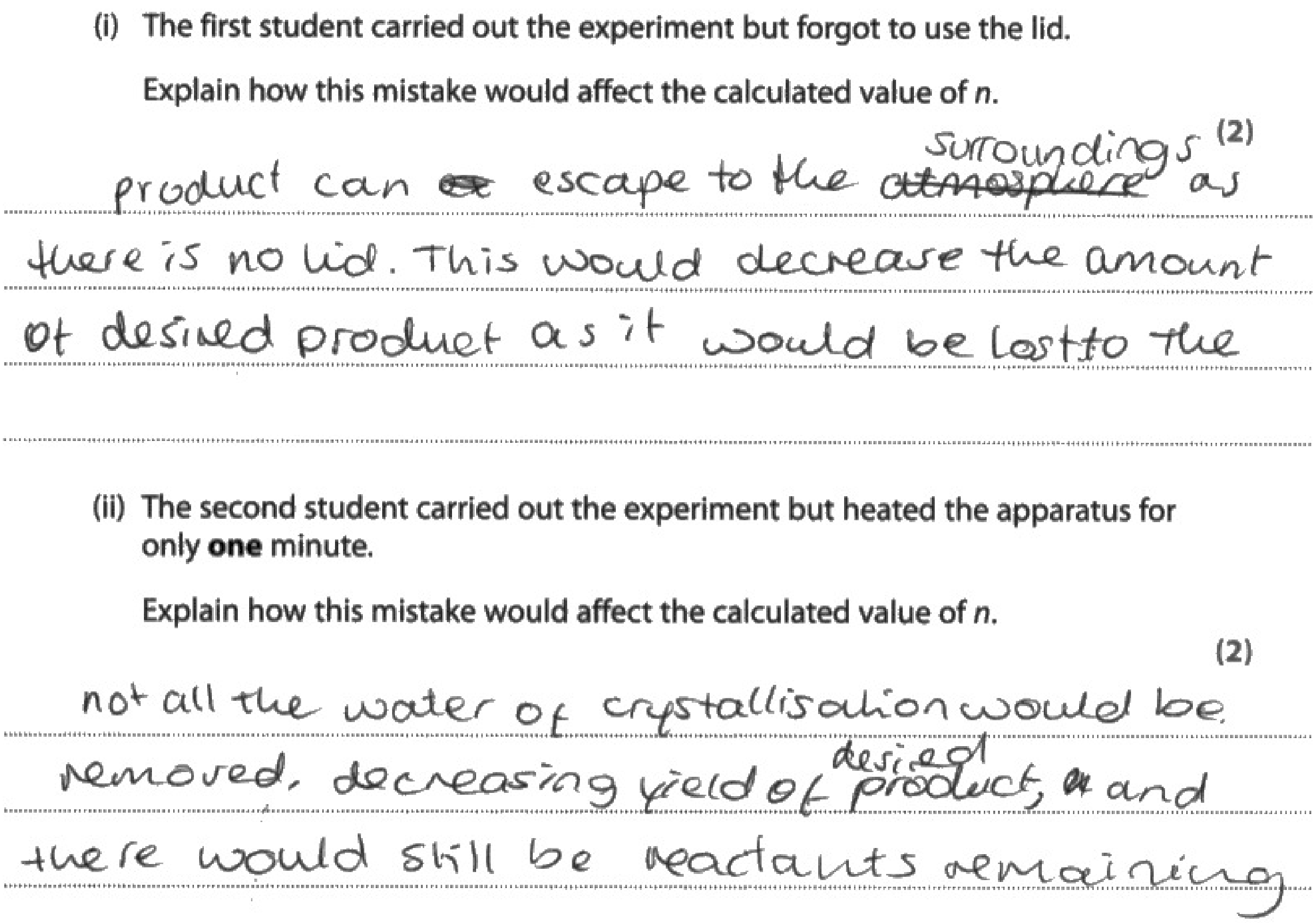
This candidate scored 1 mark for calculating the number of moles of potassium carbonate. They did not realise that the remaining 28.1% of the crystals was water so they could then have calculated the number of moles of water.

ResultsPlus
Examiner Tip

Try to use all of the information in the question. If 71.9% of the crystals is potassium carbonate, the remaining percentage must be water.

Question 3 (c)(i-ii)

Few candidates scored any marks for Q03ci as they did not understand the significance of the lid in the experiment. They often wrote about the water of crystallisation being able to escape if there was no lid and some mentioned that the salt would decompose, releasing a gas. Only a small minority realised that there would be a possibility that some of the solid could be lost from the crucible during heating. Many more candidates scored two marks for Q03cii as they did realise that insufficient heating would result in not all of the water of crystallisation being driven off the solid so the value of *n* would be lower than expected. Some candidates were unable to relate the mass change to the change in the value of *n*.



(i) **The first student carried out the experiment but forgot to use the lid.**

Explain how this mistake would affect the calculated value of *n*.

(2)

product can ~~or~~ escape to the ~~atmosphere~~ surroundings as there is no lid. This would decrease the amount of desired product as it would be lost to the

(ii) **The second student carried out the experiment but heated the apparatus for only one minute.**

Explain how this mistake would affect the calculated value of *n*.

(2)

not all the water of crystallisation would be removed, decreasing yield of desired product, ~~a~~ and there would still be reactants remaining

ResultsPlus
Examiner Comments

This candidate scored 1 mark for each part of the question. They have given correct statements about what happens but they have not linked these to how the calculated value of *n* would be affected.

ResultsPlus
Examiner Tip

Check your answers to make sure that you have answered the question in full.

Question 4 (a)

There were many excellent answers to the calculation in Q04ai and they were approximately evenly split between those who calculated ΔS_{total} and those who calculated ΔG. The most common errors were to forget to change one of the initial values so that they were in consistent units for the final step in the calculation and to give J K^{-1} mol^{-1} as units for ΔG.

In Q04aii, the most common errors were to fail to convert the temperature to ^{o}C or to include too many significant figures in the final answer.

4 This question is about the white solid barium carbonate.

(a) Barium carbonate decomposes under suitable conditions to form barium oxide and carbon dioxide.

$$BaCO_3(s) \rightarrow BaO(s) + CO_2(g) \qquad \Delta_r H^{\ominus} = +169.3\ kJ\ mol^{-1}$$

Standard molar entropy data related to this reaction are shown.

Substance	Standard molar entropy, $S^{\ominus}$ / $J\,K^{-1}\,mol^{-1}$
$BaCO_3(s)$	112.1
$BaO(s)$	70.4
$CO_2(g)$	213.6

(i) Show that barium carbonate is thermally stable at 298 K, using the data in the equation and in the table.

(5)

$\Delta S_{system} = (70.4 + 213.6) - (112.1)$

$= 171.9$

$G = \Delta H - T\Delta S$

$= 169300 - (298 \times 171.9)$

$= 118073.8$

(ii) Calculate the lowest temperature, in °C, at which it is thermodynamically feasible for barium carbonate to decompose.
Give your answer to three significant figures.

(3)

$$T = \frac{\Delta H}{\Delta S}$$

$$= \frac{169300}{171.9} = 984\ K$$

ResultsPlus Examiner Comments

(a)(i) scored 3 marks as the candidate has calculated ΔG correctly. However, they have not included units and not stated how the value shows that barium carbonate is thermally stable.

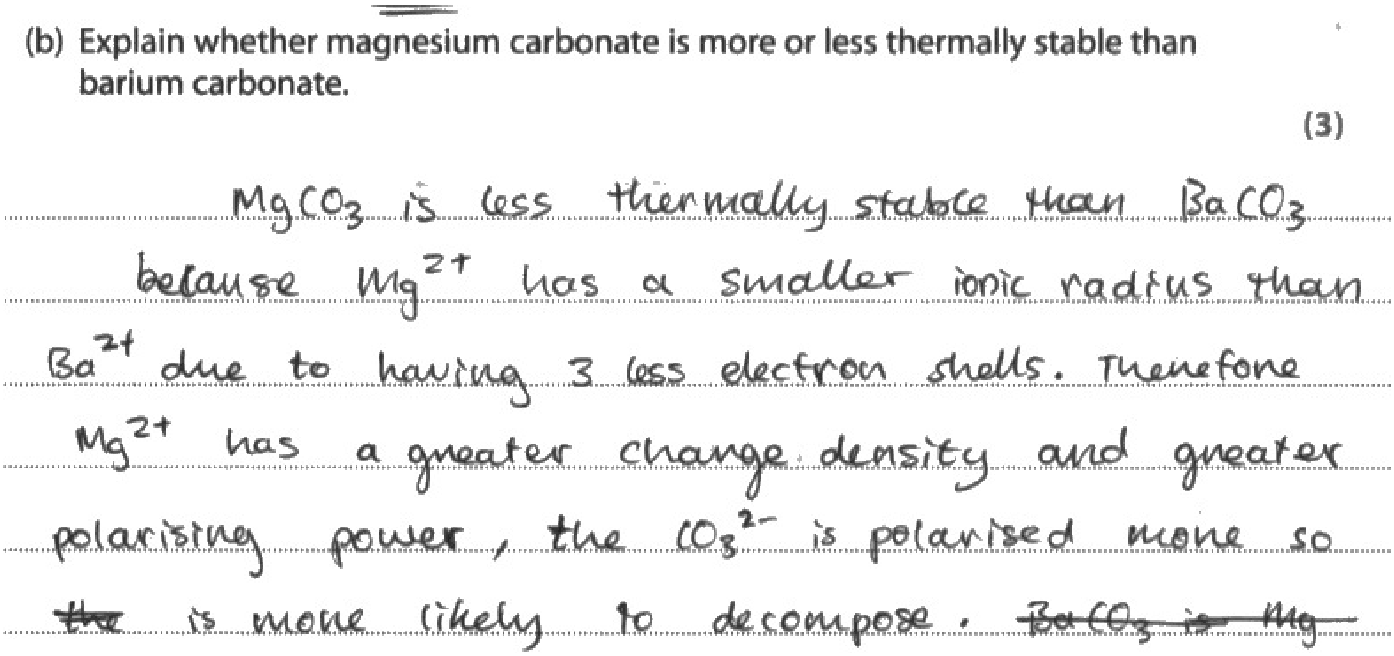
In (a)(ii), the candidate has substituted the correct values into the expression and rearranged it to calculate the temperature so scored 2 marks. The question asks for the temperature in ^{o}C and the candidate has left it in K so not scored the third mark. Even if this candidate had converted their final answer into the correct units, they would not have scored the final mark as the full answer is 984.87 K and they have incorrectly rounded this down to 984 K.

ResultsPlus Examiner Tip

Always re-read the question and make sure that you have answered all parts of it.

Question 4 (b)

Many candidates had a clear understanding of why magnesium carbonate is less thermally stable than barium carbonate. Unfortunately many candidates lost marks through the poor use of scientific terminology. For example, candidates referred to magnesium being smaller than barium instead of a magnesium ion having a smaller radius than a barium ion. A significant minority of candidates thought that the ionic bond between the cation and anion was weakened and many just stated that 'bonds are weakened' without specifying which bonds.



(b) Explain whether magnesium carbonate is more or less thermally stable than barium carbonate.

(3)

$MgCO_3$ is less thermally stable than $BaCO_3$ because Mg^{2+} has a smaller ionic radius than Ba^{2+} due to having 3 less electron shells. Therefore Mg^{2+} has a greater charge density and greater polarising power, the CO_3^{2-} is polarised more so ~~the~~ is more likely to decompose. ~~$BaCO_3$ is Mg~~

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Examiner Comments

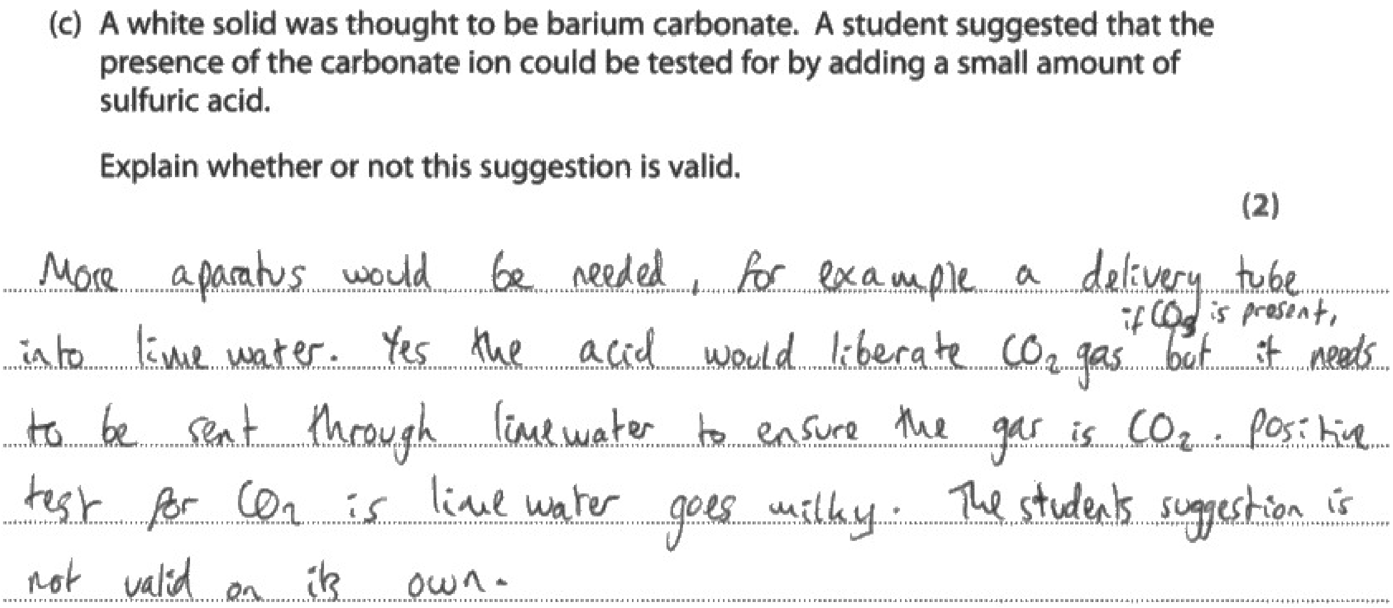
This candidate has had a good attempt at answering this question and scored 2 marks. They have identified that it is the cations that are important and stated that the magnesium ion has a smaller ionic radius and the barium ion so it has a greater polarising power on the carbonate ions. However, they have not stated that this polarisation will result in a weakening of the C-O bonds so magnesium carbonate will decompose more easily.

ResultsPlus
Examiner Tip

When metal carbonates decompose, it is a C-O bond that weakens and breaks to leave a metal oxide and release carbon dioxide gas.

Question 4 (c)

Most candidates were unsure about how to answer this question. Many knew that the usual reaction between an acid and a carbonate produces carbon dioxide and some realised that barium sulfate would form as a white precipitate. Few candidates could link those two ideas together to deduce that bubbles of gas would not be expected when sulfuric acid is used due to the insoluble surface layer of barium sulfate formed.



(c) A white solid was thought to be barium carbonate. A student suggested that the presence of the carbonate ion could be tested for by adding a small amount of sulfuric acid.

Explain whether or not this suggestion is valid.

(2)

More aparatus would be needed, for example a delivery tube into lime water. Yes the acid would liberate CO_2 gas if CO_2 is present, but it needs to be sent through limewater to ensure the gas is CO_2. Positive test for CO_2 is lime water goes milky. The students suggestion is not valid on its own.

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Examiner Comments

This response scored 1 mark for the idea of carbon dioxide is formed when a carbonate reacts with an acid. However, this candidate has not realised that barium carbonate will react with sulfuric acid to form insoluble barium sulfate, which will impede the reaction.

ResultsPlus
Examiner Tip

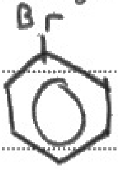
Try to use all the information given in the question.

Question 5

This extended open response was straightforward for the candidates who had revised the reactions of bromine with benzene and with phenol, but the full range of marks were seen. Some candidates did not look carefully enough at the statement telling them to include the type of reaction, the products that form and any conditions required so some of these were often missing. The explanation of why phenol is more reactive than benzene in terms of the lone pair of electrons on oxygen being delocalised into the ring system so increasing its electron density, was often well-known. Many candidates did not know that both reactions are electrophilic substitution and many addition reactions were seen, along with nucleophiles. This type of question is best dealt with as a comparison for each of the points but many candidates just wrote two separate paragraphs and did not link them. Candidates would benefit from planning out a structure to their answer before writing it out in full.

Benzene is less reactive than phenol as ~~the~~ electrons from the OH group in phenol become part of the delocalised ring of electrons, making it more reactive with electrophiles, like bromine, than benzene.

This is seen with the bromination of benzene which requires a halogen carrier in the form of $FeBr_3$, which reacts with Br_2 to form $FeBr_4^-$ and Br^+, which attacks the benzene ring ~~dow~~ via electrophilic ~~substit~~ substitution. This forms a single product, bromobenzene. Heating is also required.



On the other hand, phenol reacts readily with bromine at room temperature without the need of a halogen carrier. This reaction forms 2 products: 2-bromophenol and 4-bromophenol. This is also an electrophilic substitution. In both, reactions, HBr is formed.

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Examiner Comments

This candidate has made a reasonable attempt at an answer and has started with a plan. In the main part of their answer, they have included that both reactions are electrophilic substitution, benzene is less reactive than phenol and the correct conditions for the reactions. They have the right idea about why phenol is more reactive than benzene but have just stated that the electrons from the OH group become part of the delocalised ring, rather than stating that it is the lone pair of electrons on the oxygen atom. They have omitted to mention that this causes an increased electron density of the ring. They also did not know that phenol reacts with bromine water to form 2,4,6-tribromophenol.

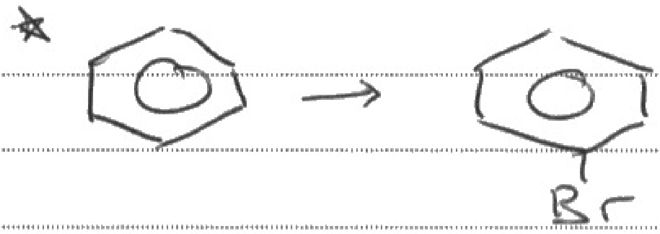
This response had credit for 3 Indicative Points, which gives 2 marks, and they were given 1 mark for structure and lines of reasoning, giving a total of 3 marks.

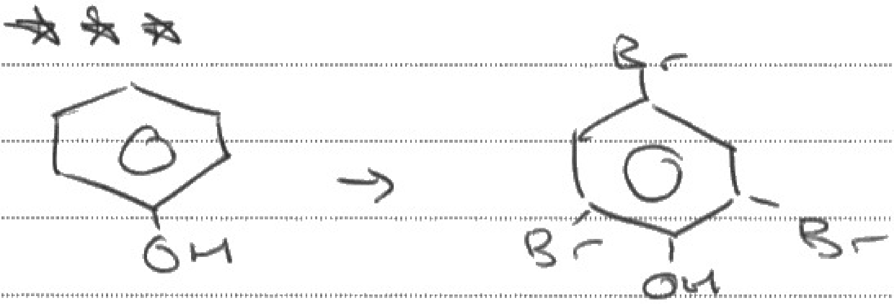
***5** Explain the difference in the reactivity of bromine with benzene and with phenol.

Include the type of reaction, the products that form, and any conditions required. Mechanisms for the reactions are **not** required.

(6)

Phenol is more reactive than benzene due to the lone pair on the oxygen overlapping with the delocalised pi system of the benzene ring and becoming incorporated with the system creating a higher electron density making it more susseptible to electrophilic attack. Therefore benzene needs a catalyst of a halogen carrier, $FeBr_3$, in order for bromine to react. The halogen carrier reacts with liquid bromine to create a positive bromide ion which subtitutes once onto the benzene ring* creating one molecule of HBr in production. This also uses heat to help the reaction. As phenol is more reactive no catalyst is necessary or added heat. A solution of bromine reacts with the phenol and substitutes three times onto the benzene ring** producing three molecules of HBr.





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Examiner Comments

This is a good answer with a clear comparison between the reactions. The only Indicative Point missing is that both reactions are electrophilic substitution.

5 Indicative Points gives 3 marks, and 2 marks were awarded for structure and lines of reasoning, giving a total of 5 marks.

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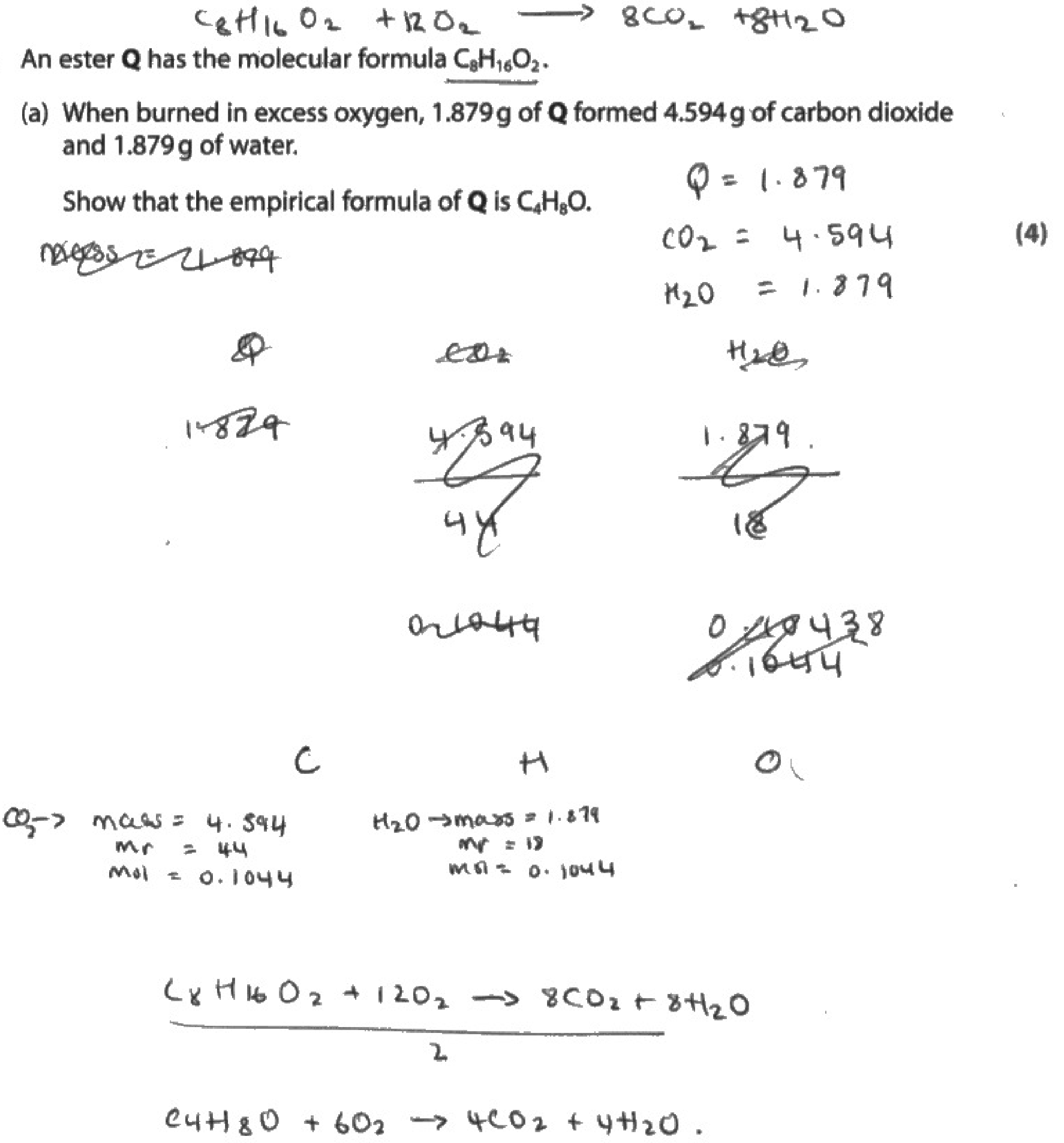
Examiner Tip

Check your answer against the question to make sure that you have included all the necessary points. The type of reaction is asked for in this question.

Question 6 (a)

Many candidates were able to calculate the masses of carbon, hydrogen and oxygen in ester **Q** and then confirm the empirical formula. Some candidates were able to calculate the masses of carbon and hydrogen but did not know how to calculate the mass of oxygen. Some candidates worked out the numbers of moles of carbon dioxide and water but were unable to proceed any further. Many candidates would benefit from more practice at this style of calculation.



$C_8H_{16}O_2 + 12O_2 \longrightarrow 8CO_2 + 8H_2O$

6 An ester **Q** has the molecular formula $C_8H_{16}O_2$.

(a) When burned in excess oxygen, 1.879 g of **Q** formed 4.594 g of carbon dioxide and 1.879 g of water.

Show that the empirical formula of **Q** is C_4H_8O.

(4)

~~mass = 4.894~~

Q = 1.879

CO_2 = 4.594

H_2O = 1.879

~~Q~~ ~~CO_2~~ ~~H_2O~~

1.879

$\cancel{\frac{4.594}{44}}$ $\cancel{\frac{1.879}{18}}$

~~0.1044~~ 0.10438 ~~0.1044~~

C H O

CO_2 -> mass = 4.594
Mr = 44
Mol = 0.1044

H_2O -> mass = 1.879
Mr = 18
Mol = 0.1044

$$\frac{C_8H_{16}O_2 + 12O_2 \longrightarrow 8CO_2 + 8H_2O}{2}$$

$C_4H_8O + 6O_2 \longrightarrow 4CO_2 + 4H_2O$.

ResultsPlus
Examiner Comments

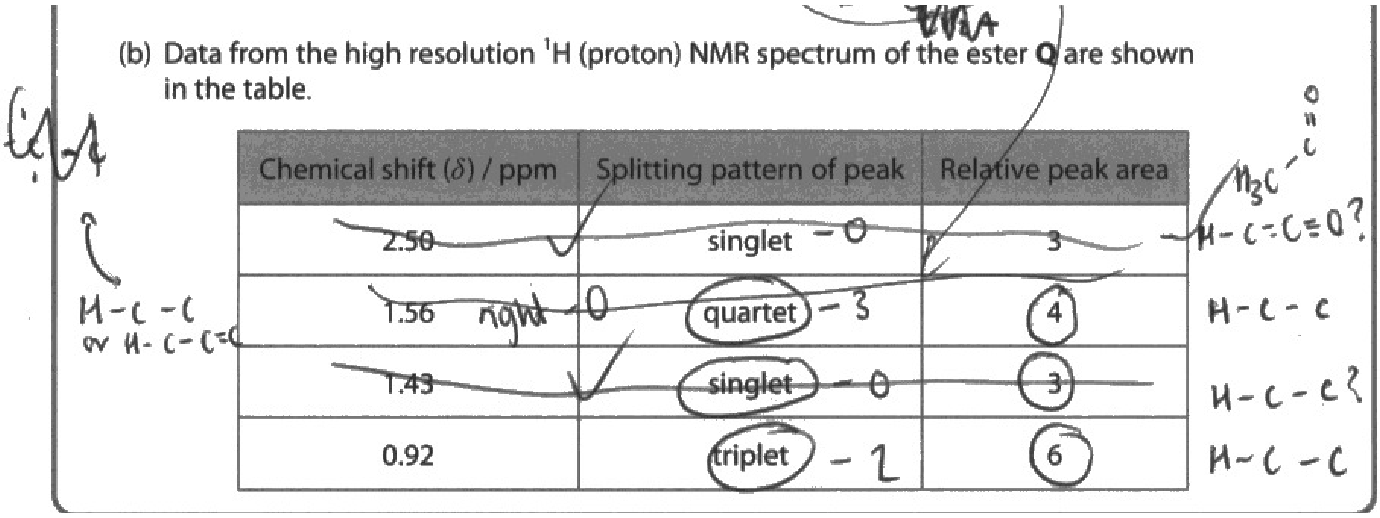
This candidate worked out the numbers of moles of carbon dioxide and water so scored 1 mark. They did not realise that they could have worked out the number of moles of **Q** used from the mass and the relative formula mass. They tried to write a balanced equation but forgot that there are two atoms of oxygen in one molecule of **Q**.

ResultsPlus
Examiner Tip

Practise working out empirical and molecular formulae of organic compounds using data from combustion.

Question 6 (b)

This was a challenging question using data from proton NMR spectroscopy and it was pleasing to see many candidates using all the information to deduce the correct structure of **Q** and justify their answers. The clearest answers labelled the different proton environments on their diagrams of the structures and related them to the chemical shifts in the table. Even if candidates could not deduce the correct structure, they received credit for each piece of data they interpreted from the table, for example, relating the peak areas to the numbers of protons in each environment or explaining the meaning of the splitting patterns. It was expected that all candidates would identify the peak at 2.50 ppm due to the CH_3CO part of the ester as that part of the structure was given on the question paper, however, not all candidates were able to do that. Some candidates were confused between proton NMR and ^{13}C NMR so wrote about carbon environments.



(b) Data from the high resolution ^1H (proton) NMR spectrum of the ester **Q** are shown in the table.

Chemical shift (δ) / ppm	Splitting pattern of peak	Relative peak area
2.50 ✓	singlet – 0	3
1.56 right – 0	quartet – 3	4
1.43 ✓	singlet – 0	3
0.92	triplet – 2	6

H–C–C

or H–C–C=C

H_3C

H–C=C=O?

H–C–C

H–C–C?

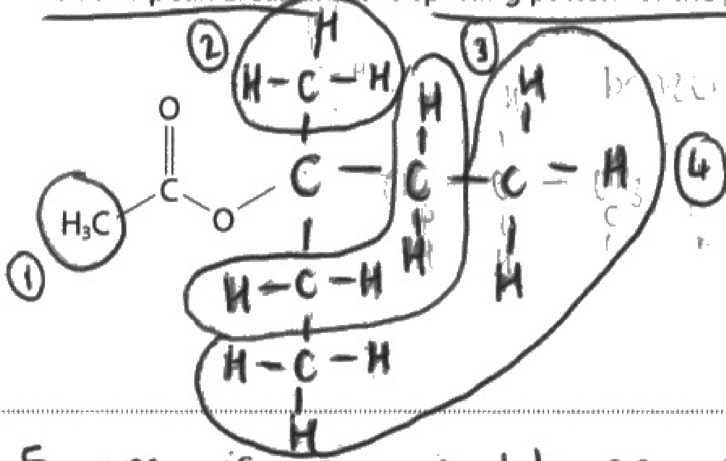
H–C–C

Part of the structure of **Q** is shown. ester

Complete the structure of **Q**.
Justify your answer by linking the proton environments in your structure to the relative peak areas and the splitting pattern of the peaks.

(7)

~~[illegible] C_4H_8O~~!



2.5ppm is a singlet so adjacent to a carbon with no Hydrogens attached, ~~so~~ 3 Hs involved due to relative area 3 and shift is H-C-C=O 2.8-1.8 so must be H_3C - C = O. Proton environment ①.
1.43 ppm shift is a singlet so adjacent to a C with 0 Hs attached: relative peak 3 so 3 Hs in same proton environment (②) shift = CH_3 - C ~~[illegible]~~ - C.
then, 1.56ppm has relative peak area 4 so 4 Hs involved, and quartet splitting pattern so adjacent ~~to~~ carbon attached to 3 hydrogens. 1.56ppm shift = CH_2 - CH_3 ~~*~~ twice (molecule symmetrical so same proton environment) ③ So total 4 Hs, equalling relative area.
Finally, 0.92ppm shift is a triplet so adjacent carbon attached to 2 Hs, and relative peak area 6 so 6 Hs in same environment. 0.92ppm shift so CH_3 - CH_2, again twice as in same environment, ④, so 6 Hs in effectively same proton environment.

ResultsPlus
Examiner Comments

This is an example of an excellent answer that scored 7 marks. The candidate has annotated the table to help them with their answer, which is a good idea as they can check to make sure that they have not missed out anything. The structure of **Q** is clearly drawn and this method of labelling the proton environments is extremely helpful. The candidate has justified their structure by referring to each of the peaks and relating the peak areas to the numbers of protons and the splitting patterns to the number of protons on the adjacent carbon atoms.

ResultsPlus
Examiner Tip

When identifying compounds from NMR data, it is useful to circle and label the different proton environments and to comment on each piece of data given in the question.

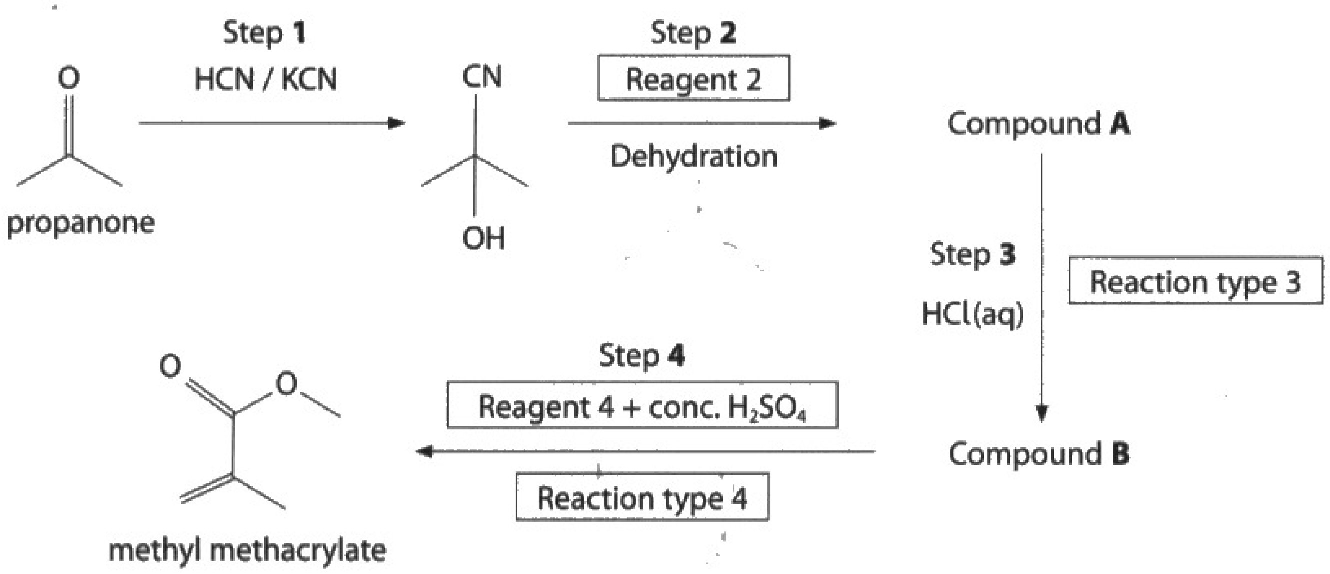
Question 7 (a)(i)

Organic mechanisms always separate out the candidates into those who understand the meaning of a curly arrow and those who try to rote learn, with little or no understanding. Candidates should understand that a curly arrow represents the movement of a pair of electrons so should start from a lone pair of electrons or a covalent bond. Many candidates lost marks by omitting the dipole on the C=O bond and/or the charge on the oxygen in the intermediate and many candidates did not know whether to include full or partial charges.

Some candidates showed the first curly arrow drawn from the nitrogen atom in the CN^- ion, showing that they had not looked at the structure of the product where the carbon atom was attached.

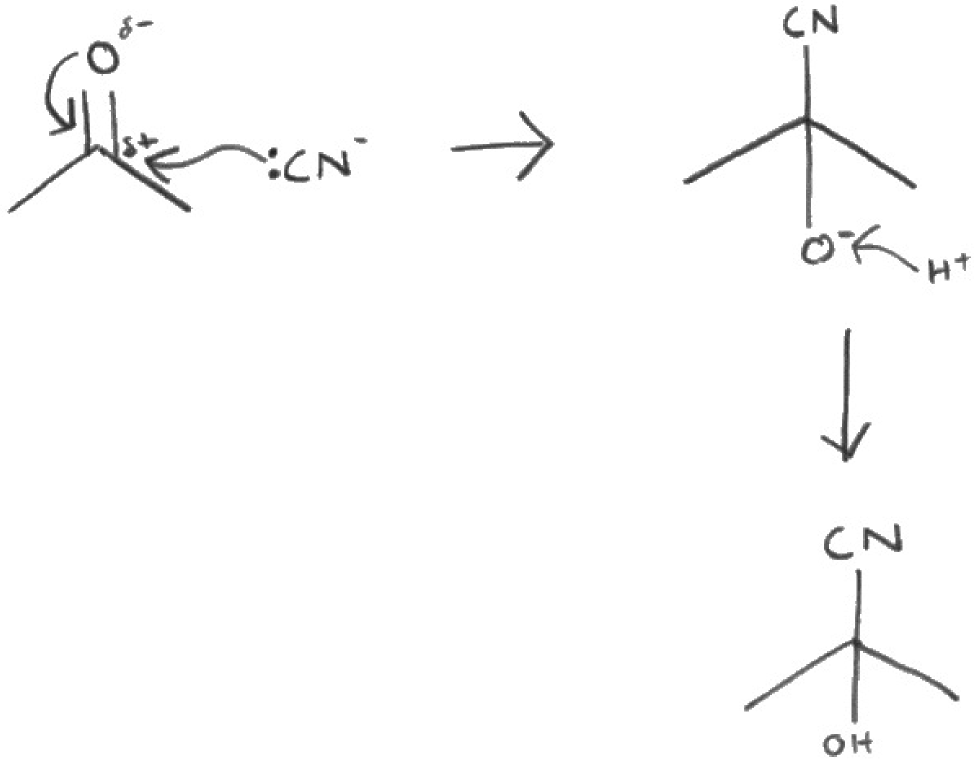
7 This question is about some reactions of carbonyl compounds.

(a) Methyl methacrylate is the monomer used to make the polymer perspex.
It can be synthesised from propanone using the reaction scheme shown.



(i) Draw the mechanism for the reaction in Step **1**.
Include curly arrows and any relevant lone pairs and dipoles.

(4)



ResultsPlus
Examiner Comments

This reponse scored 2 marks. The curly arrow from the lone pair of electrons on the CN – ion to the Cδ+ in propanone is correct. However, the curly arrow from O towards the double bond is incorrect. The structure of the intermediate is correct but a hydrogen ion does not have a lone pair of electrons so the final curly arrow is incorrect.

ResultsPlus
Examiner Tip

Make sure that you understand the meaning of a curly arrow in organic mechanisms. If you understand the mechanisms, you are less likely to make careless errors.

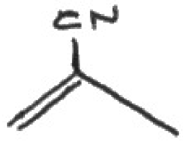
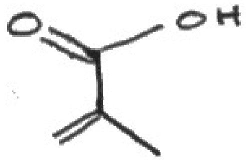
Question 7 (a)(ii)

There were many errors in completing the reagents, types of reaction and structures of products in the table. Many candidates had not revised these reactions carefully enough to score high marks. The esterification in Reaction 4 was more familiar to candidates than the hydrolysis in Reaction 4. Many candidates were careless in drawing structures using skeletal formulae. Unless a question specifically asks for a skeletal formula, it is acceptable to use structural or displayed formulae, provided the functional groups are clear. Some candidates included steam with phosphoric acid for reagent 2 and had not looked carefully enough at the reaction scheme to notice that this reaction had been labelled as dehydration. A common incorrect reagent was $LiAlH_4$.

(ii) Complete the table to show the information missing from the reaction scheme.

C = C – C

(6)

Reagent 2	Conc phosphoric acid
Structure of compound **A**	
Reaction type 3	Acid Hydrolysis of Nitriles
Structure of compound **B**	
Reagent 4	Ethanol
Reaction type 4	Esterification

ResultsPlus
Examiner Comments

This is an example of a very good response that scored 5 marks. The candidate has just made one error in which they gave reagent 4 as ethanol instead of methanol. The 'methyl' part of the name was a clue to use methanol.

ResultsPlus
Examiner Tip

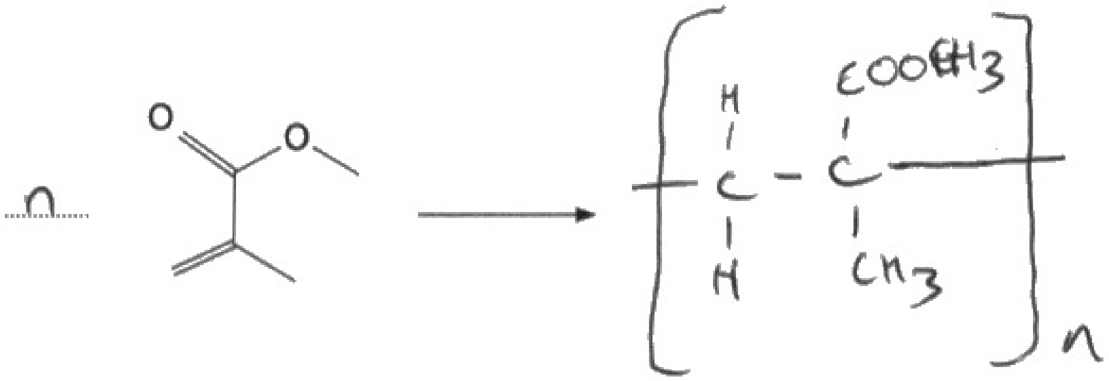
Check your work carefully to make sure that you have used all the information in the question.

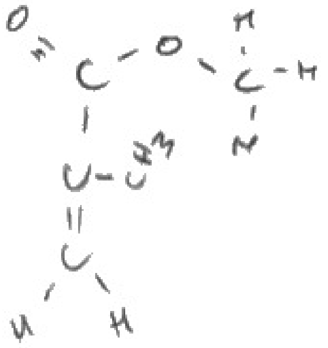
Question 7 (a)(iii)

Many candidates did not understand the skeletal formula of methyl methacrylate so they were unable to complete the equation for the formation of the polymer. The most successful candidates redrew the structure as a displayed formula and they almost all scored 2 marks, although a few omitted the hydrogen atoms on the CH_2 group. Some candidates tried to write an equation with 2s instead of ns.

(iii) Complete the equation for the formation of the polymer from methyl methacrylate.

(2)





ResultsPlus
Examiner Comments

This candidate has redrawn the monomer as a displayed formula so they have completed the equation correctly and scored 2 marks.

ResultsPlus
Examiner Tip

Practise drawing skeletal formulae from displayed formulae and vice versa.

Question 7 (b)

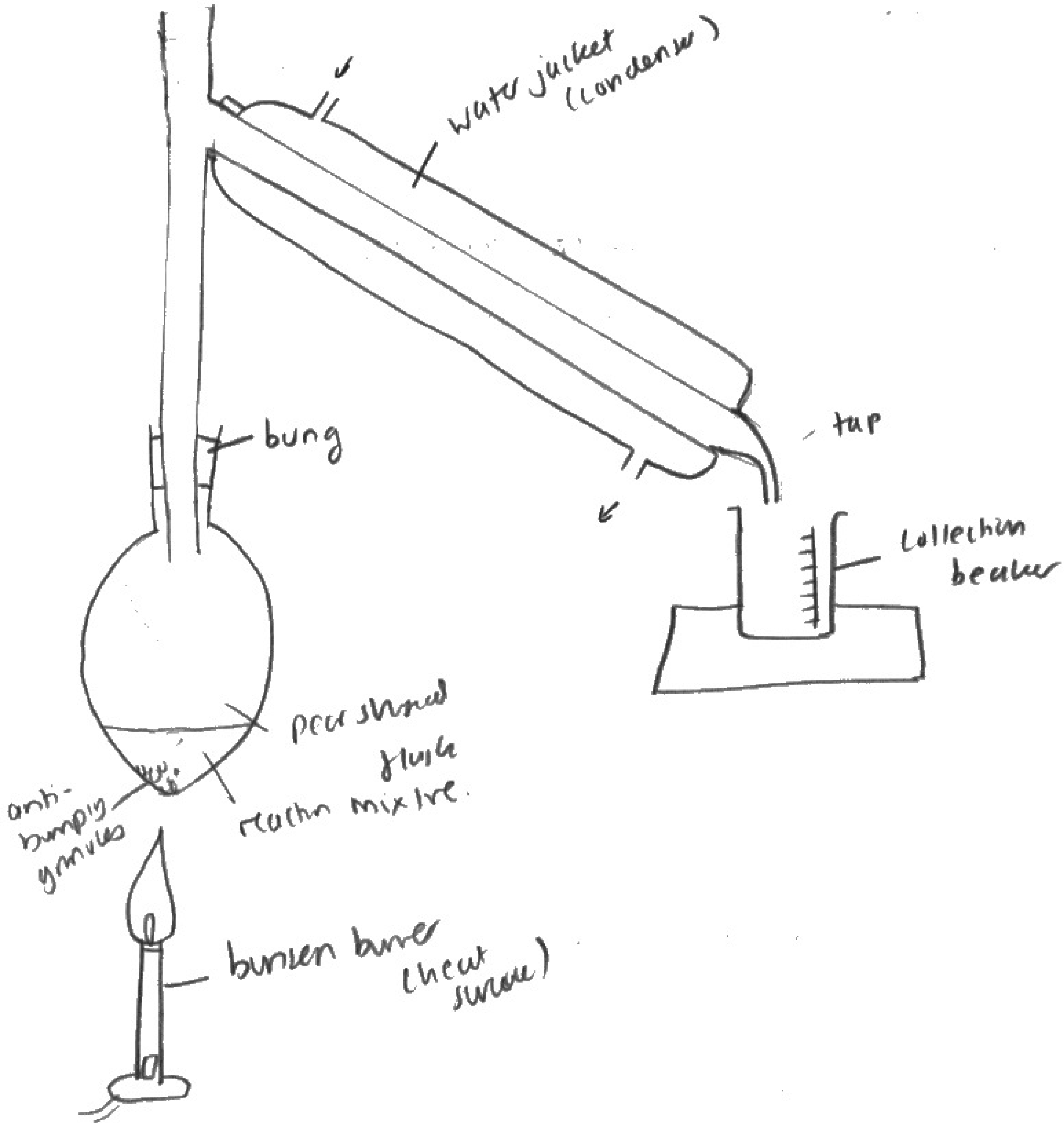
Candidates drew the distillation apparatus with varying degrees of success. There were many good diagrams of apparatus that would work, but there were more that had careless errors showing that the candidates did not think about how distillation could take place in the apparatus they had drawn. The left-hand side of the apparatus proved to be the most difficult, with many candidates drawing a conical flask for heating, not showing a still head or having noticeable gaps around the joints so gas could escape. A thermometer was not essential, but if it was drawn, the bulb needed to be in the still head and not in the liquid. The majority of candidates knew that water needs to enter at the lower end of the condenser but candidates lost marks for not drawing the condenser with a separate water jacket around the inner tube so the water and product would mix. Some candidates lost the final mark if their apparatus was sealed. Some candidates did not read the question and drew apparatus for heating under reflux, using a separating funnel or filtration.

Many candidates would benefit from seeing how the common apparatus is set up and drawing it accurately.

(b) Propanone can be formed from the fermentation of polysaccharides such as starch. The propanone can be separated from the fermentation mixture by distillation.

Draw the apparatus used in the laboratory for distillation of propanone from the reaction mixture.

(3)



ResultsPlus
Examiner Comments

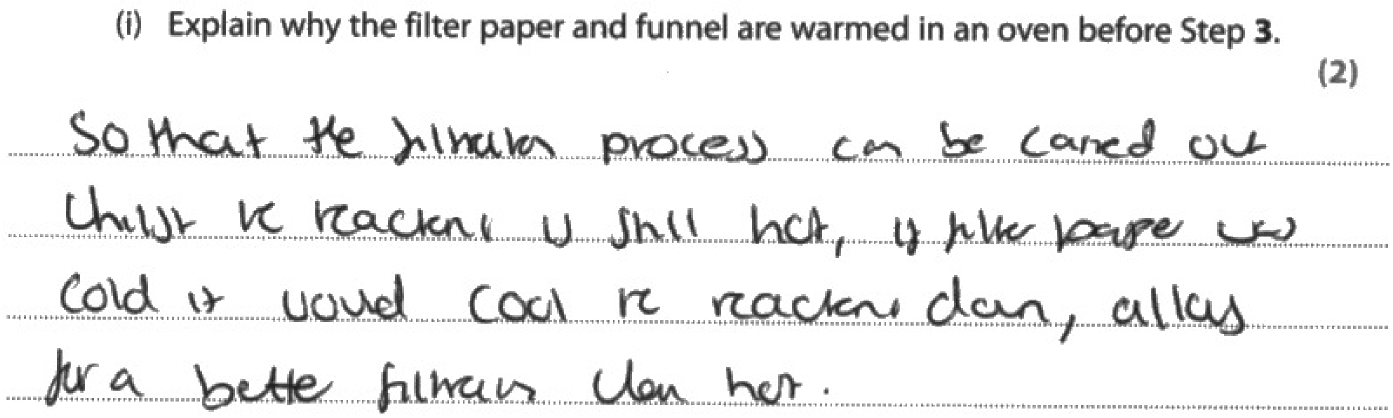
This response scored 1 mark for the open beaker collecting the product. The apparatus is open on the left-hand side so the product would escape from the top and the water flow is incorrect through the condenser.

ResultsPlus
Examiner Tip

Practise drawing diagrams of the apparatus commonly used in school laboratories.

Question 7 (c)(i)

Many candidates were familiar with recrystallisation and understood why the filter paper and funnel need to be warmed before Step **3**. However, a significant number did not understand the process of hot filtration and wrote about removing impurities rather than preventing crystallisation. The solvent chosen for recrystallistion is one in which the compound is soluble when hot but only sparingly soluble when cold. If filtration was carried out using equipment that had not been heated, the solution would cool and crystals would form.



(i) Explain why the filter paper and funnel are warmed in an oven before Step **3**.

(2)

So that the filtration process can be carried out whilst the reaction is still hot, if filter paper was cold it would cool the reaction down, allows for a better filtration when hot.

ResultsPlus
Examiner Comments

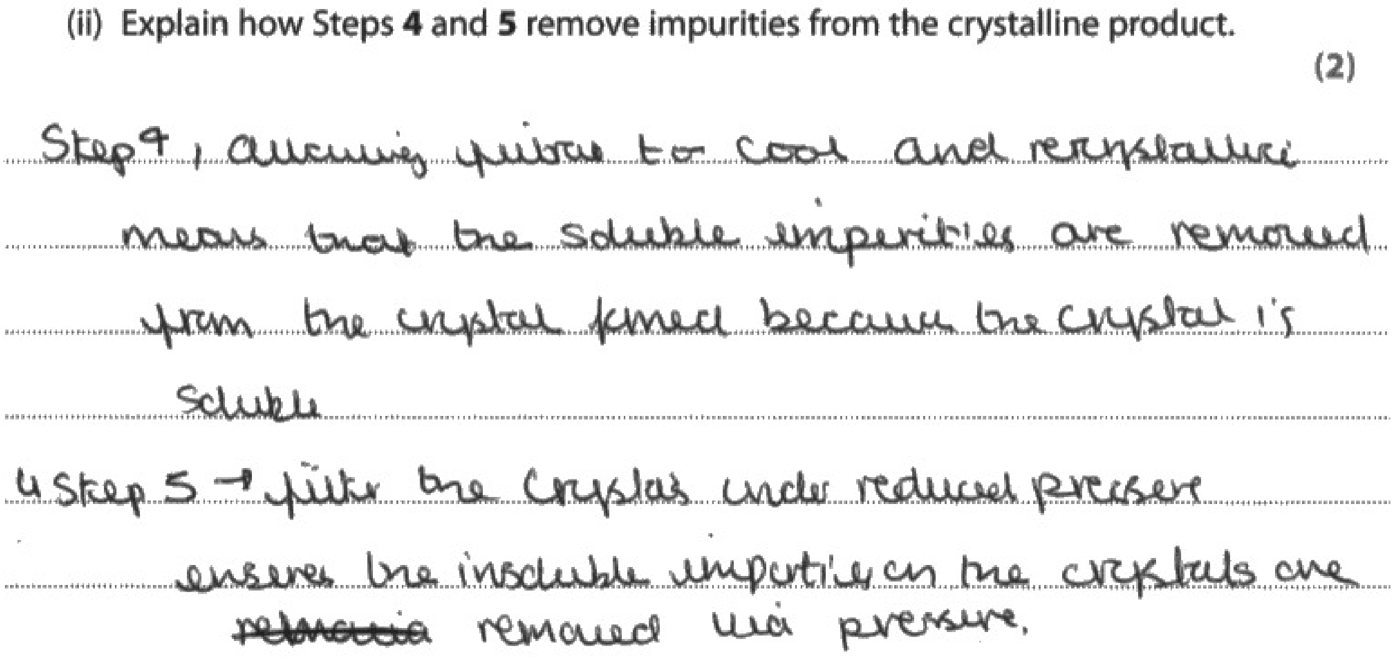
This response scored 1 mark for the idea of keeping the mixture hot. However, the candidate has not understood that crystals would form if it was allowed to cool.

ResultsPlus
Examiner Tip

Revise recrystallisation carefully and make sure that you understand what is happening at each stage in the process.

Question 7 (c)(ii)

Many candidates almost repeated their answer to Q07ci in cii, showing that they did not understand what is happening at each stage of recrystallisation. Answers tended to be very confused as many thought that the impurities would be left on the filter paper. Only a small proportion of candidates were able to clearly explain that the solubility of the hydrazone product decreases as the temperature decreases and that these crystals are pure as the soluble impurities remain in solution. Most candidates would benefit from a review of this process to make sure that they understand how the soluble and insoluble impurities are removed and how the solubility of the desired product varies with temperature.



(ii) Explain how Steps **4** and **5** remove impurities from the crystalline product.

(2)

Step4, allowing mixture to cool and recrystallise means that the soluble impurities are removed from the crystal formed because the crystal is soluble

4 Step 5 → filter the Crystals under reduced pressure ensures the insoluble impurities on the crystals are ~~[illegible]~~ removed via pressure.

ResultsPlus
Examiner Comments

This is an example of an answer that is confused as the candidate does not understand about the impurities and the solubility of the product so it scored 0. Step **4** is incorrect because the crystals are only sparingly soluble in the cold solvent. Step **5** is incorrect as it is the soluble impurities that are removed in the filtrate during filtration and the solid crystals remain on the filter paper.

ResultsPlus
Examiner Tip

Revise the process of recrystallistion carefully to make sure that you understand what is happening in each step.

(ii) Explain how Steps **4** and **5** remove impurities from the crystalline product.

(2)

As it cools the precipitate will crystalise out and the impurities will be left in the solution. Then filtering the crystals under reduced pressure will suck the liquid with the impurities leaving the pure crystals on the the filter paper.

ResultsPlus
Examiner Comments

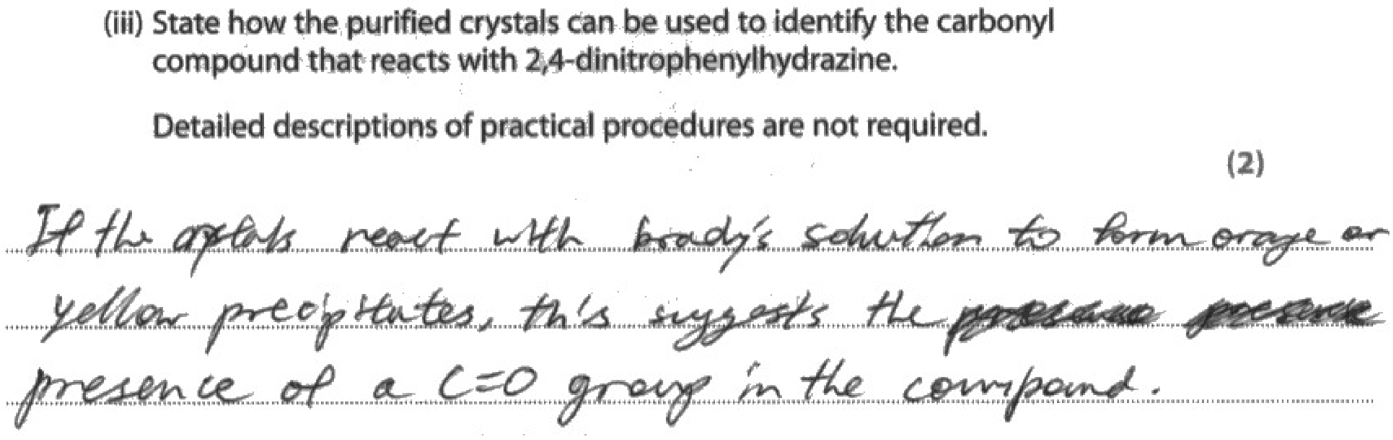
This is an example of a good response that scored 2 marks. This candidate has understood what is happening in Steps **4** and **5** and communicated it clearly using correct terminology.

ResultsPlus
Examiner Tip

Make sure that you understand the stages involved in recrystallisation and you can communicate your answers using correct terminology.

Question 7 (c)(iii)

Many candidates knew that the carbonyl compound could be identified by measuring the melting point of the pure crystalline product and comparing it with values in a data book. A few candidates suggested measuring the boiling point and some suggested just looking at the colour of the crystals would be sufficient to identify them. Some suggested using qualitative tests, for example, using Tollens' reagent or Fehling's solution.



(iii) State how the purified crystals can be used to identify the carbonyl compound that reacts with 2,4-dinitrophenylhydrazine.

Detailed descriptions of practical procedures are not required.

(2)

If the crystals react with brady's solution to form orange or yellow precipitates, this suggests the ~~presence~~ ~~presence~~ presence of a C=O group in the compound.

ResultsPlus
Examiner Comments

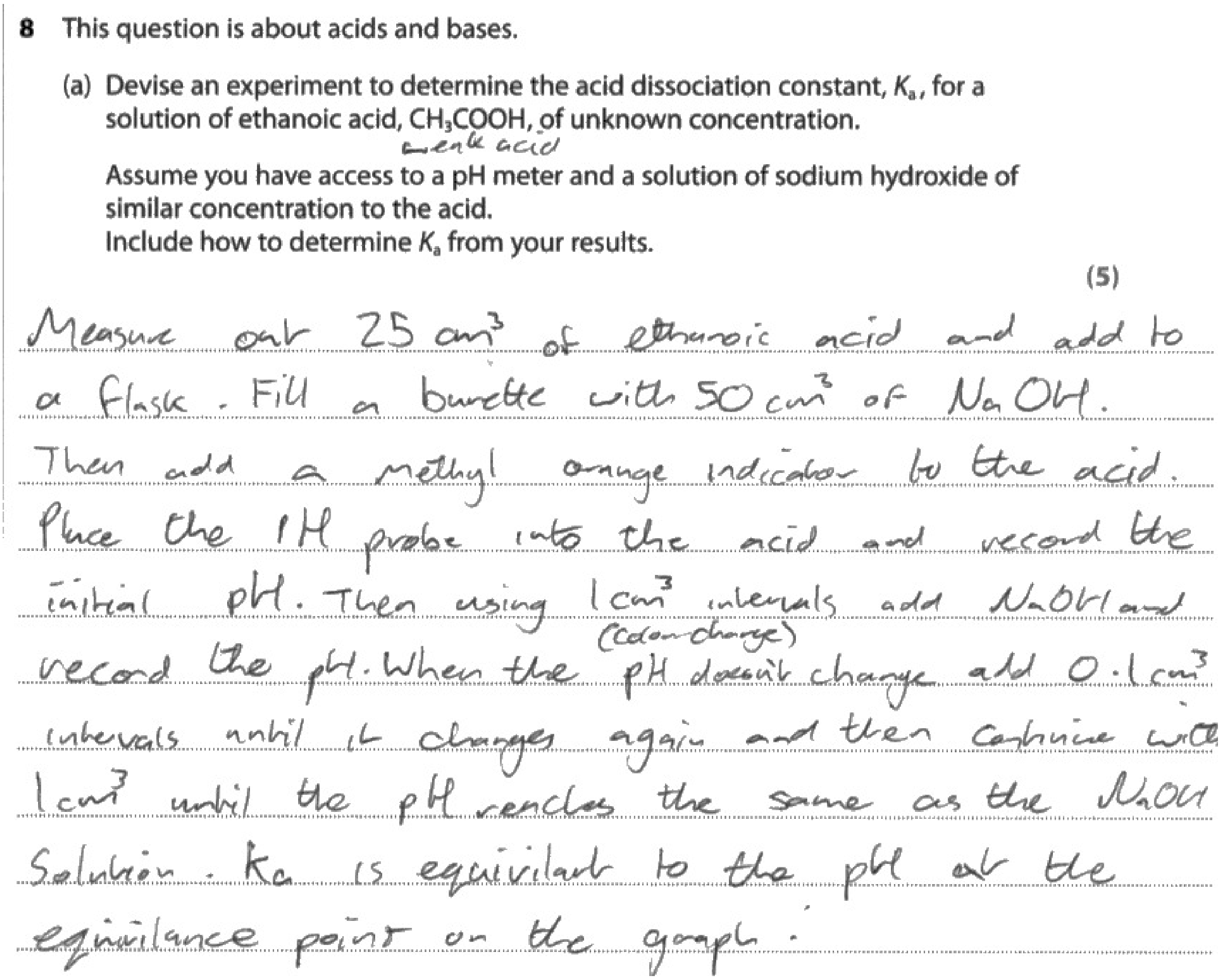
This response scored 0 as the candidate has just repeated the information given in the stem of Q07c. The candidate has not understood that a melting point determination must be carried out and then this is compared with known values from a data book to identify the carbonyl compound.

ResultsPlus
Examiner Tip

Pure solids can be identified by comparing their melting points against known values in a data book.

Question 8 (a)

Many candidates gave excellent descriptions of an experiment to determine the K_a value for ethanoic acid. There are two different methods that are commonly used for this – one involving a titration using an indicator and the other involving the measurement of pH at regular intervals as alkali is added. A significant number of candidates mixed up the two methods. Those who used the indicator often omitted to add the initial volume of acid to the mixture at the end point. The majority of candidates knew how to calculate K_a from the pH at the half neutralisation point. Some candidates spent time describing how to make a standard solution and others gave a lot of detail about how to calibrate the pH probe, which were not required in this question. Some did not read the question and assumed that they knew the exact concentration of the alkali so could calculate the concentration of the acid just by doing a titration.



8 **This question is about acids and bases.**

(a) Devise an experiment to determine the acid dissociation constant, K_a, for a solution of ethanoic acid, CH_3COOH, of unknown concentration.

weak acid

Assume you have access to a pH meter and a solution of sodium hydroxide of similar concentration to the acid.
Include how to determine K_a from your results.

(5)

Measure out 25 cm^3 of ethanoic acid and add to a flask. Fill a burette with 50 cm^3 of NaOH. Then add a methyl orange indicator to the acid. Place the pH probe into the acid and record the initial pH. Then using 1 cm^3 intervals add NaOH and record the pH. When the (colour change) pH doesn't change add 0.1 cm^3 intervals until it changes again and then continue with 1 cm^3 until the pH reaches the same as the NaOH solution. Ka is equivilant to the pH at the equivilance point on the graph.

ResultsPlus
Examiner Comments

This response scored 2 marks for carrying out a titration and measuring the pH at regular intervals while adding the sodium hydroxide solution. An indicator is not necessary when this method is used and methyl orange is not a suitable indicator to use with a weak acid. The candidate has mentioned a graph but has not stated that it is a graph of pH against volume of alkali added. Ka is equal to the pH at the half equivalence point so the last statement is incorrect.

ResultsPlus
Examiner Tip

This question is based on Core Practical 9. Make sure that you are familiar with the Core Practicals as you prepare for your examinations.

Question 8 (b)

Many candidates were able to calculate the concentration of hydrogen ions from the pH but only a few were able to substitute this into the expression for K_a to determine the ratio of the concentrations of the acid and salt then to determine the actual volumes to use to make up 500 cm^3 of the buffer solution. A common error was to treat the buffer solution as a normal weak acid and to use $K_a = [H^{+]2}/[HA]$. Most candidates would benefit with more practice at calculations involving buffer solutions.

(b) 500 cm^3 of a buffer solution of pH = 4.70 is required.

Calculate the volume of 0.800 mol dm^{-3} sodium ethanoate solution and of 0.800 mol dm^{-3} ethanoic acid needed to make this buffer.

[K_a for ethanoic acid = 1.74×10^{-5} mol dm^{-3}]

(3)

$pH = 4.7$

$[H^+] = 1.99526 \times 10^{-5}$

$$ka = \frac{[H^+][CH_3COO^-]}{[CH_3COOH]}$$

$$ka = \frac{[H^+][\text{salt}]}{[\text{acid}]}$$

$$\frac{1.74 \times 10^{-5}}{1.99526 \times 10^{-5}} = \frac{[\text{salt}]}{[\text{acid}]}$$

$$0.8720658 = \frac{[\text{salt}]}{[\text{acid}]}$$

$\therefore$ $[\text{acid}]\ 0.8720658 = [\text{salt}]$

salt = 0.8720658 mol dm^{-3}

= 0.4360 moles

=

ResultsPlus
Examiner Comments

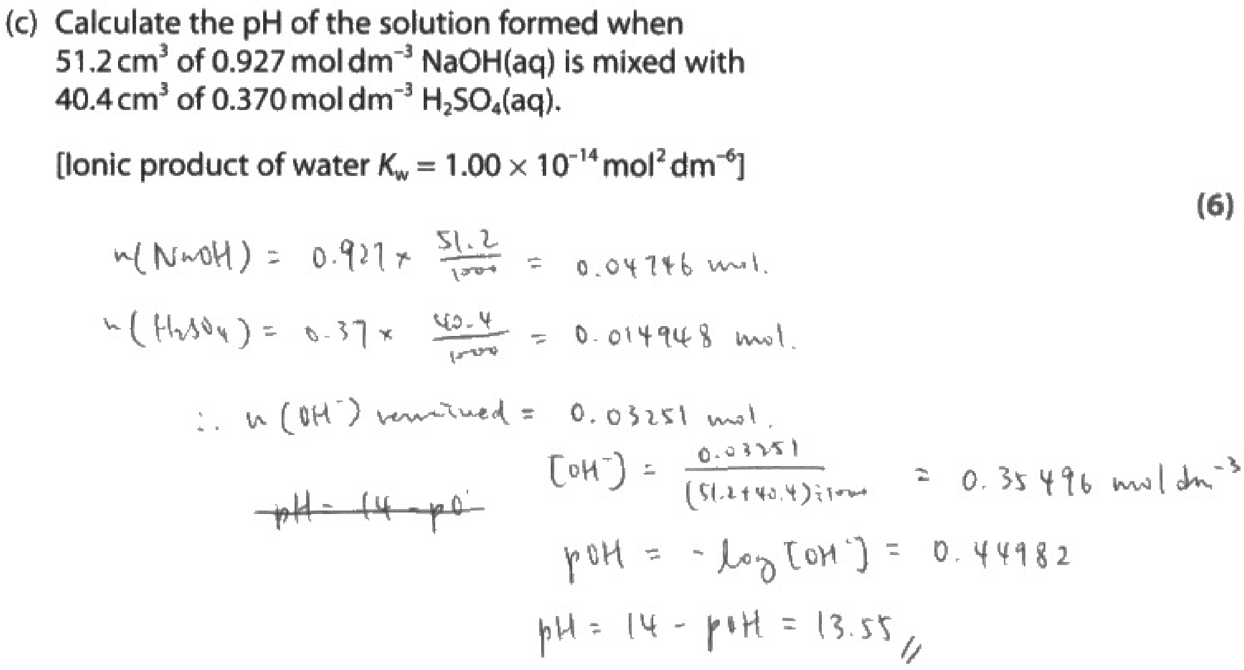
This response scored 2 marks for calculating the concentration of hydrogen ions from the pH and for calculating the ratio of [salt] : [acid]. The candidate could have scored the third mark by calculating the volume of each solution needed by using the ratio and the total volume of solution needed (500 cm^3).

ResultsPlus
Examiner Tip

Check the information in the question carefully to make sure that you use all essential data.

Question 8 (c)

This style of calculation seemed more familiar to candidates than the buffer solution calculation in Q08b. The majority of candidates scored two marks for calculating the number of moles of sulfuric acid and sodium hydroxide. A significant number did not realise that the number of moles of hydrogen ions available in the solution is twice the number of moles of sulfuric acid. However, they could still score 5 marks if they carried out the other steps correctly. Some candidates just calculated the number of moles of excess hydroxide ions and did not convert it into a concentration before determining the pH. Candidates who wrote a few words to explain the steps in their calculation were more likely to be awarded transferred error marks if they made a mistake as the examiner could follow what they had done. Those who just wrote a jumble of numbers in a seemingly random order, would not receive credit if it was not clear what they were calculating.



(c) Calculate the pH of the solution formed when $51.2\,cm^3$ of $0.927\,mol\,dm^{-3}$ $NaOH(aq)$ is mixed with $40.4\,cm^3$ of $0.370\,mol\,dm^{-3}$ $H_2SO_4(aq)$.

[Ionic product of water $K_w = 1.00 \times 10^{-14}\,mol^2\,dm^{-6}$]

(6)

$n(NaOH) = 0.927 \times \frac{51.2}{1000} = 0.04746$ mol.

$n(H_2SO_4) = 0.37 \times \frac{40.4}{1000} = 0.014948$ mol.

$\therefore$ $n(OH^-)$ remained $= 0.03251$ mol.

~~pH = 14 - pO~~

$[OH^-] = \frac{0.03251}{(51.2+40.4) \div 1000} = 0.35496\,mol\,dm^{-3}$

$pOH = -\log[OH^-] = 0.44982$

$pH = 14 - pOH = 13.55$ //

ResultsPlus

Examiner Comments

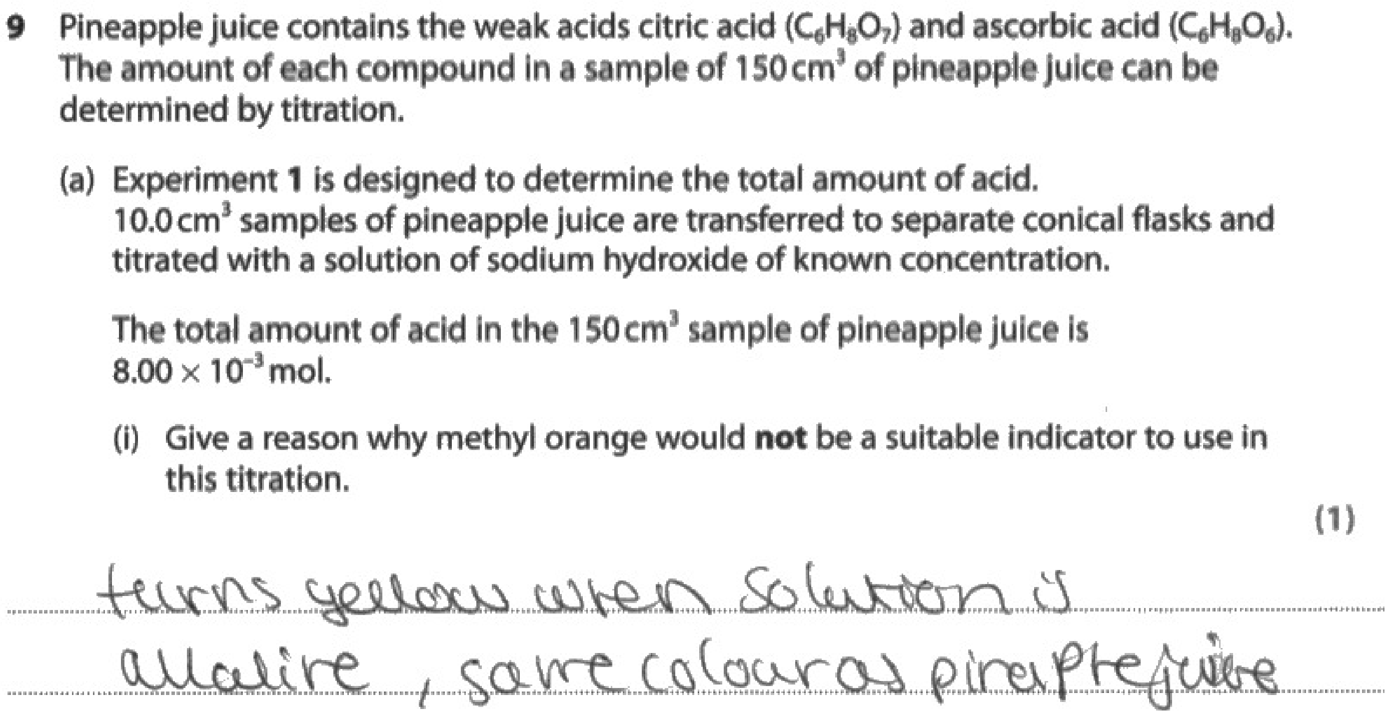
This candidate has made a good attempt at this question and scored 5 marks. They have explained their working so it is clear to see that they have just omitted to multiply the number of moles of sulfuric acid by 2 to determine the number of moles of H^+ ions.

ResultsPlus
Examiner Tip

Remember that 1 mole of a diprotic acid, such as H_2SO_4, produces 2 moles of H^+ ions when it reacts in a titration.

Question 9 (a)(i)

The majority of candidates could give an acceptable reason why methyl orange is not a suitable indicator to use in the titration. A higher proportion of candidates referred to the pH range of methyl orange than to the colour being masked by the colour of the pineapple juice.



9 Pineapple juice contains the weak acids citric acid ($C_6H_8O_7$) and ascorbic acid ($C_6H_8O_6$). The amount of each compound in a sample of 150 cm^3 of pineapple juice can be determined by titration.

(a) Experiment **1** is designed to determine the total amount of acid. 10.0 cm^3 samples of pineapple juice are transferred to separate conical flasks and titrated with a solution of sodium hydroxide of known concentration.

The total amount of acid in the 150 cm^3 sample of pineapple juice is 8.00×10^{-3} mol.

(i) Give a reason why methyl orange would **not** be a suitable indicator to use in this titration.

(1)

turns yellow when Solution is alkaline , same colour as pineapple juice

ResultsPlus
Examiner Comments

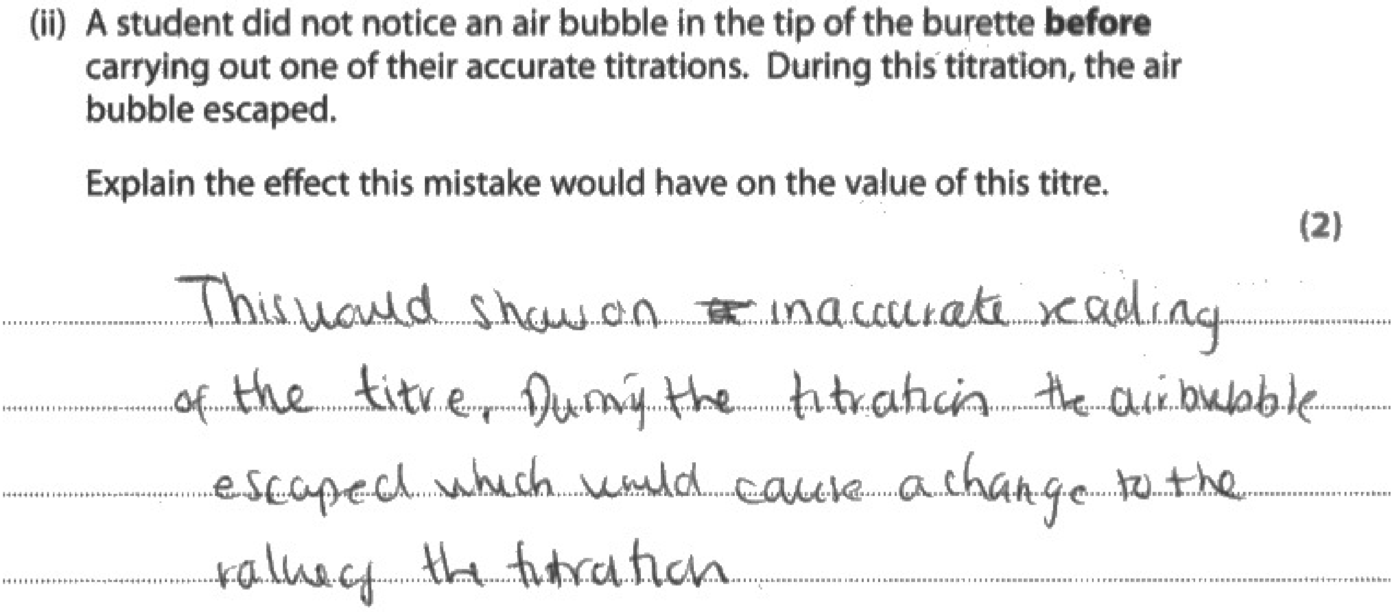
This response scored 1 mark for the idea of the colour of the indicator and the pineapple juice being the same.

ResultsPlus
Examiner Tip

Remember that if a titration is carried out using a coloured solution, it may be more difficult to see the colour change of the indicator.

Question 9 (a)(ii)

Many candidates scored 1 mark for stating that the titre would be greater than expected but they could not all give a clear reason for this. There was quite a lot of confusion between the reading on the burette and the titre, so answers such as 'the initial reading was too high so the titre would be too low' were often seen.



(ii) A student did not notice an air bubble in the tip of the burette **before** carrying out one of their accurate titrations. During this titration, the air bubble escaped.

Explain the effect this mistake would have on the value of this titre.

(2)

This would show an ~~[illegible]~~ inaccurate reading of the titre, During the titration the air bubble escaped which would cause a change to the value of the titration

ResultsPlus
Examiner Comments

This answer scored 0 as it was too vague. An 'inaccurate reading' is not sufficient as it must state whether it is higher or lower. The idea of the air bubble escaping is correct but just stating 'which would cause a change to the value of the titration' is insufficient.

ResultsPlus
Examiner Tip

If there is a change during an experiment, always state whether the change is an increase or a decrease.

(ii) A student did not notice an air bubble in the tip of the burette **before** carrying out one of their accurate titrations. During this titration, the air bubble escaped.

Explain the effect this mistake would have on the value of this titre.

(2)

It would increase the titre. ~~At~~ ~~As a tar~~
As more sodium hydroxide would be
required.

ResultsPlus
Examiner Comments

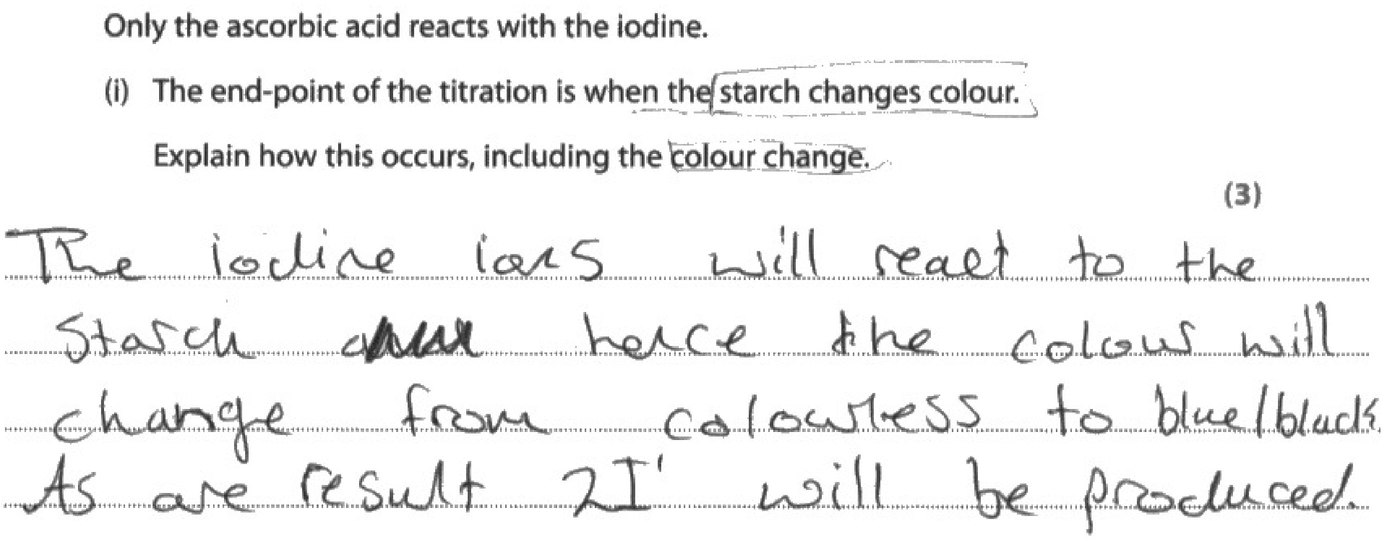
This response scored 1 mark for 'increase the titre'. However, 'more sodium hydroxide would be required' is just restating that the titre would be higher so it does not score a mark.

ResultsPlus
Examiner Tip

An explanation requires a reason for the statement you have made.

Question 9 (b)(i)

It was disappointing to see how few candidates knew that starch reacts with iodine to give a blue-black complex. A significant number of candidates wrote that starch reacts with iodide ions or iodine ions to give a blue-black colour and it would turn colourless at the end point. Only a small minority of candidates could explain that the iodine produced when iodate(V) ions react with iodide ions immediately reacts with ascorbic acid so it is only when all the ascorbic acid is used up that iodine can react with the starch to form the blue-black colour.



Only the ascorbic acid reacts with the iodine.

(i) The end-point of the titration is when the starch changes colour.

Explain how this occurs, including the colour change.

(3)

The iodine ions will react to the starch ~~[illegible]~~ hence the colour will change from colourless to blue/black. As are result $2I^-$ will be produced.

ResultsPlus
Examiner Comments

This response scored 1 mark for the correct colour at the end. It is iodine molecules that react with starch, not iodine ions or iodide ions.

ResultsPlus
Examiner Tip

Learn what happens in titrations involving iodine and starch.

Question 9 (b)(ii)

Many candidates were able to calculate the mass of citric acid in the 150 cm^3 sample of pineapple juice. Almost all candidates could calculate the number of moles of iodate(V) ions used, however, a significant number used an incorrect mole ratio to calculate the number of moles of iodine and hence ascorbic acid. Most realised that they had to multiply by 30 to find the number of moles in the 150 cm^3 sample. They could then do a subtraction and multiply the number of moles by the relative formula mass to determine the mass of citric acid, although some used the relative formula mass of ascorbic acid. Candidates were awarded transferred error marks if they omitted one or more steps.

(ii) The **total** amount of acid in the 150 cm³ sample is 8.00×10^{-3} mol.

The mean titre in Experiment **2** using 5.00 cm³ of pineapple juice is 9.50 cm³.

Calculate the mass of **citric acid** in the 150 cm³ sample.

(5)

~~concentration of acid~~

moles ascorbic acid:

titre = 9.5cm³.   0.001 KIO_3

moles $KIO_3 = 0.0095 \times 0.001 = 9.5 \times 10^{-6}$

moles Iodine produced $= 9.5 \times 10^{-6} \times 3 = 2.85 \times 10^{-5}$

2.85×10^{-5} moles ascorbic acid.

$C_6H_8O_6$ $(8.00 \times 10^{-3}) - (2.85 \times 10^{-5})$

$72 + 8 + 96 = 176$ $= 7.97 \times 10^{-3}$ moles citric ~~acid~~ acid.

$C_6H_8O_7$

192

moles $= \frac{mass}{mr}$

mass $= 192 \times (7.97 \times 10^{-3})$

$= 1.53024$ g

$= 1.53$ g

ResultsPlus
Examiner Comments

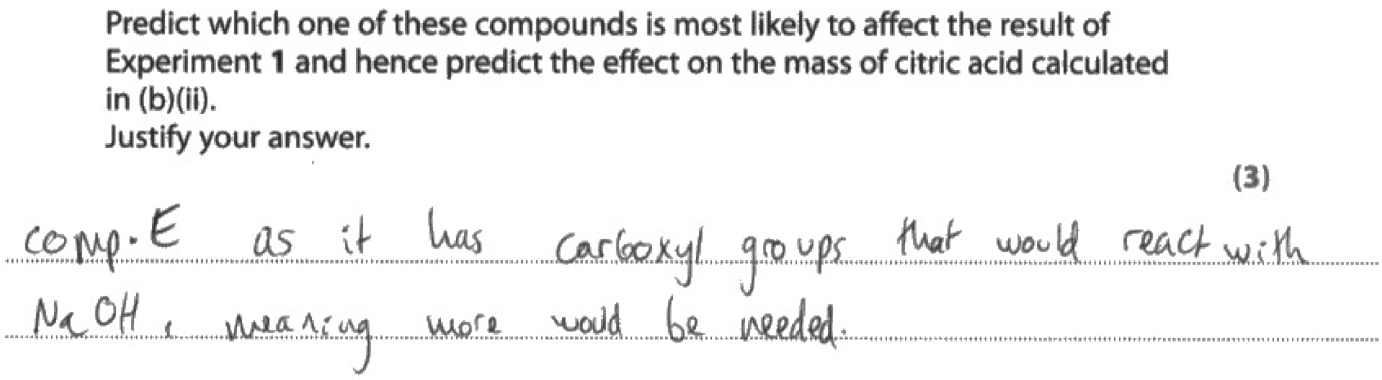
This candidate has made a good attempt at this calculation and explained their working. They were awarded 4 marks for this answer. The only step they omitted was to work out the amount of ascorbic acid in the 150 cm^3 sample.

ResultsPlus
Examiner Tip

Explain your working clearly so that examiners can award you transferred error marks if you make an error or omit a step in a calculation.

Question 9 (c)

Many candidates realised that compound **E** contained carboxylic acid groups so it would also react with sodium hydroxide during the titration in Experiment **1** so the final mass of citric acid calculated would be greater than the true amount. Some candidates thought that the OH groups would react with sodium hydroxide.



Predict which one of these compounds is most likely to affect the result of Experiment **1** and hence predict the effect on the mass of citric acid calculated in (b)(ii).
Justify your answer.

(3)

comp. E as it has carboxyl groups that would react with NaOH, meaning more would be needed.

ResultsPlus
Examiner Comments

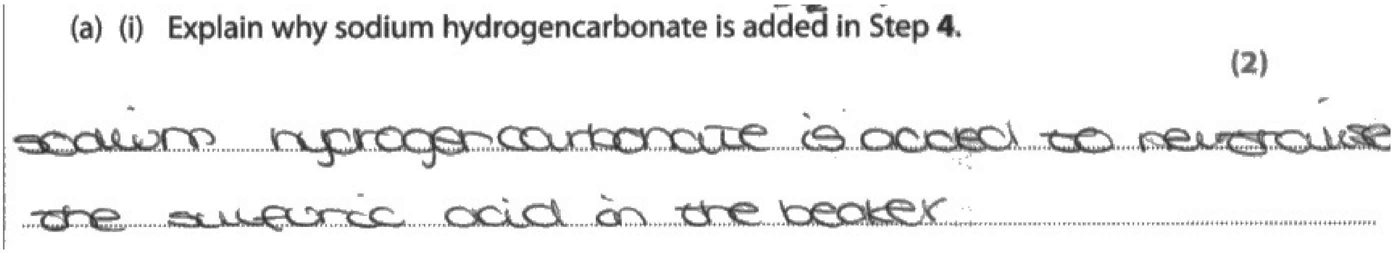
This response scored 2 marks for identifying compound E has carboxyl groups that would also react with sodium hydroxide. However, they have not completed their answer by predicting the effect on the mass of citric acid.

ResultsPlus
Examiner Tip

Check your answers to make sure that you have answered all parts of the question.

Question 10 (a)(i)

The majority of candidates knew that sodium hydrogencarbonate was added to quench the reaction but many of them did not go on to say that it does this by neutralising the sulfuric acid.



(a) (i) Explain why sodium hydrogencarbonate is added in Step **4**.

(2)

sodium hyprogencarbonate is added to neutralise the sulfuric acid in the beaker

ResultsPlus
Examiner Comments

This response scored 1 mark for sodium hydrogencarbonate neutralises the sulfuric acid. To score a second mark, they would need to state that this quenches or stops the reaction.

ResultsPlus
Examiner Tip

Explanations require a reason for your answer.

Question 10 (a)(ii)

It was disappointing that very few candidates were able to write the ionic equation for the reaction between sodium hydrogencarbonate and acid. A common error was to use carbonate ions instead of hydrogencarbonate ions. However, many candidates tried to include iodine and iodide ions in their equation.

(ii) Write the **ionic** equation for the reaction that takes place during Step **4**.
State symbols are not required.

(1)

$$CO_3^{2-} + 2H^+ \rightarrow CO_2 + H_2O$$

ResultsPlus
Examiner Comments

This was a common incorrect answer that scored 0. This would be the ionic equation if sodium carbonate was used.

ResultsPlus
Examiner Tip

Remember that sodium hydrogen carbonate contains hydrogencarbonate ions, HCO_3^-.

Question 10 (b)

It was disappointing that many candidates did not score 2 marks for plotting the graph. The points at 6.5 and 10.5 min were often plotted incorrectly. Candidates who chose a difficult scale for volume, invariably plotted at least one point incorrectly. Just a few candidates plotted time on the y axis or did not chose a suitable scale so the points cover at least half the available space.

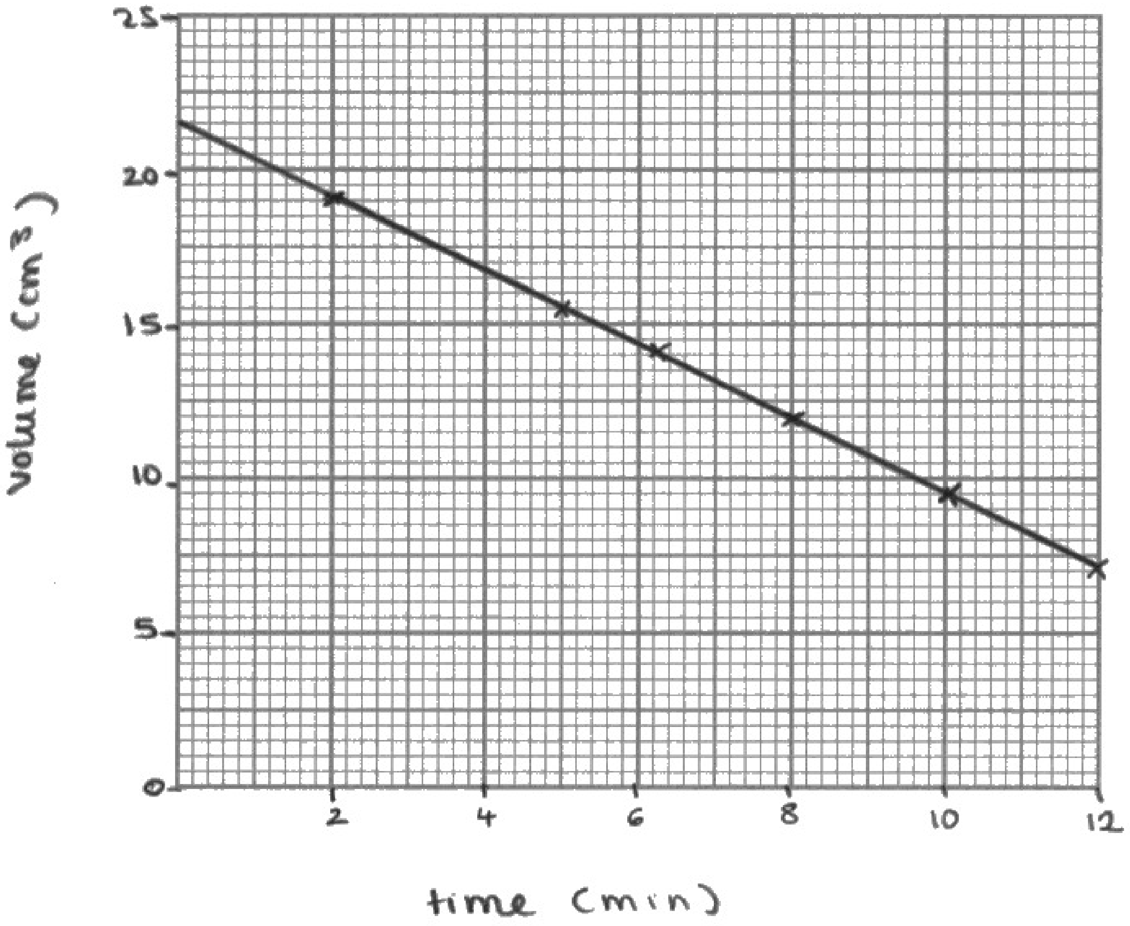
Many candidates skipped the link between volume of sodium thiosulfate and concentration of iodine and just wrote what they knew about zero order reactions rather than apply their knowledge to this particular experiment and graph. Most candidates scored a mark for mentioning that the graph is a straight line. Many candidates were confused with first order reactions and wrote about half lives.

(b) Some data from the experiment are shown.

Time sodium hydrogencarbonate is added / min	2.0	5.0	6.5	8.0	10.5	12.0
Volume of sodium thiosulfate / cm^3	19.2	15.5	14.0	12.1	9.5	7.2

(i) Plot a graph of the volume of sodium thiosulfate against the time the sodium hydrogencarbonate is added.

(2)



(ii) Explain how the graph of volume of thiosulfate against time confirms the reaction is zero order with respect to iodine, I_2.

(3)

the graph is a straight line. Therefore the rate is independent of the volume of I_2.

ResultsPlus
Examiner Comments

This response scored 1 mark for the graph. The candidate has plotted the points for 6.5 min and 10.5 min incorrectly.

1 mark was awarded for the statement that the graph is a straight line. The candidate has not made the important link that the volume of sodium thiosulfate is proportional to the concentration of iodine so the rate of reaction is independent of the concentration of iodine, not its volume.

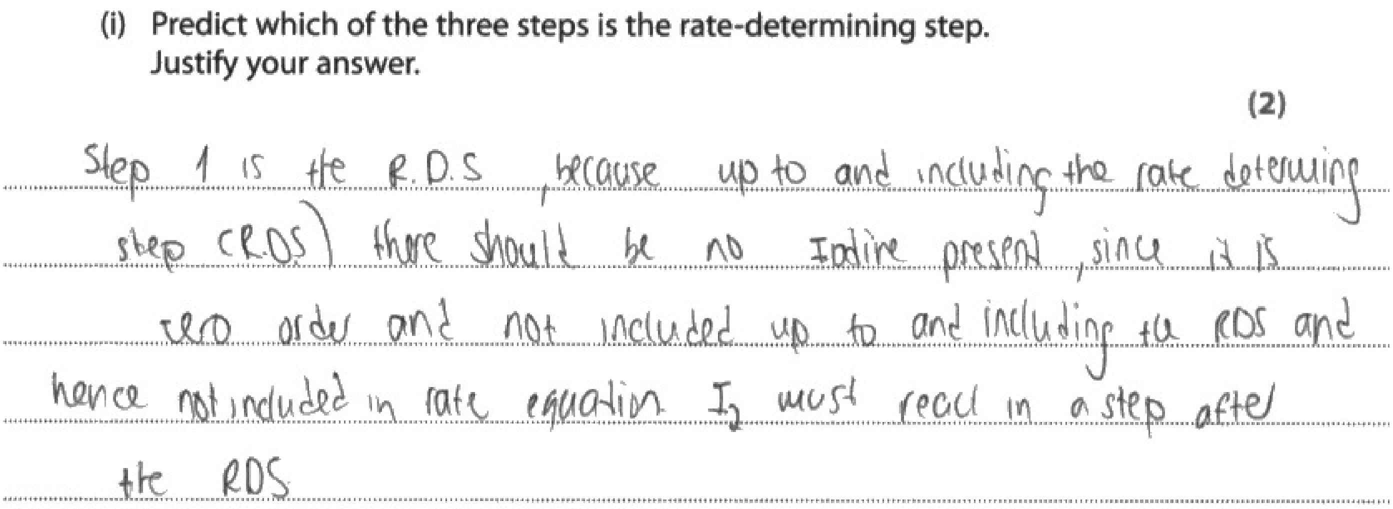
ResultsPlus
Examiner Tip

Always check that you have plotted the points correctly on a graph.

Orders of reactions show how the rate of reaction is related to the concentrations of the reactants.

Question 10 (c)(i)

Many candidates could predict the rate-determining step and explain this using the rate equation.



(i) Predict which of the three steps is the rate-determining step.
Justify your answer.

(2)

Step 1 is the R.D.S, because up to and including the rate determining step (R.D.S) there should be no Iodine present, since it is zero order and not included up to and including the RDS and hence not included in rate equation I_2 must react in a step after the RDS

ResultsPlus
Examiner Comments

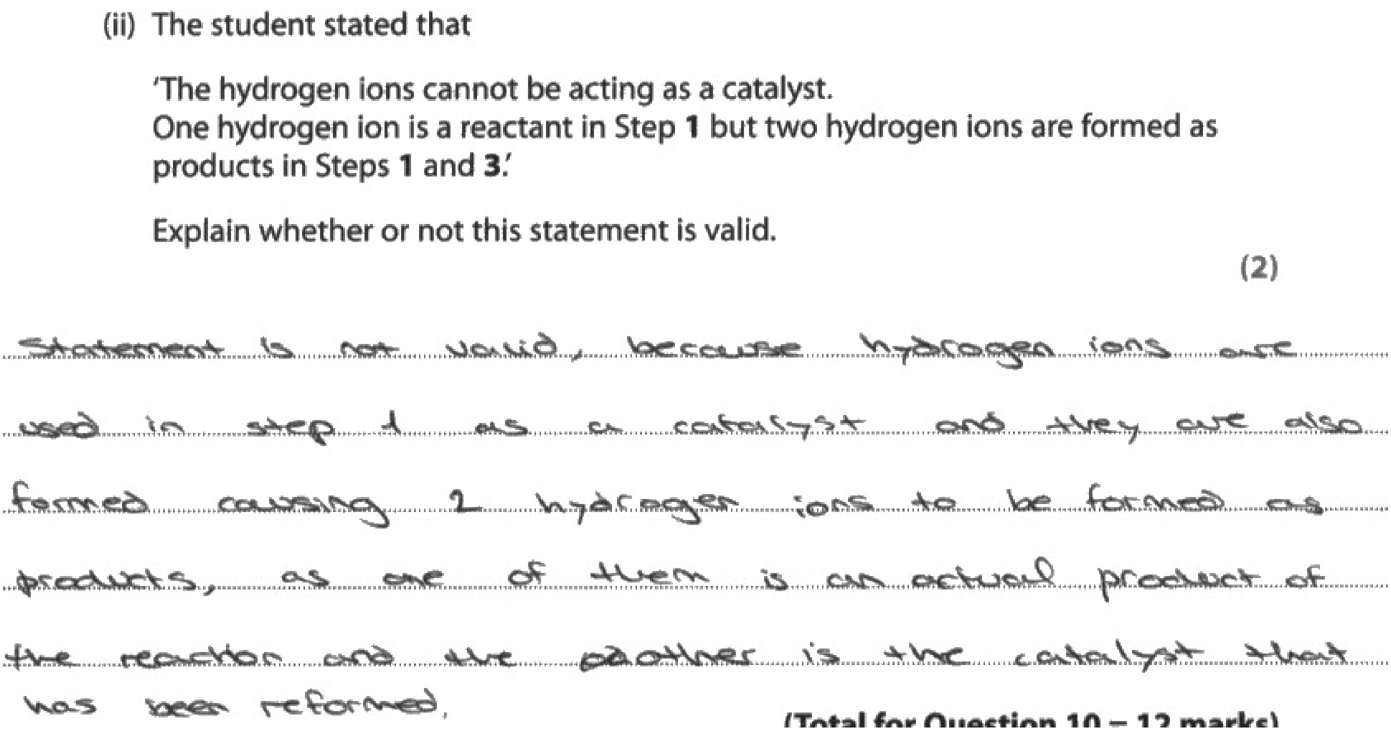
This is an example of a good answer that focused on why iodine is not included in the rate-determining step as it is zero order.

ResultsPlus
Examiner Tip

Make sure that you understand the significance of a reaction being zero order with respect to a particular reactant.

Question 10 (c)(ii)

Some candidates were not clear about how to answer this question. Many scored a mark for the idea that a hydrogen ion is used up in Step **1** but is regenerated later so it is a catalyst. Fewer candidates worked out that another hydrogen ion is a product of the reaction.



(ii) The student stated that

'The hydrogen ions cannot be acting as a catalyst.
One hydrogen ion is a reactant in Step **1** but two hydrogen ions are formed as products in Steps **1** and **3**.'

Explain whether or not this statement is valid.

(2)

Statement is not valid, because hydrogen ions are used in step 1 as a catalyst and they are also formed causing 2 hydrogen ions to be formed as products, as one of them is an actual product of the reaction and the another is the catalyst that has been reformed.

(Total for Question 10 = 12 marks)

ResultsPlus
Examiner Comments

This is an example of a response that scored 2 marks. The candidate has the correct idea that one hydrogen ion is used and reformed so is a catalyst but another is a product of the reaction.

ResultsPlus
Examiner Tip

Remember that a catalyst can take part in a reaction but it will be reformed at the end. For example when Fe^{2+} ions are used to catalyse the reaction between I^- and $S_2O_8^{2-}$, they are oxidised to Fe^{3+} by reacting with the persulfate ions then reduced back to Fe^{2+} by reacting with the iodide ions.

Paper Summary

On the basis of their performance on this paper, candidates are offered the following advice:

- always read the question carefully and check that you have understood what is required
- after you have written your answer, re-read the question and your answer to ensure you have fully answered the question
- practise converting a skeletal formula into a displayed formula and vice versa
- explain all your working in unstructured calculations so that if you make an error, you have the opportunity to be awarded transferred error marks
- draw organic mechanisms accurately, remembering that curly arrows need to be precisely located
- practise answering extended writing questions so you undertand how to improve your performance by giving more relevant details
- make sure you understand the practical techniques used in the Core Practicals
- practise drawing apparatus used in the preparation and purification of organic liquids and solids
- practise evaluating the results of experiments.

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