Examiners' Report
June 2017

GCE Chemistry 8CH0 02

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Introduction

The paper opened with two relatively easy multiple choice questions followed by a short basic calculation style question. This seemed to settle the candidates well for the more challenging questions that followed. The paper was designed to keep most candidates engaged for the entire 90 minutes but there was no evidence that candidates were running out of time. Most candidates attempted all the questions and nearly all made some effort to complete the final question, Question 8(c), which was a relatively lengthy calculation.

Most candidates wrote legibly and there were very few instances where examiners reported that they were unable to decipher the candidates' writing. This was particularly important in the longer free response question, Question 6(a), which required candidates to complete up to one page of continuous writing.

Only one question, Question 4(a), seemed to cause issues with writing in the space provided on the question paper. The candidates' responses could easily have been accommodated within the space provided, and the majority gave their answers within this allocated space. However, the mass spectrum that followed inadvertently provided a substantial adjacent space and some candidates used this area to write a more expansive answer. Please could centres remind their candidates to write only in the spaces provided?

Question 3 (a)

Most candidates appeared to have some idea of how to approach this question. Most attempted to convert the mass of carbon dioxide and the mass of water into moles, but then problems were encountered by those who failed to recognise that water contains two hydrogens.

A number of candidates managed to introduce oxygen into this hydrocarbon.

Full marks were awarded if both the correct molecular and empirical formulae were given. There are many different ways to calculate either formula, the other formula can then easily be deduced from the first. Some candidates omitted one or more stages in their calculation, notably the calculation of moles of H. Many of these candidates still progressed to a correct molecular and/or empirical formula. The mark scheme recognised that some stages of the calculation might have been held on a calculator and not therefore written down.

A common error was an attempt to introduce oxygen as an additional element in the compound A, even though the question clearly states that A is a hydrocarbon.

3 (a) In an experiment, 1.000 g of a hydrocarbon, **A**, was burned completely in oxygen to produce 3.143 g of carbon dioxide and 1.284 g of water.

In a different experiment, the molar mass of the hydrocarbon, **A**, was found to be 84.0 g mol^{-1}.

Calculate the empirical formula and the molecular formula of the hydrocarbon, **A**.

(4)

CO_2		H_2O	
3.143g		1.284g	~~mol~~ ~~1/mol = g mol^{-1}~~
44g mol^{-1}		18g mol^{-1}	
0.0714 mol		0.0713 mol	
1	:	1	

$CH_2 + 1\frac{1}{2}O_2 \rightarrow CO_2 + H_2O$

$CH_2 = 14g\,mol^{-1}$

$84 / 14 = 6$

hydrocarbon A empirical formula = CH_2

molecular formula = C_6H_{12}

ResultsPlus
Examiner Comments

Mark awarded = 4

In this response the candidate has correctly deduced the empirical formula, and from that and the molar mass, the correct molecular formula. Several stages of the calculation have been omitted from the response as written here; namely the moles of H and the ratio C:H. However, the candidate must have processed this information (possibly on a calculator) to get the correct empirical formula.

ResultsPlus
Examiner Tip

Show **all** stages in your calculation.
In this example the empirical and molecular formulae have both been correctly deduced so full marks were awarded. However, if something goes wrong in a calculation the examiner will need to see exactly where the error occurred so that credit can be given for work that has been correctly done. This is particularly relevant where transferred errors apply.

3 (a) In an experiment, 1.000 g of a hydrocarbon, **A**, was burned completely in oxygen to produce 3.143 g of carbon dioxide and 1.284 g of water.

In a different experiment, the molar mass of the hydrocarbon, **A**, was found to be 84.0 g mol^{-1}.

Calculate the empirical formula and the molecular formula of the hydrocarbon, **A**.

(4)

$X + O_2 \rightarrow CO_2 + H_2O$

1g 1.1424 3.143 1.284 $n = \frac{mg}{Mr}$

mr = 84

$\frac{3.143}{44}$ $\frac{1.284}{18}$

$\frac{1}{84}$ = 0.0119 = 0.0714 = 0.07133

7 7

X

CO_2 3.143 + 1.284 = 4.427

H_2O Oxygen = 4.427 − 1

= 3.427g

$\frac{1}{84} = 0.0119$

6

$\frac{0.0119}{0.0119} = 1$

$\frac{3.427}{16} = 0.2141$

$\frac{3.143}{44} = 0.07143$ $\frac{0.2141}{0.0119} = 17.99$

$\frac{1.284}{18} = 0.07133$ $\frac{0.07143}{0.0119} = 6.00$

$\frac{0.07233}{0.0119} = 6.07$

$\Rightarrow C_6H_{17}O_6$

ResultsPlus
Examiner Comments

Mark awarded = 1

This is an example of a response where a mass of oxygen has been introduced. The early part of the answer is correct; the candidate has correctly calculated the moles of carbon dioxide/carbon. The moles of water have also been calculated but not then x2 to get moles of hydrogen. The rest of the answer is then made impossible by the introduction of a mass of oxygen.

ResultsPlus
Examiner Tip

Read the question carefully. If the compound is a hydrocarbon there is no oxygen in the empirical or molecular formulae.

This is an example of a response that gained full marks and included all the essential stages in the calculation with relatively little extraneous written material.

3 (a) In an experiment, 1.000 g of a hydrocarbon, **A**, was burned completely in oxygen to produce 3.143 g of carbon dioxide and 1.284 g of water.

In a different experiment, the molar mass of the hydrocarbon, **A**, was found to be 84.0 g mol^{-1}.

Calculate the empirical formula and the molecular formula of the hydrocarbon, **A**.

(4)

mols of $CO_2 = 3.143 \div (12+16+16) = 0.0714$

mols of $H_2O = 1.284 \div (2+16) = 0.0713$

C	H
0.0714	0.0713 × 2
	= 0.143
÷ 0.0714	÷ 0.0714
= 1	≈ 2

empirical formula = CH_2

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

$84 \div 14 = 6$

molecular formula = C_6H_{12}

ResultsPlus
Examiner Comments

Mark awarded = 4

Full marks awarded. Every stage is clearly written down and the calculation is easy to follow.

ResultsPlus
Examiner Tip

This is a good example of clear thinking and an answer that shows all the essential stages of the calculation.

Question 3 (b) (i)

This question tested the candidates' ability to carry out a calculation of the heat energy required to raise the temperature of a given volume of water, and then to convert this to the enthalpy change for a combustion reaction. The third mark required the candidate to recognise that the reaction was exothermic and to give the final answer to an appropriate number of significant figures.

(i) Use these results to calculate the enthalpy change of combustion of hydrocarbon **A** in kJ mol^{-1}.

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

(3)

$Q = mc\Delta T$

$= (250 \times 1) \times 4.18 \times (29.5 - 21.3)$

$= 8569\ J.$

$n_{(A)} = \frac{m}{M} = \frac{112.99 - 112.732}{84} = 0.258\ mol.$

$\Delta H_c^{\ominus} = \frac{8569}{0.258} = 33213\ J mol^{-1}$

$= 33.2\ kJ mol^{-1}$

ResultsPlus
Examiner Comments

Mark = 1

The calculation of Q has been successfully completed for M1. The calculation of moles of hydrocarbon is incorrect. M2 not awarded.
The mark scheme allows for a transferred error from Q but not from the moles of hydrocarbon. The negative sign is missing from the final answer. M3 not awarded.

ResultsPlus
Examiner Tip

Read the question carefully. If a sign is required, it MUST be included (+ or –).

This response was awarded full marks.

(i) Use these results to calculate the enthalpy change of combustion of hydrocarbon **A** in kJ mol^{-1}.

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

(3)

$Q = mc\Delta T$

$= \frac{250}{1} \times 4.18 \times (21.3 - 29.5)$

$= -8569 \text{ J}$

$= -8.569 \text{ kJ}$

$m_A = 112.99 - 112.732 = 0.258$

$n_A = \frac{0.258}{84} \approx 0.0031 \text{ mol}$

$\frac{Q}{n_A} = -2789.91 \text{ kJ mol}^{-1} \simeq -2800 \text{ kJ mol}^{-1}$

So, the enthalpy change of combustion is $-2800 \text{ kJ mol}^{-1}$

ResultsPlus
Examiner Comments

Mark = 3

An example of a fully correct calculation, clearly presented.
The final answer is presented to 2 SF.
2 or 3 SF were allowed in the mark scheme.

ResultsPlus
Examiner Tip

The answer has been rounded to 2 SF, which is appropriate since some of the data is to 3 SF but other data, for example the temperature change, is to 2 SF. A sign is included, as required by the question. Retain accuracy by working to a higher number of significant figures throughout the calculation; adjust the final answer to the appropriate number of significant figures.
The units are not essential in the final answer because the question specifies the units. If they are given, they must be correct (as here).

Question 3 (b) (ii)

This question concerned the practical aspects of the experiment which had been described in the question. It tests the ability of the candidate to recognise that copper, as a metal, is a better thermal conductor than glass.

Although the question could be answered by comparing the insulation properties of copper and glass, a common error was to think that copper was a better insulator than glass.

This response was not awarded any credit.

(ii) The beaker used in this experiment was made of copper rather than glass.
Give a reason for this. unreactive

(1)

Copper is ~~unreactive and~~ will not absorb heat energy unlike glass. If glass was used it would absorb heat energy and affect the result.

ResultsPlus
Examiner Comments

Mark = 0

This answer relates to the heat capacity of copper and glass and therefore does not explain why copper is used. In fact, the thermal capacity of copper is significantly greater than glass.

ResultsPlus
Examiner Tip

You are not expected to know the relative thermal conductivities of glass and copper (or the thermal capacities). Just use your general knowledge of metals and non-metals.

This is another response that did not gain any credit.

(ii) The beaker used in this experiment was made of copper rather than glass.
Give a reason for this.

(1)

~~glass conducts heat wh~~ copper is an insulator so does not (~~remove~~) use heat from experiment.

ResultsPlus
Examiner Comments

Mark = 0
As a metal, the thermal losses from copper would be greater than those from glass.

ResultsPlus
Examiner Tip

Use your general knowledge of metals and non-metals.

This response was also awarded 0 marks.

(ii) The beaker used in this experiment was made of copper rather than glass.
Give a reason for this.

(1)

Copper absorbs less heat energy than glass.

ResultsPlus
Examiner Comments

Mark = 0
This answer refers to heat capacity.

(ii) The beaker used in this experiment was made of copper rather than glass.
Give a reason for this.

(1)

Copper is a better conductor than glass. Heats the water better.

ResultsPlus
Examiner Comments

Mark = 1

This response identifies copper as a better conductor than glass. Since the question concerns thermal energy, it may be assumed that the candidate is referring to thermal conduction.

ResultsPlus
Examiner Tip

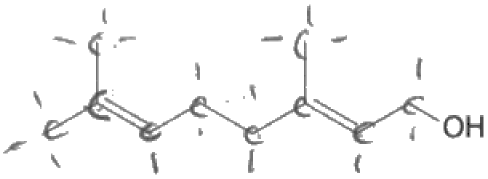
A better answer would refer to THERMAL or HEAT conduction, to distinguish from electrical conduction (which is not relevant here).

Question 4 (a)

This question required the conversion of a skeletal formula to a molecular formula. The geraniol molecule used in the question is quite large and considerable care was required to correctly assess the number of hydrogen atoms.

Some candidates were unable to deduce the molecular formula but were still able to successfully calculate the molar mass from the skeletal formula.

4 (a) The characteristic smell of pine wood is due, partly, to the presence of a group of compounds called terpenes. One of the simpler terpenes is a compound called geraniol, which is an oily liquid at room temperature and pressure. The structure of geraniol is



Deduce the molecular formula of geraniol. Use your answer to calculate the molar mass of geraniol in g mol^{-1}.

(2)

10 C = 120 Mr

18 H = 18 Mr

1 O = 16 Mr +

→ 154 g mol^{-1}

~~$CH_3C(CH_3)CH$~~

~~$C_{10}H_{17}OH$~~

ResultsPlus

Examiner Comments

Mark = 1

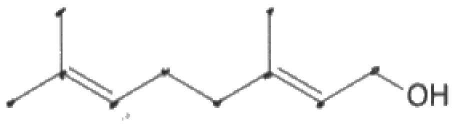
The number of atoms of each element has been correctly deduced but no molecular formula has been included. M1 is not awarded. The correct molar mass is given for M2.

ResultsPlus

Examiner Tip

If a molecular formula is required, ensure that you write one. Although the correct numbers of each atom have been identified here, the examiner cannot know how they might have been arranged in a formula.

4 (a) The characteristic smell of pine wood is due, partly, to the presence of a group of compounds called terpenes. One of the simpler terpenes is a compound called geraniol, which is an oily liquid at room temperature and pressure. The structure of geraniol is



Deduce the molecular formula of geraniol. Use your answer to calculate the molar mass of geraniol in g mol^{-1}.

(2)

$C_{10}H_{17}(OH)$

$M = 12 \times 10 + 17 \times 1 + 16 + 1$

$= 154 \text{ g mol}^{-1}$

ResultsPlus
Examiner Comments

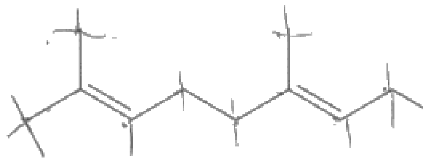
Mark = 1

This response demonstrates a common error; the formula given is not a molecular formula, so M1 is not awarded. The molar mass has been correctly calculated for M2.

ResultsPlus
Examiner Tip

Ensure that you know what is meant by the different types of formula (empirical, molecular, displayed, structural etc.).

4 (a) The characteristic smell of pine wood is due, partly, to the presence of a group of compounds called terpenes. One of the simpler terpenes is a compound called geraniol, which is an oily liquid at room temperature and pressure. The structure of geraniol is



Deduce the molecular formula of geraniol. Use your answer to calculate the molar mass of geraniol in g mol^{-1}.

(2)

~~$C_9H_{17}OH$~~ $C_{10}H_{18}O$

molar mass = 154 ~~136~~ ~~148~~ g mol^{-1}

ResultsPlus
Examiner Comments

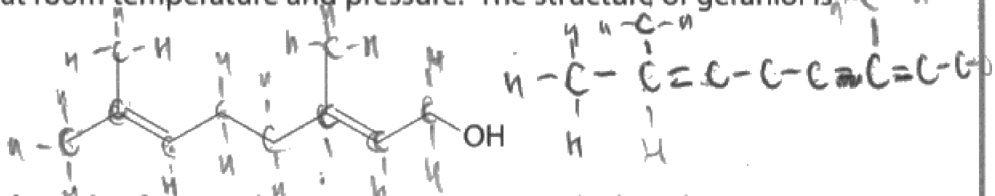
Mark = 2

This is an example of a completely correct answer which was awarded both marks.

ResultsPlus
Examiner Tip

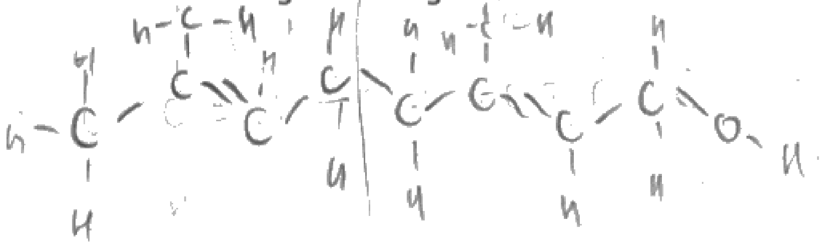
The units have been included in this answer but there would have been no penalty if they had been omitted because the question asks for the molar mass in g mol^{-1}.

4 (a) The characteristic smell of pine wood is due, partly, to the presence of a group of compounds called terpenes. One of the simpler terpenes is a compound called geraniol, which is an oily liquid at room temperature and pressure. The structure of geraniol is



Deduce the molecular formula of geraniol. Use your answer to calculate the molar mass of geraniol in g mol^{-1}.

(2)



$C_{10}H_{18}OH$

$= 155 \text{ g mol}^{-1}$

ResultsPlus
Examiner Comments

Mark = 0
The number of hydrogens has been incorrectly interpreted from the skeletal formula. There is no TE for M2 from an incorrect molecular formula.

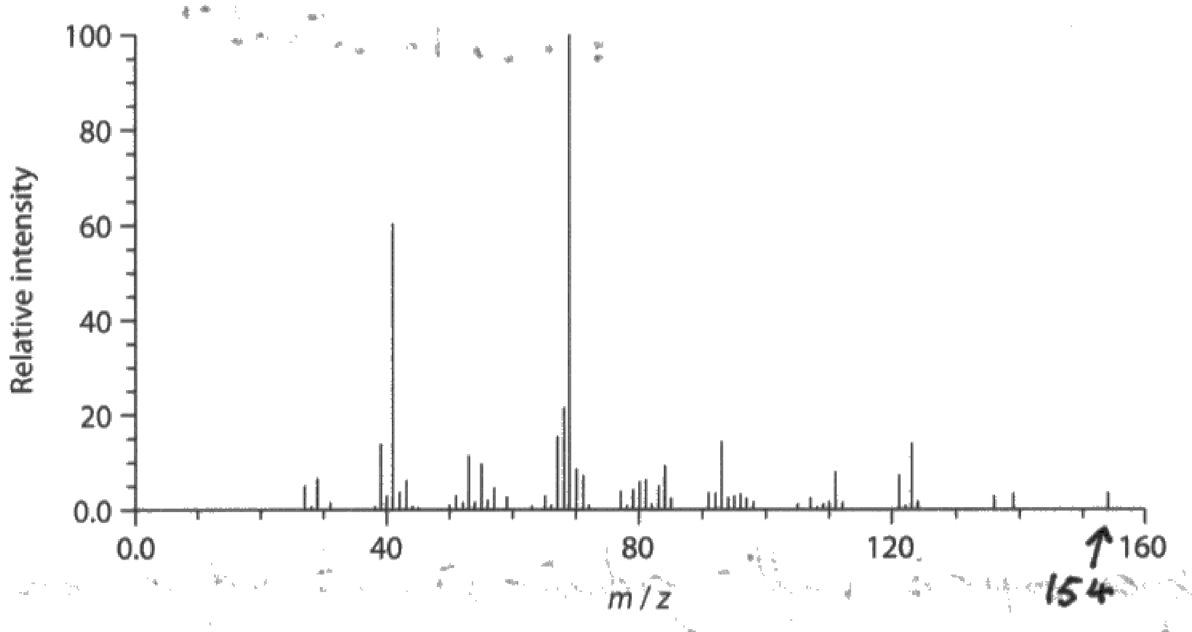
ResultsPlus
Examiner Tip

Ensure that you can interpret skeletal formulae. Practice interconversion between the various types of formulae.

Question 4 (b) (i)

This question tested the ability to recognise that the highest *m/z* peak, also called the parent ion peak/molecule ion peak, is likely to be the molecule (with one electron removed). This should then be related to the molar mass of geraniol. Although the scale is small, inspection of the peak places it slightly below halfway between 150 and 160, i.e. at 154. Those candidates who thought the peak was at 155 or higher should have checked this against their answer to Question 4(a) and recognised the error.

(b) The mass spectrum of geraniol is shown.



(i) Show that this mass spectrum can be used to confirm the molar mass of geraniol. **(1)**

The highest peak is the mr of geraniol. This is at 154, so mr = 154.

ResultsPlus
Examiner Comments

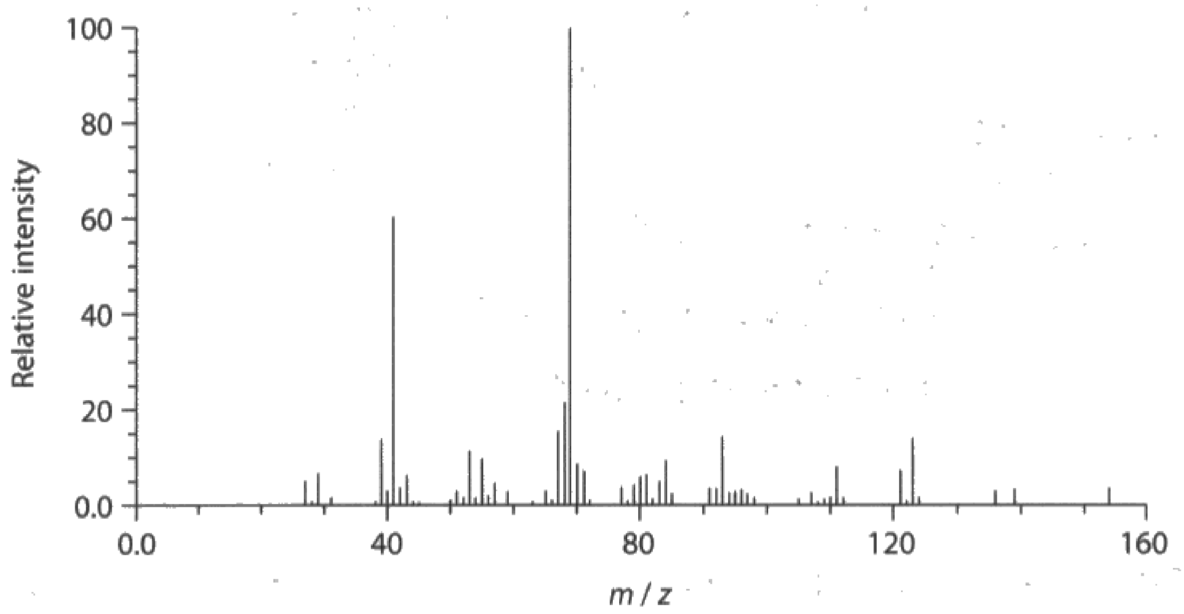
Mark = 1

This answer just gets the mark. The 'highest peak' alone would not have been awarded the mark because 'highest' could also mean the tallest peak. It is the identification of the peak at 154 that has secured the mark.

ResultsPlus
Examiner Tip

Identify the peak as the parent peak/ molecular ion peak/last peak on the right/ highest *m/z* peak.
If you use the term 'M^+ peak' you should explain what you mean by this.

(b) The mass spectrum of geraniol is shown.



(i) Show that this mass spectrum can be used to confirm the molar mass of geraniol.

(1)

There is a peak at the m/z value of 154 so shows the molecular ion and confirms its RFM is 154 $g\,mol^{-1}$.

ResultsPlus
Examiner Comments

Mark = 1

This is equivalent to molecule ion peak at 154. The answer refers to the RFM rather than molar mass but the meaning is clear. The number 154 is quoted as the molecular ion, which confirms the molar mass.

Question 4 (b) (ii)

This question required the candidate to consider the skeletal formula presented in Question 4(a) and then decide how the molecule could have been broken up to produce a fragment with *m/z* = 69.

The correct charge on the fragment was also required.

(ii) Identify an ion that could be responsible for the peak at *m* / *z* = 69. **(1)**

$(CH_3)_2CCHCH_2^+$

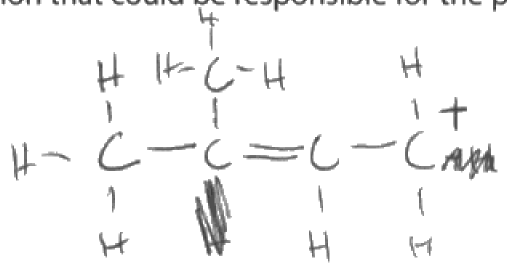
ResultsPlus
Examiner Comments

Mark = 1
The skeletal formula has been correctly interpreted to deduce a structural formula for the fragment. The charge has also been included.

ResultsPlus
Examiner Tip

Remember that the charge will always be +, and must be included. In this instance, any style of formula for the correct fragment was acceptable but you could be asked for a displayed, skeletal or structural formula etc.

(ii) Identify an ion that could be responsible for the peak at *m* / *z* = 69. **(1)**



$(CH_3C(CH_3)=CHCH_2^+)$

ResultsPlus
Examiner Comments

Mark = 1

The type of formula required was not specified in the question, so any correct formula (structural, displayed, skeletal etc.) is acceptable, but the charge must be shown.

ResultsPlus
Examiner Tip

If the formula of the fragment is presented in two or more different forms, here as displayed and structural formulae, both must be correct.

(ii) Identify an ion that could be responsible for the peak at *m* / *z* = 69. **(1)**

$C_5H_9^{2-}$

ResultsPlus
Examiner Comments

Mark = 0
$C_5H_9^+$ would have been an acceptable way to write the formula, but in this example the sign and magnitude of the charge are incorrect.

ResultsPlus
Examiner Tip

The fragments in mass spec will always have a + charge. It is essential to include the charge.

Question 4 (c)

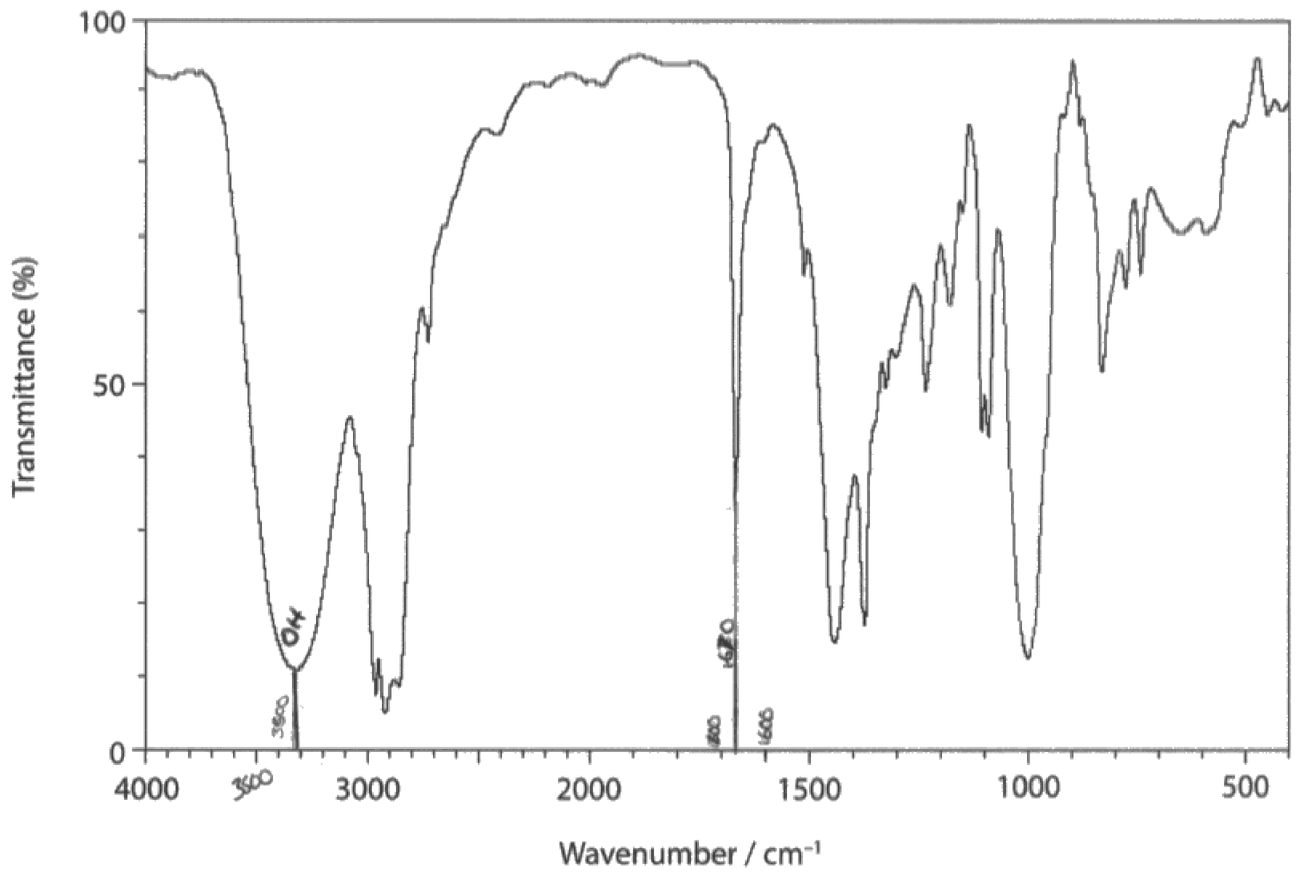
This question required the interpretation of infrared spectra to identify the two functional groups in geraniol. The functional groups were easily identified from the skeletal formula given in Question 4(a) and candidates could look for absorptions that corresponded to these functional groups. The question required the name of each functional group, plus the wavenumber range and the bond responsible in each case.

Common errors included functional groups that were not present in the geraniol, e.g. aldehyde, carboxylic acid and amine. Alkane was also occasionally seen as a functional group.

Other errors included the omission of the bond responsible (1 rescue mark was available if this was omitted from both functional groups). The name of the functional group was also occasionally missing, even though this requirement was bold on the question paper.

Candidates were sometimes a little vague about the bond responsible for the absorption, for example, – O-H could mean the O-H bond or it might mean the C-O bond.

(c) The infrared spectrum of geraniol is shown.



Using the table of absorptions from the Data Booklet and the infrared spectrum, give the **names** of the two functional groups present in geraniol.
To confirm these functional groups, give the wavenumber ranges and their corresponding bonds.

(2)

First functional group OH (hydroxide) has a wavenumber range of 3770-3200 and peaked at about 3310. This makes it an alcohol.

Second functional group C=C (unsaturated) has a wavenumber range of 1669 – 1645 and peaked at around 1670. This makes it an alkene.

ResultsPlus
Examiner Comments

Mark = 1

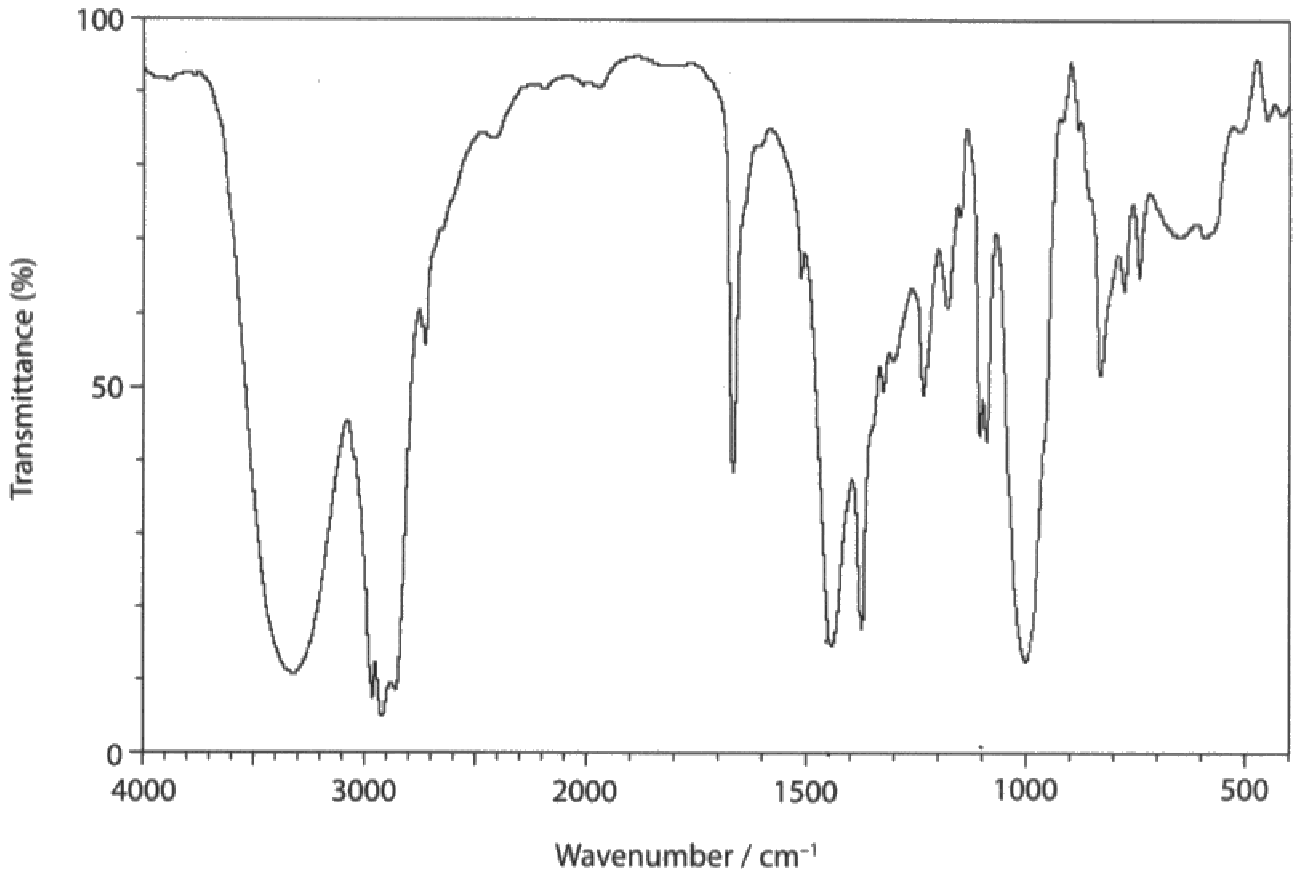
The first functional group is identified as an alcohol, the correct bond is identified and the wavenumber range is that of an alcohol. However, the group is also identified as a hydroxide, which negates the mark.
A single wavenumber within the allowed range would have been sufficient.

The second functional group is correctly identified as an alkene, with the correct bond and wavenumber range.

ResultsPlus
Examiner Tip

Be aware that additional incorrect answers may negate a correct answer. Alcohols can be identified as hydroxyl compounds but they are not hydroxides.

(c) The infrared spectrum of geraniol is shown.



Using the table of absorptions from the Data Booklet and the infrared spectrum, give the **names** of the two functional groups present in geraniol.
To confirm these functional groups, give the wavenumber ranges and their corresponding bonds.

(2)

First functional group hydroxyl (-OH) functional group as there's a broad absorption between the values 3200-3750 cm^{-1}, ~~&~~ showing the O-H bond stretching vibrations

Second functional group ~~alkene~~ carbon to carbon double bond functional group (C=C), as there's a sharp absorption ~~between~~ at wavenumber 1450 cm^{-1}, showing the C=C stretching vibrations

ResultsPlus

Examiner Comments

Mark = 1

First functional group – this is identified as a hydroxyl compound rather than an alcohol, but this is allowed by the mark scheme. The bond and the wavenumber range are correctly identified.

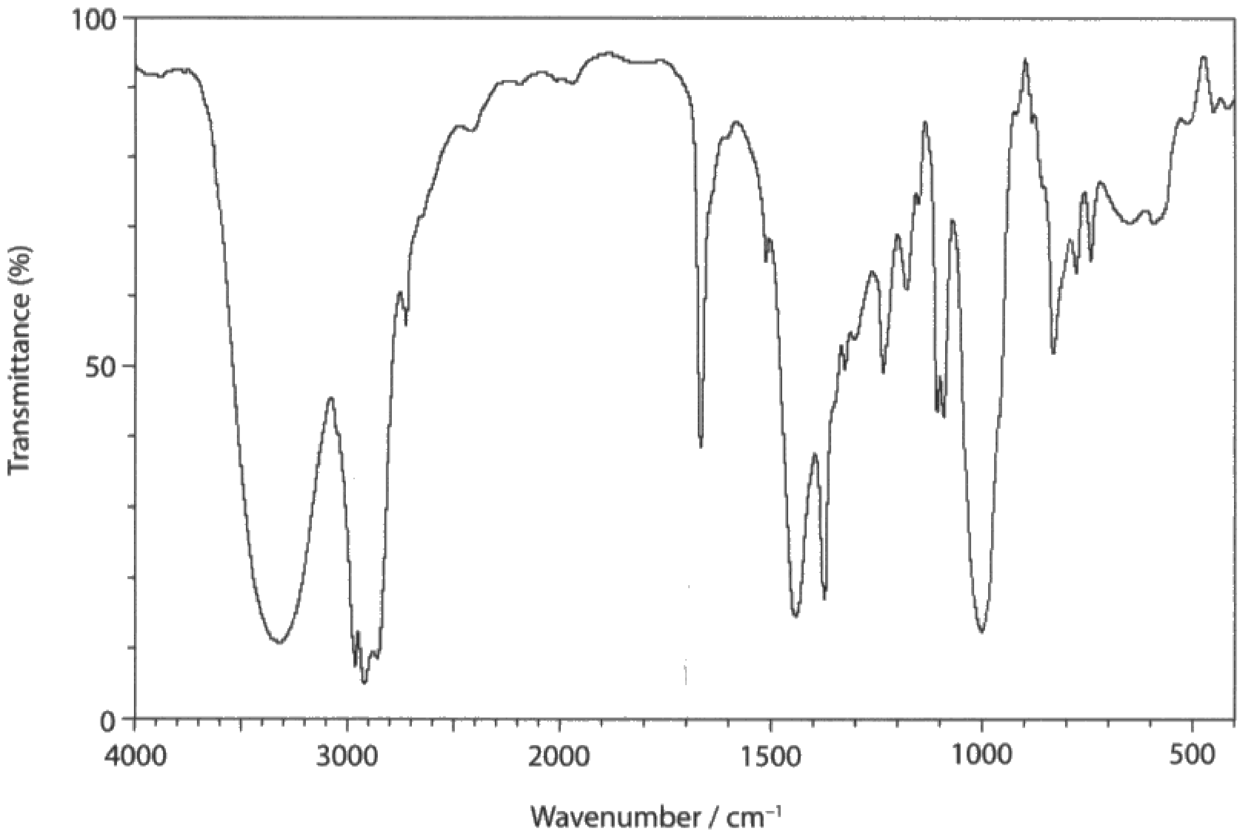
Second functional group – the name is given correctly and the bond is also correctly identified. However, the wavenumber is that of an arene, so the mark is not awarded.

ResultsPlus

Examiner Tip

Check that all your data is correct for the question.

(c) The infrared spectrum of geraniol is shown.



Using the table of absorptions from the Data Booklet and the infrared spectrum, give the **names** of the two functional groups present in geraniol.
To confirm these functional groups, give the wavenumber ranges and their corresponding bonds.

(2)

First functional group OH (O – H)

wavenumber range : 3200 – 3750

Second functional group C=O

wave number range : 1680 – 1700

ResultsPlus
Examiner Comments

Mark = 0
First functional group – the bond is identified and the range is that of an alcohol, but the alcohol group is not identified. No mark awarded.
Second functional group – there is no carbonyl group present. No mark awarded

ResultsPlus
Examiner Tip

Ensure that you answer all the question. In this question, 3 things were required for each mark; name, bond and wavenumber (range).

Question 4 (d)

This question linked with the response in Question 4(c). Candidates were expected to provide a test and the expected result for each of the (correct) functional groups identified in Question 4(c). No TE was permitted for incorrect functional groups identified in Question 4(c); a candidate who recalled a correct test/result for an aldehyde, for example, could not get credit in Question 4(d) for a non-existent functional group listed in Question 4(c).

First functional group ~~[illegible]~~ Alkane functional group wavenumber 1485 - 1365 ~~[illegible]~~ bending and 2962 - 2853 stretching

Second functional group ~~Alkyne 3300 stretching C-H vibrations~~ Alkene 3095 - 3010

(d) Give **one** chemical test that you could use to confirm the presence of each of the two functional groups suggested in part (c). Predict a result for each test.

(4)

Test and result for first functional group ~~[illegible]~~ Try cracking it with a phosphoric acid catalyst if alkene forms it was alkane

Test and result for second functional group Bromine water turns from orange to colourless.

ResultsPlus
Examiner Comments

Mark = 2

The groups identified in Question 4(c) are alkene and alkane (irrespective of any omissions of the bonds or wavenumbers). No test/result marks can be awarded in Question 4(d) for alkane, because it is not a functional group. The test and result for alkene are correct.

ResultsPlus
Examiner Tip

Ensure that you know what is meant by a functional group. Do not include other functional groups just because you can recall a test for their presence.

First functional group ~~Amine (N-H) Carboxylic acid 3500 – 3300 cm^{-1} 3300 – 2500~~

Carboxylic acid O-H ~~Amine N-H~~
3300 - 2500 ~~3500-3300~~

Second functional group Alkane C-H
2962 cm^{-1} — 2853 cm^{-1}

(d) Give **one** chemical test that you could use to confirm the presence of each of the two functional groups suggested in part (c). Predict a result for each test.

(4)

Test and result for first functional group Carboxylic acid - add sodium carbonate and there should be effervescence if ~~co~~ acid is present

Test and result for second functional group Alkane - add bromine water and alkane should not change colour → remains orange.

ResultsPlus
Examiner Comments

Mark = 0

Carboxylic acid was not identified in Question 4(c) and even if it had been, no mark could have been awarded because it is not present in geraniol. Alkane is not a functional group.

ResultsPlus
Examiner Tip

Negative test results are not sufficient to identify any functional group, and alkane is not a functional group.

First functional group O–H group at 3300–2500 which indicates a carboxylic acid.

Second functional group C=C ~~at about 1450~~ showing an arene.

(d) Give **one** chemical test that you could use to confirm the presence of each of the two functional groups suggested in part (c). Predict a result for each test.

(4)

Test and result for first functional group you could use ~~KOH~~ ~~...~~ ethanolic solution of which would produce water ~~...~~

Test and result for second functional group you could add bromine water to the compound. If C=C is present the colour will go from orange/brown to colourless

ResultsPlus

Examiner Comments

Mark = 0

The functional groups identified in Question 4(c) are carboxylic acid and arene, neither of which is present. No marks are available for tests/results of groups that are not present.

ResultsPlus

Examiner Tip

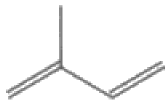
Ensure that you are able to identify the infrared wavenumber range that corresponds to a functional group. Cross-check carefully between the data booklet and the infrared spectrum.

Question 4 (e)

This question required candidates to consider the formulae of geraniol and isoprene. From this they could predict the number of isoprene molecules used by plants to make geraniol. Arguments based on the number of hydrogen atoms or molar mass, do not work. However, the answer is clear when considering the numbers of carbon atoms in each molecule. Some candidates even deduced that a water molecule was also involved, although this was not tested.

Answers that included fractions of a molecule were not appropriate.

(e) Some plants are able to make terpenes by linking together several molecules of 2-methylbuta-1,3-diene, also known as isoprene.
The skeletal formula of 2-methylbuta-1,3-diene is



Predict the number of isoprene molecules that would be needed to make a single geraniol molecule. Justify your answer.

(2)

2 , there only 2 C-C double bonds in geraniol, as isoprene forms geraniol 2 double bonds are lost, leaving 2 behind. the

ResultsPlus
Examiner Comments

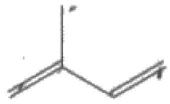
Mark = 1
M1 is awarded for the answer '2'. The justification, which here relates to the number of double bonds, is incorrect. M2 is not awarded.

ResultsPlus
Examiner Tip

The justification provided here is very complex and does not really hold together. Explanations are usually quite simple.

This response was awarded both marks.

(e) Some plants are able to make terpenes by linking together several molecules of 2-methylbuta-1,3-diene, also known as isoprene.
The skeletal formula of 2-methylbuta-1,3-diene is



Predict the number of isoprene molecules that would be needed to make a single geraniol molecule. Justify your answer.
(2)

2 because isoprene has 5 carbon atoms in and a geraniol molecule has 10 and $2 \times 5 = 10$

ResultsPlus
Examiner Comments

Mark = 2

This is a good example of a fully correct answer.

ResultsPlus
Examiner Tip

Answers should be clear and concise.

Question 4 (f)

The question asked for the formulae of **four** isomers produced when **excess** HBr reacts with the diene. Displayed, structural and skeletal formulae were all acceptable.

Enantiomers are also possible products in this reaction but none were seen. Enantiomers are beyond the spec of this course but correct enantiomers would have been rewarded.

Many candidates ignored the hint given by the word **excess** which was emboldened in the question, and restricted themselves to the monobromo products. Some credit was given for correct monobromo isomers.

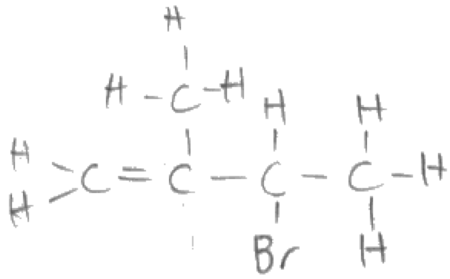
Some attempts at substitution reactions were seen where addition reactions were clearly required.

(f) 2-methylbuta-1,3-diene can react with hydrogen bromide.

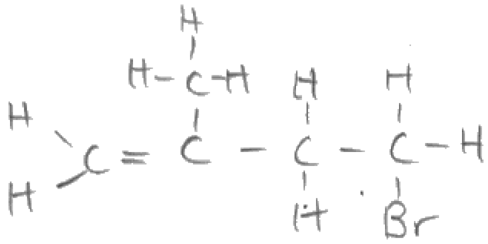
When 2-methylbuta-1,3-diene reacts with **excess** hydrogen bromide, several isomeric products are possible. Give the structures of **four** isomeric products.

(4)

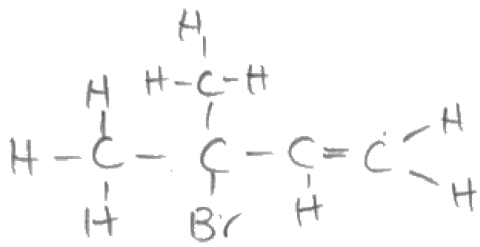
①



②



③



④

ResultsPlus
Examiner Comments

Mark = 1
Three correct monobromo isomers have been drawn. A fourth correct monobromo isomer would have gained a second mark. (All 4 correct monobromo isomers get 2 marks.)

ResultsPlus
Examiner Tip

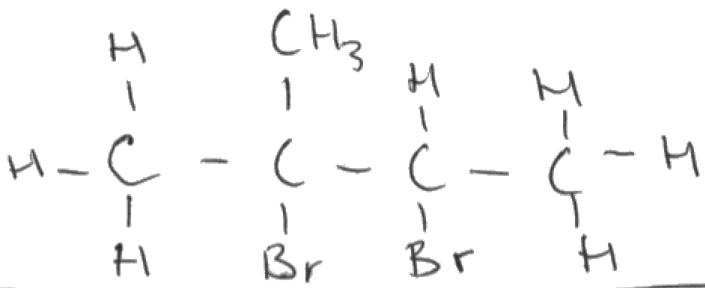
If the question asks for **four** structures, ensure you write four.

(f) 2-methylbuta-1,3-diene can react with hydrogen bromide.

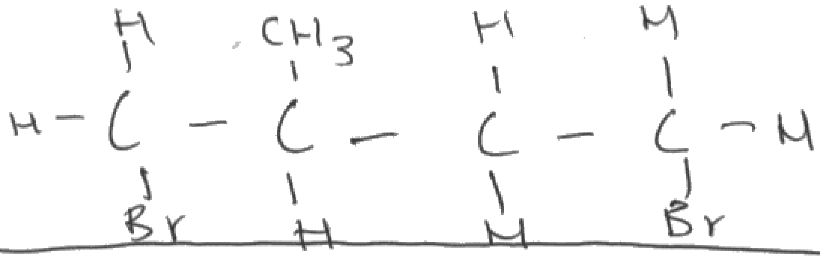
When 2-methylbuta-1,3-diene reacts with **excess** hydrogen bromide, several isomeric products are possible. Give the structures of **four** isomeric products.

(4)

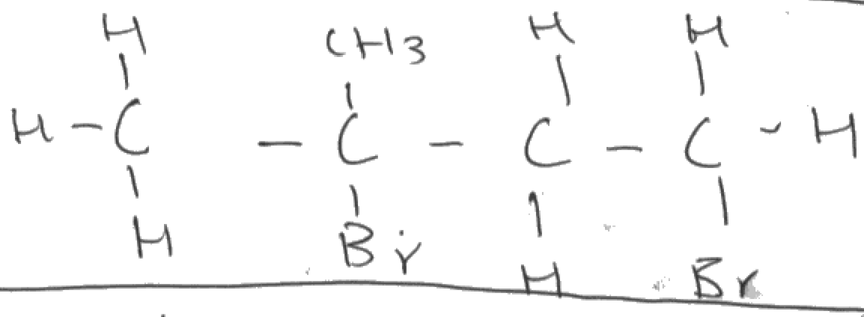
1)



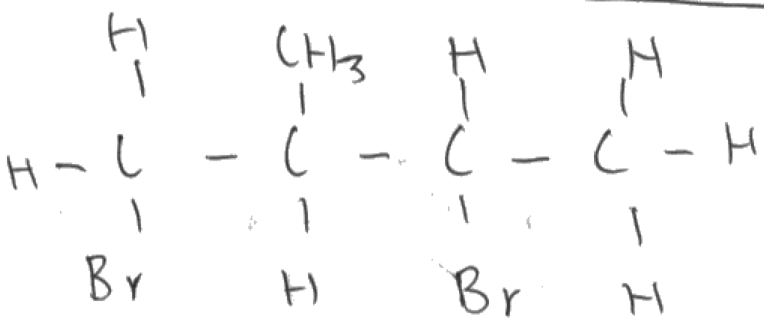
2)



3)



4)



ResultsPlus
Examiner Comments

Mark = 4
All four dibromo isomers are correctly drawn. The candidate has recognised the significance of the **excess** HBr.

ResultsPlus
Examiner Tip

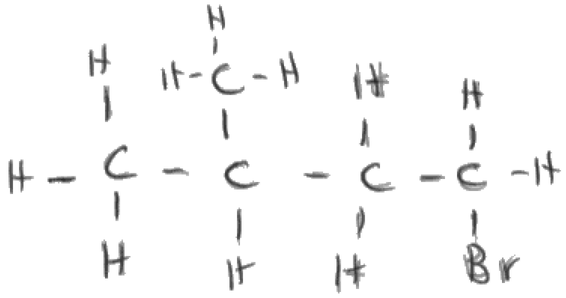
If a word is included in **bold**, it has special significance. Ensure that you think about why the word (or phrase) is printed in bold.

(f) 2-methylbuta-1,3-diene can react with hydrogen bromide.

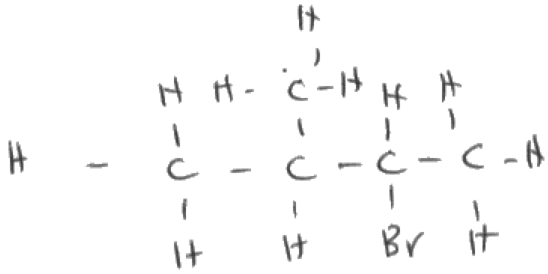
When 2-methylbuta-1,3-diene reacts with **excess** hydrogen bromide, several isomeric products are possible. Give the structures of **four** isomeric products.

(4)

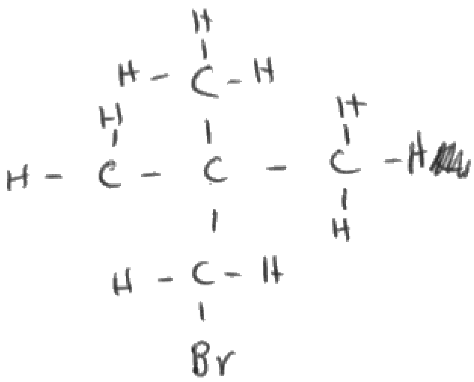
1.



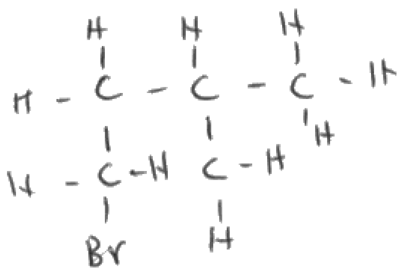
2.



3.



4.



ResultsPlus
Examiner Comments

Mark = 0
For structures 1 and 2, HBr has been correctly added across one of the double bonds but hydrogen has also been added across the other double bond.
For structure 3, the carbon backbone has been rearranged.
Structure 4 would have been the same as structure 1.
There is also a hydrogen atom missing.

ResultsPlus
Examiner Tip

Always check that there are no missing hydrogen atoms in displayed formulae.

Question 5 (a)

This was a straightforward definition and it was surprising that so many candidates did not score the mark. Many thought that it had something to do with the number of moles in a fixed volume.

5 (a) State what is meant by the term **molar volume of a gas.**

(1)

The volume taken up by one mole of a gaseous substance.

ResultsPlus
Examiner Comments

Mark = 0

There is no reference to either temperature or pressure.

ResultsPlus
Examiner Tip

Learn and understand basic definitions, it will help you to analyse problems.

5 (a) State what is meant by the term **molar volume of a gas.**

(1)

the volume that one mole of any gas has, at a temperature of 298 K, and a pressure of 1 atmosphere.

ResultsPlus
Examiner Comments

Mark = 1

This is a completely correct response. The specified temperature and pressure need not be those given here but there is a requirement for both to be included in the response.

ResultsPlus
Examiner Tip

The answer includes the three essentials: volume, 1 mole and the conditions.

5 (a) State what is meant by the term **molar volume of a gas**.

(1)

A gas that occupies 24 dm^3 of volume at room temperature and pressure

ResultsPlus

Examiner Comments

Mark = 0

The fact that one mole of gas does occupy about 24 dm^3 under these conditions is not part of the definition. There is no mention of 1 mole in this answer.

ResultsPlus

Examiner Tip

Read the question carefully. It is clear that this response does not answer the question.

Question 5 (b) (i) and (ii)

(b)(i) This question required the calculation of the percentage uncertainties in volume and mass based on the uncertainty in the measurements caused by the equipment used.

(b)(ii) The second part of the question required the candidates to determine the effect on the % uncertainty of an increase in volume and also, since the mass increase with the volume of the gas, the effect of an increase in mass on its % uncertainty.

Many candidates seemed unaware that for full marks, the command word 'Determine' requires a mathematical content. For full marks the volume and mass % uncertainties both halve. 1 rescue mark was available for responses which recognised that both uncertainties decreased but where the size of the decrease was not quantified.

(i) The gas syringe has a total uncertainty of $\pm 0.5\ cm^3$.
Each reading on the balance has an uncertainty of ± 0.0005 g.

Calculate the percentage uncertainty in the measurement of the volume and mass of gas used in this procedure.

(2)

$\frac{0.5}{50} = 1\% \quad + \quad \cancel{\frac{0.0005}{107.563}} = \cancel{0.000}$

$\frac{0.0005}{107.655 - 107.563} = \frac{0.0005}{0.092} = 0.54\%$

$= 1.54\%$

(ii) The student repeated the experiment with $100\ cm^3$ of the gas using a $100\ cm^3$ syringe.

The total uncertainty for this larger syringe was also $\pm 0.5\ cm^3$.

Determine the effect, if any, on the volume and mass uncertainties.

(2)

$\frac{0.5}{100} = 0.5\%$ uncertainty, The mass uncertainties would decrease as this has a lower percentage uncertainty

ResultsPlus
Examiner Comments

Marks = 1, 1
(b)(i) The volume % uncertainty has been correctly calculated. Ignore the missing factor of 100 to get %, the mark is for the final answer. The answer does not specifically identify the 1% as the volume uncertainty but the calculation makes it clear that it is volume that is under consideration, not mass.
There were two measurements to determine the mass therefore the uncertainty should have been doubled.
(b)(ii) The volume % uncertainty has halved; this answer is quantified and gains 1 mark. The mass uncertainty is identified as lower, but since this answer is not quantified, the second mark is not awarded.

ResultsPlus
Examiner Tip

Where two measurements are made, e.g. use of a weighing balance or a burette, the uncertainty in the measurement is doubled. Where only one measurement is made, e.g. use of a syringe, or a pipette, the uncertainty in the measurement is used only once.

(i) The gas syringe has a total uncertainty of ±0.5 cm^3.
Each reading on the balance has an uncertainty of ±0.0005 g.

Calculate the percentage uncertainty in the measurement of the volume and mass of gas used in this procedure.

(2)

balance = $\frac{0.0005 \times 2}{0.092} \times 100 = 1.09\%$

gas syringe = $\frac{0.5}{50} \times 100 = 1\%$

(ii) The student repeated the experiment with 100 cm^3 of the gas using a 100 cm^3 syringe.

The total uncertainty for this larger syringe was also ±0.5 cm^3.

Determine the effect, if any, on the volume and mass uncertainties.

(2)

the volume uncertainty will decrease by half (0.5% uncertainty) because larger volume so reduced errors. Also, the mass uncertainty ~~won't~~ changes because larger measurements.

ResultsPlus
Examiner Comments

Marks = 2, 1
(b)(i) Both mass and volume uncertainties have been correctly calculated. Although the volume and mass uncertainties are not identified, they are clear from the different calculations.
(b)(ii) The new volume uncertainty is correctly quantified for the first mark, but the mass uncertainty is only said to 'change'. This is not sufficient for the second mark.

ResultsPlus
Examiner Tip

Ensure you know that the command word 'Determine' means that the answer should have a mathematical content for full marks.

(i) The gas syringe has a total uncertainty of ±0.5 cm^3.
Each reading on the balance has an uncertainty of ±0.0005 g.

Calculate the percentage uncertainty in the measurement of the volume and mass of gas used in this procedure.

(2)

$\frac{0.5}{50} \times 100 = 1\%$ in volume

$100 \times \frac{1 \times 10^{-3}}{0.92} = 0.001\%$ in mass

(ii) The student repeated the experiment with 100 cm^3 of the gas using a 100 cm^3 syringe.

The total uncertainty for this larger syringe was also ±0.5 cm^3.

Determine the effect, if any, on the volume and mass uncertainties.

(2)

The volume uncertainty would decrease due to the larger volume being used.
There would also be less uncertainty in mass as more mass is used with the same resolution.

ResultsPlus
Examiner Comments

Marks = 1, 1
(b)(i) The volume uncertainty is correct (identified from the calculation), but the mass uncertainty is wrong because the calculation is incorrect and because the mass is incorrect by 10x.
(b)(ii) It is stated that both uncertainties decrease but the decreases are not quantified. 1 rescue mark is awarded.

ResultsPlus
Examiner Tip

Check calculations and be careful about transfer errors from calculator to paper.

(i) The gas syringe has a total uncertainty of ±0.5 cm^3.
Each reading on the balance has an uncertainty of ±0.0005 g.

Calculate the percentage uncertainty in the measurement of the volume and mass of gas used in this procedure.

(2)

$$\frac{0.5 \times 2}{50} \times 100 = 2\%$$

~~107.563 − 107.655 =~~

$107.655 - 107.563 = 0.092$

$$\frac{0.0005 \times 2}{0.092} \times 100 = 1.08695...\%$$

$$= 1.087\%$$

(ii) The student repeated the experiment with 100 cm^3 of the gas using a 100 cm^3 syringe.

The total uncertainty for this larger syringe was also ±0.5 cm^3.

Determine the effect, if any, on the volume and mass uncertainties.

(2)

There would be no difference because the uncertainty is not determined by the volume but the amount of times you measure a value.

ResultsPlus
Examiner Comments

Marks = 1, 0
(b)(i) The volume uncertainty is incorrect – the measurement uncertainty has been doubled but only one measurement of volume is made. However, the mass uncertainty has been correctly calculated (any number of SF is acceptable). The numbers identify the second calculation as the mass uncertainty.
(b)(ii) The answer is incorrect and does not specify which of the uncertainties is being discussed (although volume uncertainty could be inferred from the context).

ResultsPlus
Examiner Tip

(b)(i) It would be useful to identify each calculation i.e. as mass or volume.
(b)(ii) Read the answer through. Does it answer the question? In this instance, clearly not.

Question 5 (b) (iii)

This calculation of molar mass tests the candidate's understanding of the term 'molar mass'.

The first mark is for the (relatively straightforward) calculation.

The second mark requires the candidate to give the final answer to a suitable number of significant figures, and to recall or deduce the correct units for molar mass.

(iii) Calculate the molar mass of the gas used in the procedure outlined in part (b).

You may assume that one mole of gas occupies 24 000 cm^3 under these conditions.

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

(2)

$M = \frac{m}{RFM}$ $\quad \frac{0.092}{480}$ $\quad$ 24 000 = 24 dm^3/mol

$\frac{24000}{} \approx 50$

0. 000192 mg/mol

$\frac{24000}{50} = 480$

x1000

0.192 g/mol

ResultsPlus

Examiner Comments

Mark = 0

There are hints that the candidate might have been thinking along the correct lines; the figure of 480 might have gained a mark if used correctly in further calculations.

ResultsPlus

Examiner Tip

Explain calculations as you go through them. Great detail is not required but a scattered mass of figures does not aid clear thinking and makes it very difficult for an examiner to find something worthy of credit.

(iii) Calculate the molar mass of the gas used in the procedure outlined in part (b).

You may assume that one mole of gas occupies 24 000 cm³ under these conditions.

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

(2)

$107.655 - 107.563 = 0.092$

$0.092g \rightarrow 50cm^3$

$x \rightarrow 24000$

$x = 44.16g$

ResultsPlus
Examiner Comments

Mark = 1

Although there is little explanation in this jumbled mass of figures, the correct answer appears. The first mark is awarded.
The second mark is lost because it is not correct to give an answer to 4 SF when some of the data has only 2 SF. The units are also incorrect.

ResultsPlus
Examiner Tip

Look at the data to get an appropriate number of significant figures, here some of the data is to 2 SF so that would be appropriate for the answer.
Check the units.

(iii) Calculate the molar mass of the gas used in the procedure outlined in part (b).

You may assume that one mole of gas occupies 24 000 cm³ under these conditions.

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

(2)

$\text{moles} = \frac{50}{24000} = 0.002083$

$\text{molar mass} = \frac{0.092}{0.002....} = 44.16 \approx \underline{\underline{44.2}}$ ~~(1dp)~~ (3sf)

ResultsPlus
Examiner Comments

Mark = 1
Here the correct calculation has been made and the final answer is corrected to 3 SF, which was allowed. M1 is awarded.
However, there are no units, so M2 is lost.

ResultsPlus
Examiner Tip

If the question asks for units, they MUST be included.

Question 5 (b) (iv)

Candidates found this question particularly difficult. Many thought that the gas inside the syringe would be at a positive pressure relative to the outside pressure. They therefore surmised that gas would escape if there was a leak.

Of those who recognised that a leak would cause air to mix with the gas inside the syringe, very few were aware that the average molar mass of air is significantly less than that of the gas being used here. The average molar mass of the gas mixture in the syringe would therefore decrease.

(iv) Explain how the student would know if the syringe had a leak in step 2 and what effect this leak would have on the molar mass determined in part (b)(iii).

(2)

The plunger wouldn't be sucked back in ~~gas~~ ~~air would have~~ after he released it as air would be filled this space due to leaks. The molar mass would be ~~higher~~ lower.

ResultsPlus
Examiner Comments

Mark = 1

M1 is awarded. The syringe plunger would not be sucked back in because the leak has caused the gas pressure to equalise inside and outside the syringe. M2 is not awarded. The answer has correctly identified that the molar mass will decrease, but there is no justification.

ResultsPlus
Examiner Tip

Carefully read the experimental procedure that is described in the question paper and try to understand it. Re-read it several times if necessary. This is particularly important if you have not carried out the experiment yourself or seen it carried out. Ask yourself what would happen to the molar mass if air were sucked into the syringe, and why.

(iv) Explain how the student would know if the syringe had a leak in step **2** and what effect this leak would have on the molar mass determined in part (b)(iii).

(2)

He would be able to see if any gas was released, The mass would be less

ResultsPlus
Examiner Comments

Mark = 0

The answer has assumed that the gas is at a higher pressure inside the syringe than outside. The answer also assumes that the gas is visible (presumably coloured). M1 is not awarded. The 'mass' is said to decrease but there is no mention of air and no explanation given so M2 is not awarded.

ResultsPlus
Examiner Tip

Do not make unjustified assumptions. There is no reason to think this gas is coloured, many gases are colourless.

(iv) Explain how the student would know if the syringe had a leak in step **2** and what effect this leak would have on the molar mass determined in part (b)(iii).

(2)

The Student would know as the volume of air inside the Syringe would decrease without the Syringe being touched. This would make the molar mass seem larger than it was

ResultsPlus
Examiner Comments

Mark = 0

This answer also assumes that the gas inside the syringe is at a higher pressure than outside, and therefore a leak would cause escape of gas (as measured by an apparent decrease in volume). The molar mass is said to increase but no explanation is given for this assertion.

ResultsPlus
Examiner Tip

Try to understand the practical aspects of the experiment from the procedure that has been described.

Question 5 (c)

The syringe is used to measure a specified volume of gas, but at lower temperatures the density of the gas is greater and a larger mass of gas will be contained in the fixed volume of the syringe. This will increase the measured molar mass.

The increased density of the gas could be recognised as an increase in the mass/moles/ molecules of gas in the fixed volume of the syringe.

Those who simply state that the volume of a gas decreases with a decrease in temperature, have not understood the experimental procedure; it is the volume that is fixed, not the mass.

M1 for the increased molar mass was designated a standalone mark because many seemed to recognise that the gas density would increase as temperature fell but did not state this in their answers. Answers that simply stated 'it would be greater' were awarded M1 because the question asks about the effect on molar mass.

(c) If the temperature had been less than 20 °C and the pressure remained at one atmosphere, deduce the effect, if any, on the molar mass calculated in part (b)(iii).

(2)

lower temperature causes gas to be more dense therefore decrease in volume of one mole of gas. This would increase the number of moles drawn out in 50 cm³ and hence decrease the molar mass. ~~[illegible]~~

ResultsPlus
Examiner Comments

Mark = 1
This answer has recognised the increase in density of the gas as temperature falls (M2 awarded) but the effect on the molar mass is (surprisingly) incorrect.

ResultsPlus
Examiner Tip

Think carefully about the experimental procedure that is described in the question. Most candidates are aware that the volume occupied by a fixed mass of gas would fall as temperature falls. However, the volume used in the syringe is fixed; therefore think about the mass of gas in the syringe.

(c) If the temperature had been less than 20 °C and the pressure remained at one atmosphere, deduce the effect, if any, on the molar mass calculated in part (b)(iii).

(2)

temperature decreases → rate decreases
→ longer time but for reaction to occur but the same molar mass be obtain.

ResultsPlus
Examiner Comments

Mark = 0

This answer attempts to relate the temperature change to rate of reaction. There is no reaction taking place in the syringe. M2 is not awarded.
M1 is also lost because the answer is incorrect; the molar mass is said to stay the same.

ResultsPlus
Examiner Tip

In a question that asks about molar mass, it is unlikely that rates of reaction are involved.

(c) If the temperature had been less than 20 °C and the pressure remained at one atmosphere, deduce the effect, if any, on the molar mass calculated in part (b)(iii).

(2)

Particles ~~will~~ would have less kinetic energy ; less frequent ~~a~~ and successful collisions so the volume ~~will~~ would be smaller . ~~So~~ Therefor the mollar mass will be bigger.

ResultsPlus
Examiner Comments

Mark = 1

This response relates to the kinetic energy of the particles and the reference to collisions implies something to do with reaction rates. The statement about volume being smaller shows that the candidate has not understood the procedure used.
M1 is awarded for a correct statement about molar mass.

(c) If the temperature had been less than 20 °C and the pressure remained at one atmosphere, deduce the effect, if any, on the molar mass calculated in part (b)(iii).

(2)

If the temperature decreased below 20 °c the molar mass calculated would be greater because the amount of gas within the syringe would be greater due to a decrease in density.

ResultsPlus
Examiner Comments

Mark = 1
M1 is awarded for the greater molar mass.
M2 is not awarded. The 'amount' of gas in the syringe is said to be greater; it is not made clear if this is the mass or the volume. Furthermore, the density of the gas is claimed to decrease as temperature falls.

ResultsPlus
Examiner Tip

Be aware that a good answer can be negated by a second incorrect answer. Even if this answer had stated that the **mass** of gas in the syringe was greater, the mark awarded would have been cancelled by the incorrect statement about the density.

Question 5 (d)

Relatively few candidates appreciated the chemistry behind this question.

Water has a lower molar mass than that identified in Question 5(b)(iii), any water vapour would therefore reduce the average molar mass of the gas in the syringe.

(d) Give a reason why the gas should be dry.

(1)

So no water molecules are suspended in the gas, it would change the molar mass.

ResultsPlus
Examiner Comments

The candidate has appreciated that the molar mass will be changed. The mark is awarded.

ResultsPlus
Examiner Tip

Read the part questions in the context of the whole question. The question is about the molar mass of a gas, so think about the effect of water vapour on the measured molar mass of gas in the syringe.

(d) Give a reason why the gas should be dry.

(1)

So that no water content will increase the mass of gas weighed.

ResultsPlus
Examiner Comments

Mark = 0
There is no reference to molar mass. The response implies that the candidate thinks that wet gas would have more mass, whereas a mixture of water vapour and the gas will have a lower molar mass.

ResultsPlus
Examiner Tip

Think about water vapour in this context, rather than water liquid.

(d) Give a reason why the gas should be dry.

(1)

wet gas would add more mass

ResultsPlus
Examiner Comments

Mark = 0

This is not true if water is present as water vapour.

(d) Give a reason why the gas should be dry.

(1)

It won't react with the air inside the bag therefore no other products will be formed.

ResultsPlus
Examiner Comments

Mark = 0
There is no reason to think that there is any reaction taking place in the syringe.

Question 6 (a)

This question required candidates to consider the effects of temperature and pressure changes on a gaseous equilibrium reaction.

There are six indicative points. These relate to the effect of temperature change on rate, yield and costs, then the effect of pressure change on rate, yield and costs.

The indicative points are then scaled and up to 2 marks are also available for the reasoning.

The catalyst used in the reaction was unchanged and therefore was not considered.

The effect of increased temperature on costs required candidates to think about the increasing energy requirements in order to achieve higher temperatures.

The effect of higher pressure on the rate of reaction has two possible answers. Many candidates recognised that an increase in pressure is equivalent to an increase in gas concentration; they then argued correctly for an increase in rate. However, in a homogeneous gas-catalysed reaction the active sites on the catalyst are probably already saturated and therefore an increase in gas pressure will have no effect on rate. This response was seen very rarely.

Common errors included not giving reasons for the effect of increased temperature and pressure on the yield (i.e. the effect of increased temperature on an exothermic reaction, and the effect of increased pressure on a reaction where the number of gas moles changes in moving from reactants to products). One rescue mark was available for candidates who did not justify both their yield predictions.

6 One of the stages in the production of sulfuric acid from sulfide ores involves the oxidation of sulfur dioxide to sulfur trioxide. The equation for the reaction is

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta_r H = -197 \text{ kJ mol}^{-1}$$

The conditions used in one industrial process are: 420 °C and a pressure of 1.7 atm together with a vanadium(V) oxide catalyst.

It is proposed to change the conditions to 600 °C and 10 atm pressure, while still using the same catalyst.

*(a) Evaluate the feasibility of each of these changes in terms of their effect on the rate, yield and economics of the reaction.

(6)

Using 600°c would not be feasible. 600°c is too hot for the Vanadium V ~~can~~ oxide catalyst to perform its function, so the rate of reaction would be severely reduced. It would reduce the yield also, because the reaction would shift in the endothermic direction (towards the reactants SO_2 and O_2), producing less SO_3. Finally, it would cost

Much more money to maintain this heat, so it is not feasible. Raising the pressure to 6 atmospheres would ~~increase the rate~~ ~~decrease~~ increase the rate of reaction because the reaction would shift towards the product (SO_3) due to le chatelier's principle. It would also increase the yield due to the reaction shifting towards the product. However, the cost of maintaining 6 atmospheres of pressure is large enough to outweigh the other positive factors, making this change unfeasible also.

ResultsPlus

Examiner Comments

Marks awarded = 3

Ignore the reference to the catalyst; the catalyst has not been changed.

The indicative point for temperature/yield is scored because the reduction in yield is correctly linked to the exothermic nature of the forward reaction.

The temperature/cost indicative point is not scored because there is no reference to energy costs.

The effect on rate of increasing pressure is correctly identified.

The pressure/yield indicative point is not scored because there is no justification.

The comment relating to the increased cost of maintaining a higher pressure is just adequate for the mark.

ResultsPlus

Examiner Tip

Identify six indicative points and ensure all are included in your answer. Provided there is no additional incorrect chemistry and there are no contradictions, a good reasoning mark should also be scored.

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It is proposed to change the conditions to 600 °C and 10 atm pressure, while still using the same catalyst.

*(a) Evaluate the feasibility of each of these changes in terms of their effect on the rate, yield and economics of the reaction.

(6)

Increasing the temperature would lead to the equilibrium shifting to the left. This is because there would a increase in kinetic energy so more of the particles reach their activation energy. This means that the forward reaction would be favoured so the equilibrium would shift to the left to counterbalance this.

The catalyst would increase rate of reaction in the forwards direction and so would increasing the pressure. The catalyst lowers activation needed for the particles to collide whilst increasing the pressure means that particles are more likely to collide with each other.

ResultsPlus
Examiner Comments

Mark = 1
The only indicative point scored here is that relating to pressure/rate.
The temperature/yield point has no reasoning attached and seems to confuse kinetic energy and activation energy with yield.
Ignore the references to the catalyst in the second paragraph but a correct reference to rate and pressure is included.

With only one indicative point given, no linkage and reasoning marks are available. However, this also means that no marks would be deducted for incorrect chemistry.

ResultsPlus
Examiner Tip

Ensure that you identify at least six indicative points. Do not include comments about factors that are excluded by the question (the catalyst in this instance).

6 One of the stages in the production of sulfuric acid from sulfide ores involves the oxidation of sulfur dioxide to sulfur trioxide. The equation for the reaction is

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The conditions used in one industrial process are: 420 °C and a pressure of 1.7 atm together with a vanadium(V) oxide catalyst.

It is proposed to change the conditions to 600 °C and 10 atm pressure, while still using the same catalyst.

*(a) Evaluate the feasibility of each of these changes in terms of their effect on the rate, yield and economics of the reaction.

(6)

By increasing the temperature from 420°C to 600°C, less ~~m~~ yield of the product will be produced. This is because the forward reaction is exothermic so increasing the temperature will favour the backwards reaction. Increasing the pressure from 1.7 atm to 10 atm will result in a higher product yield, this is because the forward reaction is favoured as it has fewer moles. Increasing the pressure, increases the rate of reaction as there will be more ~~[illegible]~~ frequent, successful collisions between the reactants meaning more of the product would be producing. Using a catalyst will mean the rate of reaction increases, this is because a catalyst provides an alternative pathway for the reaction and lowers the activation energy. This means a greater proportion of particles will have energies greater than or equal to the activation energy. 100% yield will be produced if conditions favouring forward reaction are used. However, raising the pressure can be expensive as buying equipment to produce a high pressure and then contain the high pressure can be costly. Increasing the pressure and using a catalyst is good as forward reaction is favoured, however increasing temp does not.

ResultsPlus
Examiner Comments

Marks = 4
This is a nicely legible written response where some of the indicative points are clearly made.
The temperature/yield indicative point is scored, because the decreased yield has been linked to the exothermic reaction.
The pressure/yield indicative point is scored because the increased yield has been correctly linked to the change in (gas) moles.
The effect of increasing pressure on rate is identified (and justified, although justification was not required on this occasion).
The rising cost of increasing the pressure is also identified.
There is no comment on the cost of increasing the temperature and nothing about rate/temperature.
Ignore the comments about the catalyst; the catalyst has not been changed.
Four indicative points are scaled to 3 marks.
There are no contradictions or incorrect chemistry, so 1 reasoning mark is allocated to the structure of the answer.

ResultsPlus
Examiner Tip

Pressure can affect equilibria involving **gases.**

Question 6 (b)

This question required candidates to draw reaction profiles for a catalysed and an uncatalysed reaction.

There was no instruction to label the axes but it was expected that the vertical axis would be labelled. The horizontal axis label in a reaction profile is less firmly defined and was therefore not required.

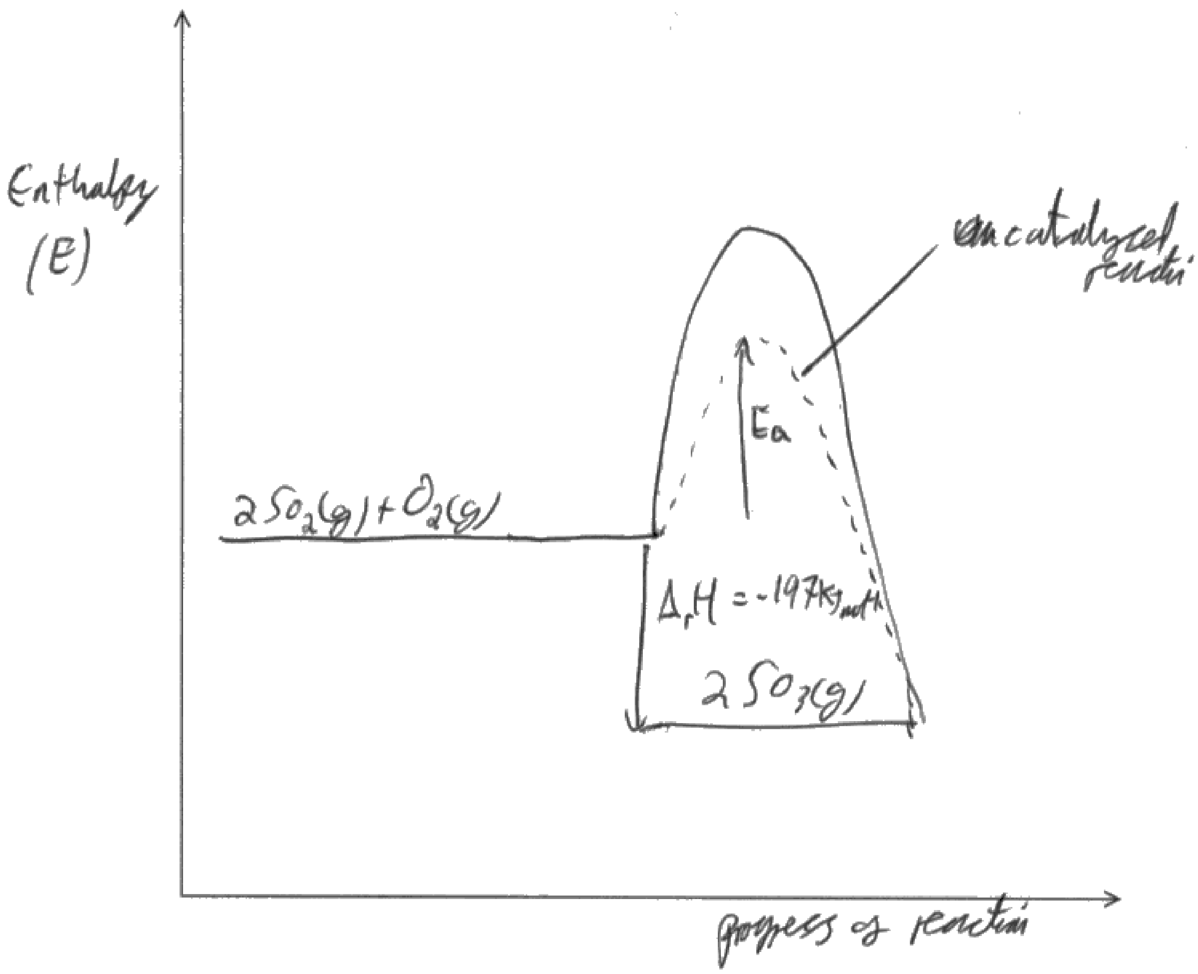
It is important for candidates to be able to draw both reaction profiles and enthalpy level diagrams, and to know the difference between the two.

(b) (i) On the axes provided, sketch the reaction profiles for the uncatalysed and catalysed reaction.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta_r H = -197 \text{ kJ mol}^{-1}$$

Label the uncatalysed reaction, **A**, and the reaction catalysed by vanadium(V) oxide, **B**.

(3)



(ii) On your reaction profile, identify and label both the enthalpy change and the activation energy for the catalysed reaction.

(2)

ResultsPlus
Examiner Comments

Marks = 3, 2

(b)(i) The vertical axis is correctly identified as 'Enthalpy'. Mark awarded.
The reactants and products are correctly represented on levels that are in the correct order. Mark awarded.
The catalysed and uncatalysed reactions have not been labelled **A** and **B** as instructed but the catalysed profile is correctly identified. Mark awarded.
(b)(ii) The activation energy for the catalysed reaction is correctly identified. Ignore the direction of the arrows and presence or absence of arrowheads. Mark awarded.
The enthalpy change is correctly labelled. Mark awarded.
Allow a little imprecision with the start and finish points for the lines representing activation energy and enthalpy change.

ResultsPlus
Examiner Tip

Take care with the start and finish points for the lines representing activation energy and enthalpy change. In this examination a certain amount of imprecision was accepted, this may not be so in future examinations. Similar considerations apply for any arrow directions.
Note that the vertical axis label is Enthalpy, not Enthalpy Change.
If the question asks you to label the profiles then they should be labelled as instructed.

(b) (i) On the axes provided, sketch the reaction profiles for the uncatalysed and catalysed reaction.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta_r H = -197\ \text{kJ mol}^{-1}$$

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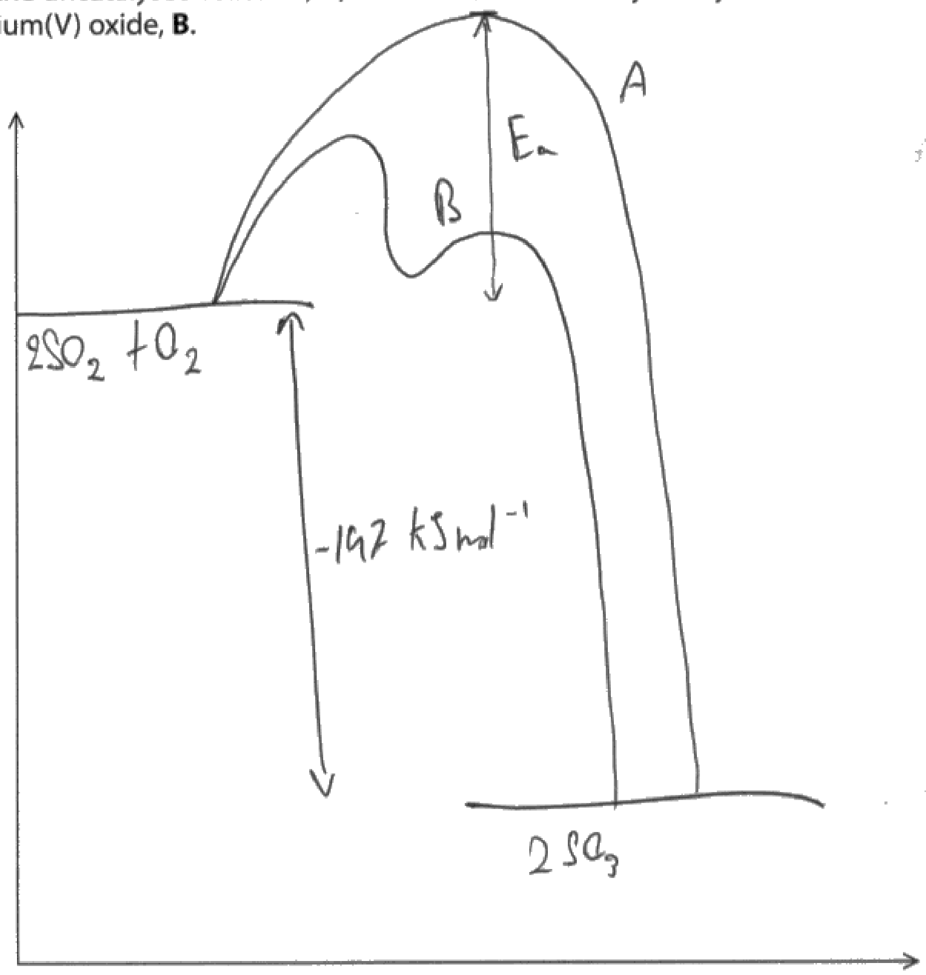


(ii) On your reaction profile, identify and label both the enthalpy change and the activation energy for the catalysed reaction.

(2)

ResultsPlus
Examiner Comments

Marks = 2, 1
(b)(i) There is no label on the vertical axis. No mark awarded.
The reactant and product energy levels are identified. In this instance, the reactants and products have been accepted even though they are written below the level line. The profiles are clearly labelled as **A** and **B**. Mark awarded.
The catalysed curve is the 'double hump' profile which is, of course, correct. Mark awarded.

(b)(ii) The enthalpy change is correctly identified. Ignore the arrowheads. Mark awarded.
The activation energy is that of the uncatalysed reaction, so this mark is not awarded.

ResultsPlus
Examiner Tip

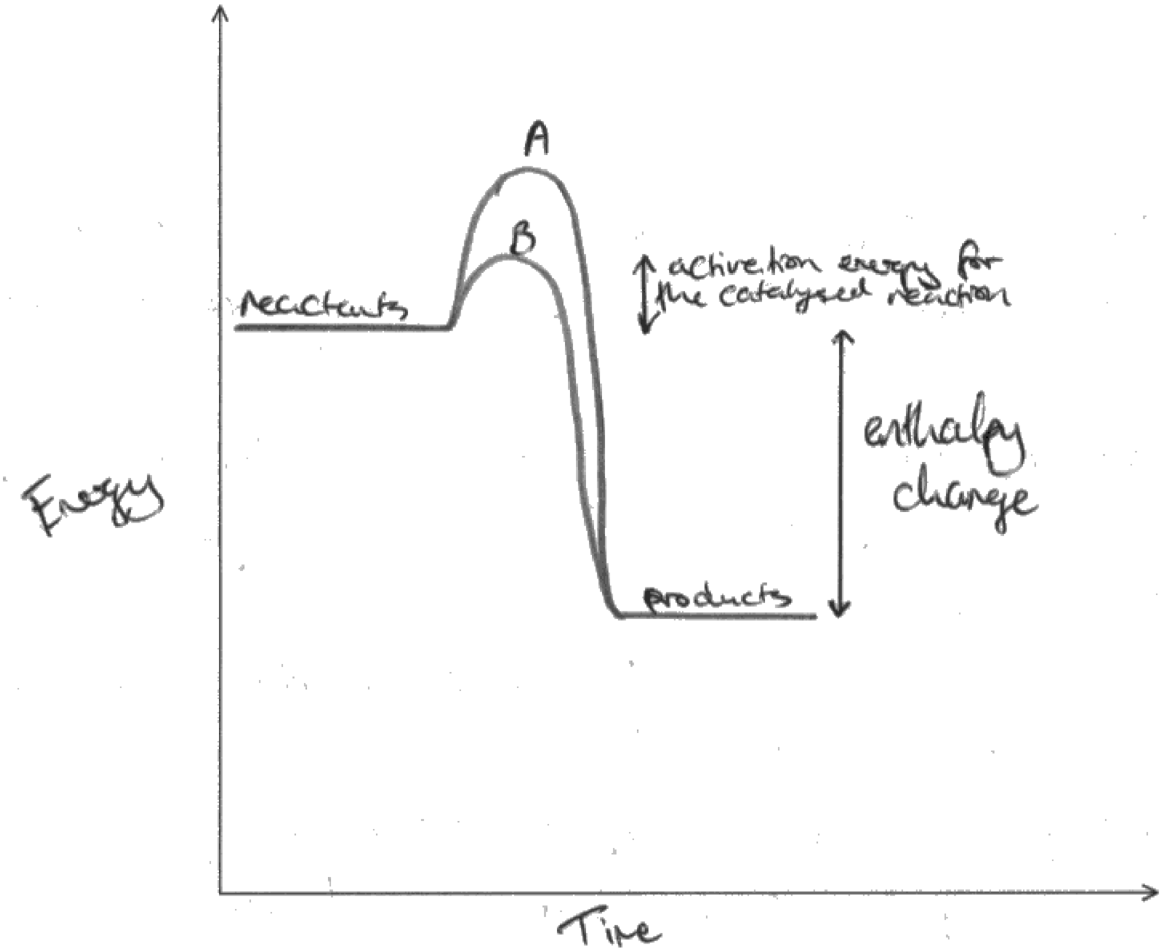
Ensure that you know how to identify the activation energy on a 'double hump' catalysed profile.
Always label the axes on graphs etc. Without them the diagram lacks meaning.

(b) (i) On the axes provided, sketch the reaction profiles for the uncatalysed and catalysed reaction.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta_r H = -197 \text{ kJ mol}^{-1}$$

Label the uncatalysed reaction, **A**, and the reaction catalysed by vanadium(V) oxide, **B**.

(3)



(ii) On your reaction profile, identify and label both the enthalpy change and the activation energy for the catalysed reaction.

(2)

ResultsPlus
Examiner Comments

Marks = 3, 2
(b)(i) An example of a completely correct answer. The levels are labelled 'reactants' and 'products' rather than using the two halves of the equation, but this is acceptable.
(b)(ii) Also completely correct. The arrows are placed some distance from the usual position but in this instance their length is acceptable and they are identified, so both marks are awarded.

ResultsPlus
Examiner Tip

It is often useful to extend the levels so that you can achieve precision with the lengths of the activation energy and enthalpy change arrows.

Question 6 (c) (i)

The expression for the equilibrium constant did not require the inclusion of *K*c.

States were not required.

Square brackets are essential to denote concentration.

Most candidates answered this well but occasionally the terms in the denominator were summed, or the expression was inverted.

Round brackets were very rarely seen.

(c) (i) Write the expression for the equilibrium constant K_c for this reaction.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

(1)

$$K_c = \frac{[SO_{3(g)}]^2}{[SO_{2(g)}]^2[O_{2(g)}]}$$

ResultsPlus

Examiner Comments

Mark = 1

This is an example of a completely correct answer.
Square brackets are used to denote concentration.
In this example, states have been included, although on this occasion, they were not required.

ResultsPlus

Examiner Tip

The *Kc* should be included to ensure a complete expression, although in this instance the *Kc* was not required to gain the mark.

(c) (i) Write the expression for the equilibrium constant K_c for this reaction.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

(1)

$$\frac{[SO_2]^2 + [O_2]}{[SO_3]^2}$$

ResultsPlus
Examiner Comments

Mark = 0

The expression has been inverted and the numerator terms have been summed.

ResultsPlus
Examiner Tip

It is acceptable to use x between concentration terms if a product is required, but usually the x is unnecessary and is omitted. + is incorrect.

(c) (i) Write the expression for the equilibrium constant K_c for this reaction.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

(1)

$$\frac{[SO_3]^2}{[SO_2]^2 + [O_2]}$$

ResultsPlus
Examiner Comments

Mark = 0

The expression is the correct way up but the denominator terms have been summed. A product is required. The *Kc* has been omitted but this is acceptable on this occasion.

ResultsPlus
Examiner Tip

Your answer must be clear to the examiner. This sign in the denominator might just be a poorly drawn x, but it looks like a + (which is incorrect). Include the *Kc* for completeness.

Question 7 (a) (ii)

The candidate is expected to recognise that aqueous silver nitrate and halogenoalkanes will not mix efficiently. The ethanol is therefore a solvent for the halogenoalkane (which will allow it to mix and react with the aqueous silver nitrate).

(ii) Give a reason for the addition of ethanol to each test tube.

(1)

ethanol is a solvent

ResultsPlus
Examiner Comments

Mark = 0

Insufficient information. The ethanol is used as a solvent but there must be recognition that it is for the halogenoalkane.

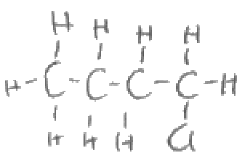
ResultsPlus
Examiner Tip

Ensure that there is enough detail in your answer.

(ii) Give a reason for the addition of ethanol to each test tube.

(1)

Ethanol dissolves the silver nitrate and the halogenoalkane.



ResultsPlus
Examiner Comments

Mark = 1

This answer demonstrates that the candidate knows that both reactants must be in solution; in effect, the ethanol is acting as a cosolvent. Ignore the fact that the silver nitrate is already in (aqueous) solution.

(ii) Give a reason for the addition of ethanol to each test tube.

(1)

It is ~~for the~~ to neutralise te silver nitrates ions

ResultsPlus
Examiner Comments

Mark = 0

Ethanol does not neutralise anything in this reaction.

Question 7 (a) (iii)

The question relates to the need for a 'fair test'. The three test tubes must all be at the same temperature at the start of the experiment.

Incorrect answers sometimes focused on the elevated temperature rather than the time to equilibrate. These answers then referred to rate rather than equilibration.

(iii) Give a reason why the test tubes were left in the water bath for five minutes before adding the halogenoalkanes.

(1)

high temperature provides the activation energy for the reaction, and makes it occur faster

ResultsPlus
Examiner Comments

Mark = 0

The mention of activation energy is a clear reference to rate of reaction. There is no appreciation of the need for all the test tubes to be at the same temperature at the start of the experiment.

ResultsPlus
Examiner Tip

Analyse the question carefully. Is it asking about the time in the water bath or the temperature of the water bath?

Question 7 (a) (iv)

The first mark was awarded for recognition that the halogenoalkane is hydrolysed by water. A common error was to identify the hydroxide ion as the nucleophile.

The second mark was for the breakage of the C-Hal bond. Some answers referred to covalent bond breakage but did not specify that the C-Hal bond breaks. A few good answers also commented on the heterolytic nature of the bond breakage (although this was not required for the mark).

(iv) The precipitates form as a result of reactions between aqueous silver ions and aqueous halide ions.

Explain why halide ions are present in the mixture containing a halogenoalkane which has only covalent bonds.

(2)

Halide ion is substituted from the alkane by OH^- ion forming an alcohol in a nucleophilic substitution reaction. This leaves the Halide ions free in the aqeous solution. The bond between carbon of the alkane and the halide is broken as the OH^- ion bonds with carbon taking ~~its~~ the halides place as carbon can only have 4 bonds.

ResultsPlus
Examiner Comments

Mark = 1

The hydroxide ion is incorrectly given as the nucleophile, M1 is not awarded. The answer refers to breakage of the carbon-halide bond. This was awarded M2, although not fully correct.

ResultsPlus
Examiner Tip

The bond that breaks is carbon-halogen, not carbon-halide. The halide ion is not formed until the heterolytic fission of the bond.

(iv) The precipitates form as a result of reactions between aqueous silver ions and aqueous halide ions.

Explain why halide ions are present in the mixture containing a halogenoalkane which has only covalent bonds.

(2)

Because in the mixture there is water as the reaction occurs in aqueous conditions ($AgNO_3$ (aq)) so the H_2O (OH^- in H_2O) helps ~~to~~ to break the C-halogen bond releasing halide ions. As a result they can react with Ag^+ and give the precipitate.

ResultsPlus
Examiner Comments

Mark = 1

M1 is not awarded because the hydroxide ion (in water) is given as the nucleophile. Without the addition in the brackets, this answer might have been awarded the mark because it identifies water as the reactant (however, hydrolysis is not mentioned).
M2 is awarded because the C-halogen bond has been identified as the bond that breaks.

ResultsPlus
Examiner Tip

Be careful that additional incorrect answers do not negate a correct response. In this question it is necessary to identify the nucleophile (water, not the hydroxide ion).

Question 7 (a) (v)

This is a relatively common question at this level and an easy mark provided that care is taken. Ensure that the minor details (charges, states etc.) are all correct.

(v) Write the ionic equation, including state symbols, for the reaction involving the silver nitrate in test tube X.

(1)

$$Cl^-(aq) + Ag^+(aq) \rightarrow AgCl(s)$$

ResultsPlus
Examiner Comments

Mark = 1

An example of a fully correct response. Everything is very clearly written.

ResultsPlus
Examiner Tip

This is a very common question at this level, ensure you know what is meant by an ionic equation and remember to give the states.

(v) Write the ionic equation, including state symbols, for the reaction involving the silver nitrate in test tube X.

(1)

$$AgNO_{3(aq)} + C_4H_9Cl_{(l)} \rightarrow AgCl_{(s)} + HNO_{3(aq)} + C_4H_8Cl$$

ResultsPlus
Examiner Comments

Mark = 0

No ions are shown in this example. The reaction is between silver ions and halide ions, so only these ions should be shown in the equation.

ResultsPlus
Examiner Tip

Ionic equations show only those ions that react. Ensure that all spectator ions are removed or cancelled.

(v) Write the ionic equation, including state symbols, for the reaction involving the silver nitrate in test tube X.

(1)

$Ag^+_{(aq)} + I^-_{(aq)} \rightarrow AgI_{(s)}$

ResultsPlus
Examiner Comments

Mark = 0

This would have been correct but the wrong halide has been used.

ResultsPlus
Examiner Tip

Read the question. Check back carefully, this question requires you to identify the halide in test tube X.

Question 7 (b)

(b)(i) Some candidates' graph drawing skills were poor, particularly when drawing a smooth line of best fit.

Some generated non-linear scales so that a straight line was produced.

The weakest aspects were the axes labels. These were given in the data table.

(b)(ii) The tangent to the curve was omitted by some candidates.

The gradient of the tangent should be determined by the slope of the line. Some candidates used only the coordinates of the point at 100s.

The units were occasionally omitted. The use of exponents in the presentation of the units was variable.

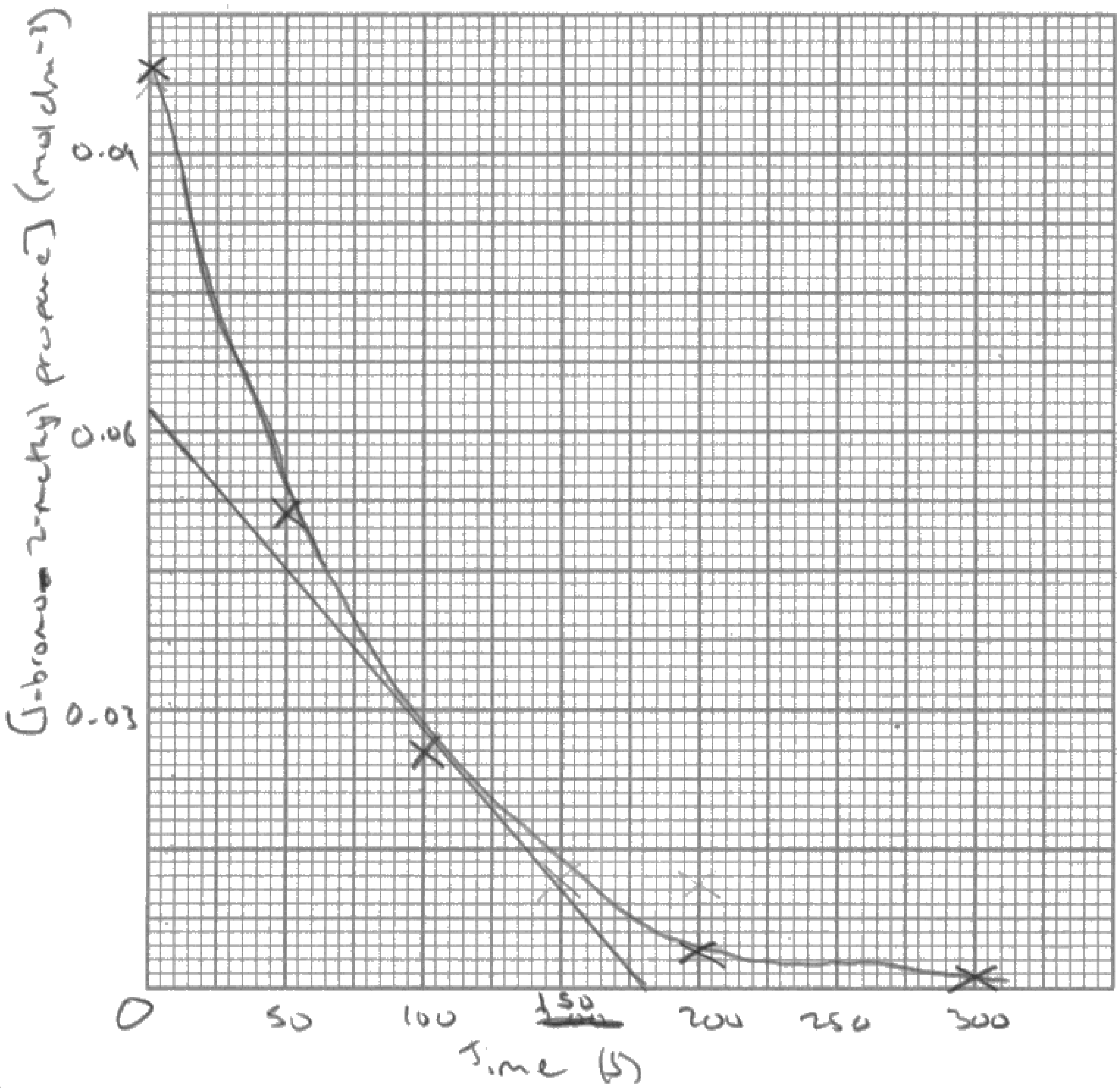
(b) 1-bromo-2-methylpropane was mixed with a large excess of potassium hydroxide solution.

The 1-bromo-2-methylpropane is hydrolysed during the reaction and its concentration decreases as the reaction proceeds. Samples of the reaction mixture were analysed at time intervals to determine the remaining concentration of 1-bromo-2-methylpropane.

Time/s	[1-bromo-2-methylpropane]/mol dm^{-3}
0	0.1000
50	0.0500
100	0.0250
200	0.0063
300	0.0016

(i) Draw a graph of [1-bromo-2-methylpropane] against time.

(3)



(ii) Use your graph to calculate a value for the rate of reaction at 100 s.
Include units in your answer.

(3)

m of tangent $= \frac{0.061}{175} = 3.4857 \times 10^{-4}$ moldm^{-3}s^{-1}

$= 3.5 \times 10^{-4}$ moldm^{-3}s^{-1}

ResultsPlus
Examiner Comments

(b)(i) Mark = 2

Both axes are correctly labelled (with units) and the selected scales use more than half the grid in each direction. The vertical scale is difficult to interpret but is correct.
The points are all plotted correctly although a calculator is required to check the accuracy of plotting.
The smooth curve is not good between 200 and 300s and just exceeds the limits of allowability.

(b)(ii) Mark = 3

A tangent to the curve has been drawn at 100s. M1 is awarded.
The gradient of the tangent is within the acceptable limits, and given to 2 SF. M2 is awarded.
The units are correct. M3 is awarded.

ResultsPlus
Examiner Tip

(b)(i) Label the axes (with units) exactly as they are given in the table of data. In this instance, don't forget the square brackets for concentration.
Select scales that are easy to use. This one is not good; it requires the use of a calculator to check the accuracy of the point plotting.
Plot all points accurately. Ensure all the points are clearly legible. The tolerance is usually half a small square.
Draw a SMOOTH curve (if a curve is required). Unless there are anomalous points, the line should run close to, or through all the plotted points. Do not allow the line to go off the used area of the graph.

(b)(ii) The tangent to the curve is the rate at that particular time.
The gradient of the tangent is calculated from the slope of the line. In this case the gradient is negative and should have been given a negative sign in the answer.
Do not attempt to calculate a gradient from only one set of coordinates.
Give the answer to an appropriate number of SF, in this example 2 SF is correct. If the calculation had given a value of exactly 3 x10^{-4} then the answer should be written as 3.0 x 10^{-4}
The units are presented in a clear, unambiguous format.

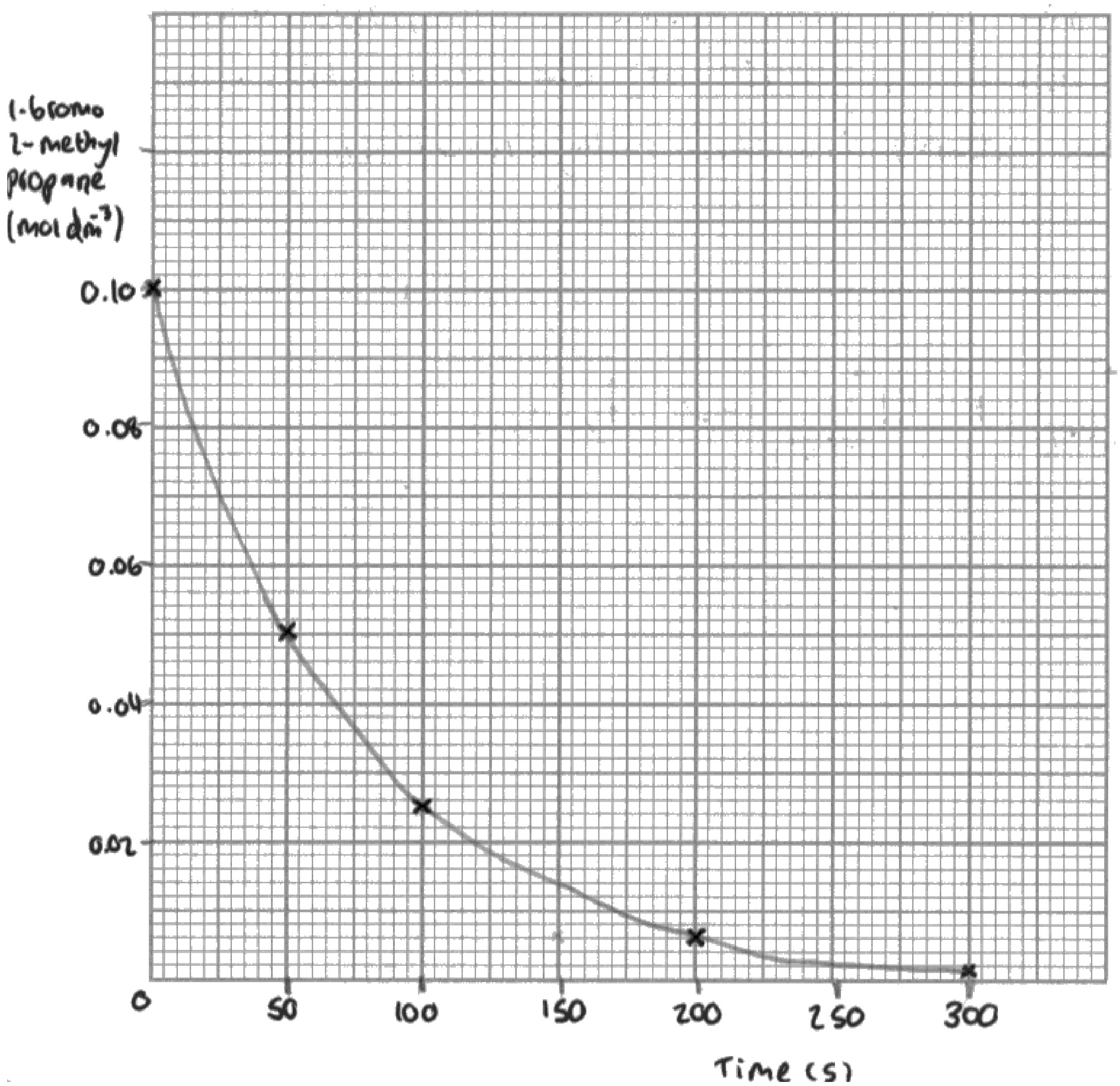
(b) 1-bromo-2-methylpropane was mixed with a large excess of potassium hydroxide solution.

The 1-bromo-2-methylpropane is hydrolysed during the reaction and its concentration decreases as the reaction proceeds. Samples of the reaction mixture were analysed at time intervals to determine the remaining concentration of 1-bromo-2-methylpropane.

Time/s	[1-bromo-2-methylpropane]/mol dm^{-3}
0	0.1000
50	0.0500
100	0.0250
200	0.0063
300	0.0016

(i) Draw a graph of [1-bromo-2-methylpropane] against time.

(3)



(ii) Use your graph to calculate a value for the rate of reaction at 100 s.
Include units in your answer.

(3)

rate $= \frac{1}{T}$

$= \frac{1}{100}$

~~$\frac{1}{100} \times 0.0250$~~

~~$= 2.5 \times 10^{-4}$ mol dm^{-3} s^{-1}~~

ResultsPlus
Examiner Comments

(b)(i) Mark = 2
A neatly drawn graph, with a good choice of scales that are easy to follow and therefore easy to check the accuracy of the plotting. Everything is correct, except that there is no reference to concentration on the vertical axis.

(b)(ii) Mark = 0
There is no tangent to the curve at 100s. M1 is not awarded.
The calculation is left as a fraction and the value would have fallen outside the allowable limits anyway. M2 is not awarded.
The units have been deleted, no alternative answer has been given but the crossed out answer is incorrect. M3 is not awarded.

ResultsPlus
Examiner Tip

(b)(i) Use the headings in the data tables to label the graph axes. Don't forget the units.
(b)(ii) If you need to cross out an answer, use a single line so that the original can still be read. If no alternative answer is offered, the examiner will try to give credit for your crossed-out answer.
Although it may be more accurate to use fractions throughout calculations, always evaluate fractions for your final answer.

(b) 1-bromo-2-methylpropane was mixed with a large excess of potassium hydroxide solution.

The 1-bromo-2-methylpropane is hydrolysed during the reaction and its concentration decreases as the reaction proceeds. Samples of the reaction mixture were analysed at time intervals to determine the remaining concentration of 1-bromo-2-methylpropane.

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0	0.1000
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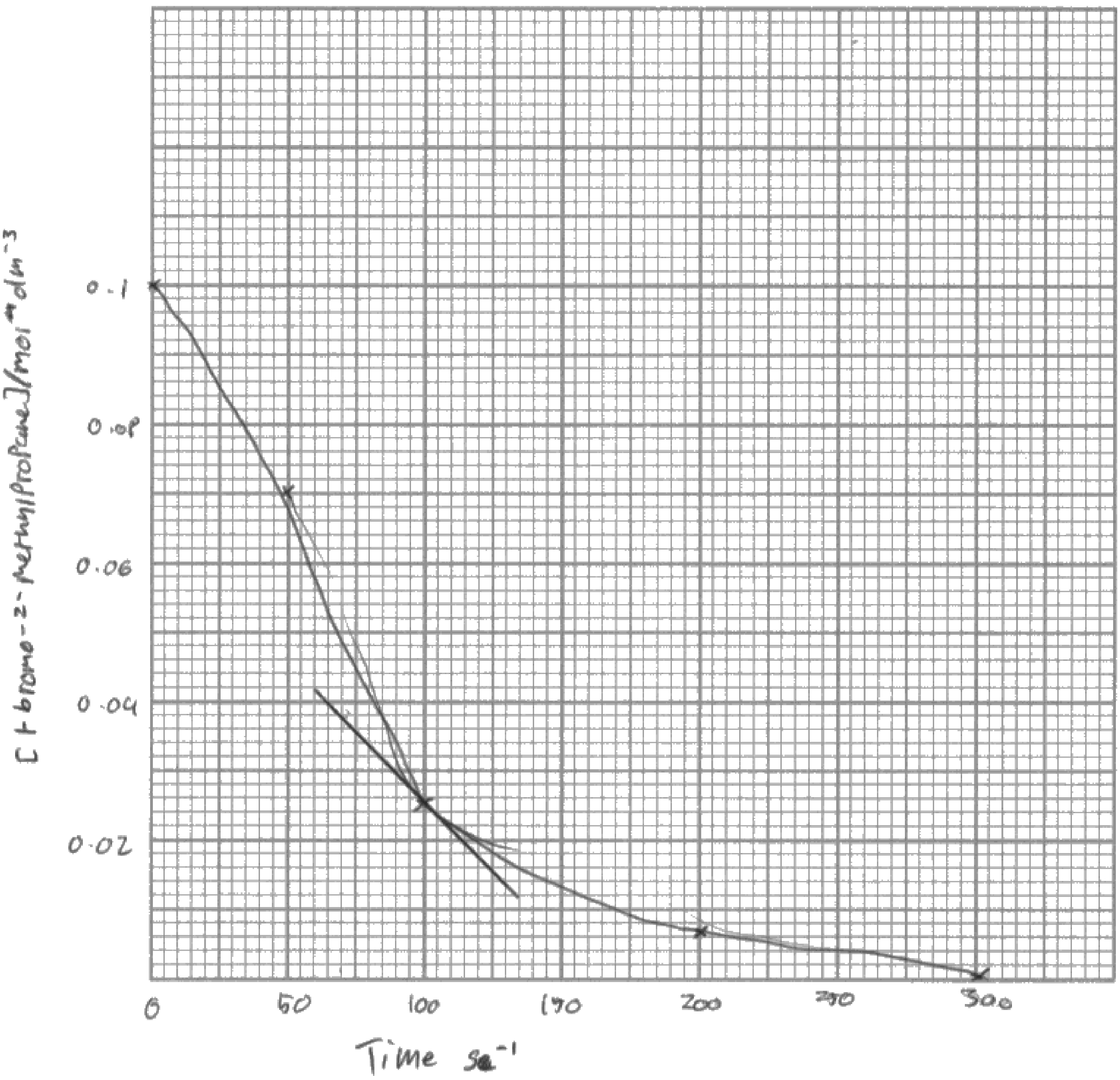
200	0.0063
300	0.0016

(i) Draw a graph of [1-bromo-2-methylpropane] against time.

(3)



(ii) Use your graph to calculate a value for the rate of reaction at 100 s.
Include units in your answer.

(3)

70 - 100 =

0.038 - 0.025

30s = 13

26 mol dm^{-3} min^{-1}

ResultsPlus
Examiner Comments

(b)(i) Mark = 0
The vertical scale is appropriate and correctly labelled. However, the horizontal axis has incorrect units for time, so M1 is lost. M2 is also lost because the point at 50s is incorrectly plotted. The incorrect plotting makes the drawing of a smooth curve particularly difficult (but not impossible); however, there are multiple lines on this poorly drawn line of best fit. M3 is also lost.

(b)(ii) Mark = 1
Here is a tangent to the (attempted) curve at 100s. M1 is awarded.
The value calculated is incorrect.
The units are incorrect. The units of time have been changed to minutes even though the graph shows time in seconds. There is nothing in the calculation to show a change from seconds to minutes.

ResultsPlus
Examiner Tip

(b)(i) If the graph seems odd, check the plotting of all points, particularly any point that does not seem to fit; it may be anomalous but alternatively, it may have been incorrectly plotted.
If it becomes necessary to redraw a line of best fit, ensure that the old line is fully erased.
(b)(ii) In general, do not change the units, e.g. seconds to minutes. It is sometimes acceptable to change J to kJ or J mol^{-1} to kJ mol^{-1} but make sure that the numbers clearly reflect the units.

(b) 1-bromo-2-methylpropane was mixed with a large excess of potassium hydroxide solution.

The 1-bromo-2-methylpropane is hydrolysed during the reaction and its concentration decreases as the reaction proceeds. Samples of the reaction mixture were analysed at time intervals to determine the remaining concentration of 1-bromo-2-methylpropane.

Time/s	[1-bromo-2-methylpropane]/mol dm^{-3}
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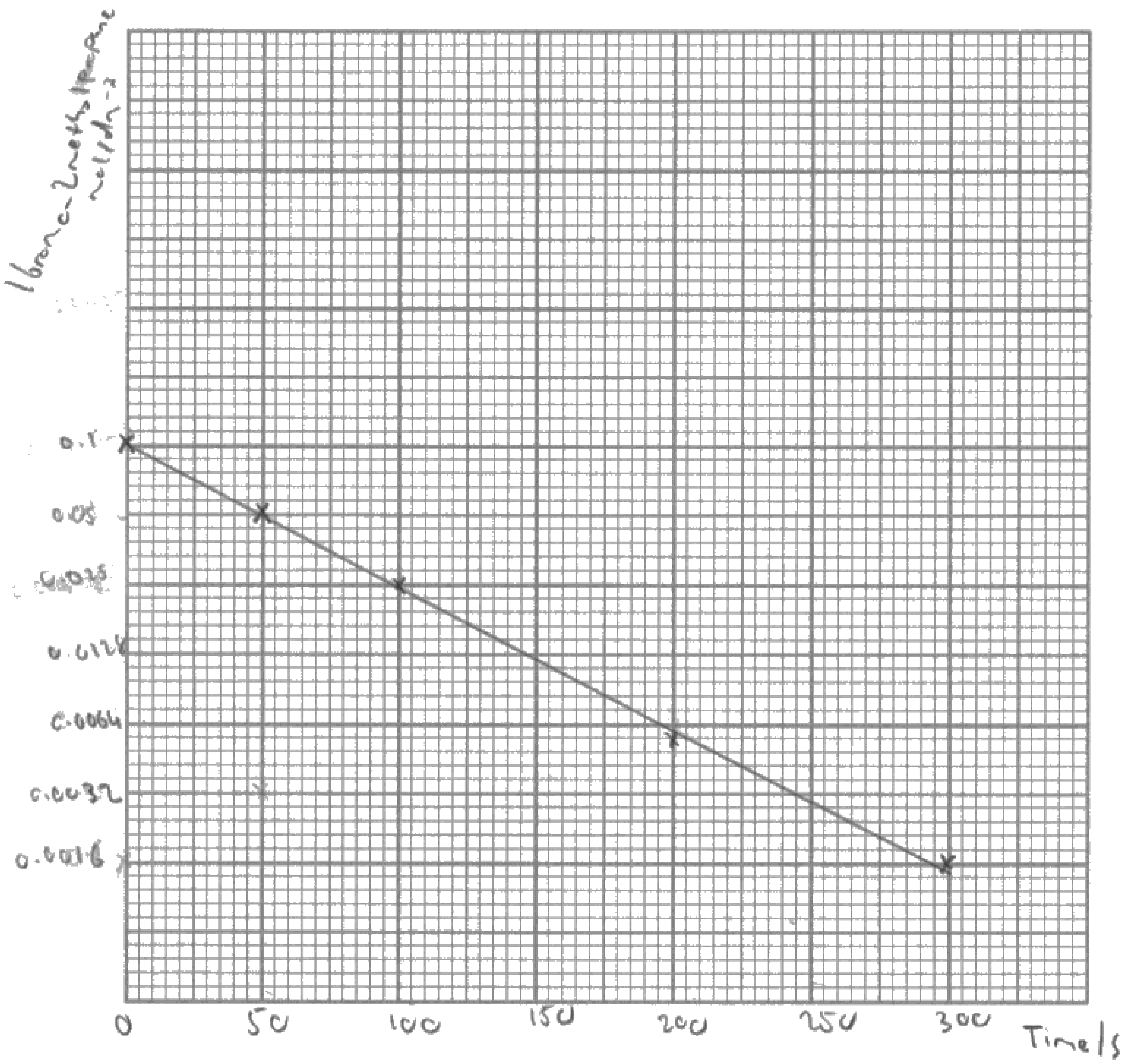
(i) Draw a graph of [1-bromo-2-methylpropane] against time.

(3)



(ii) Use your graph to calculate a value for the rate of reaction at 100 s.
Include units in your answer.

(3)

0.1 − 0.0250 = 0.075 mol dm⁻³ difference

$\frac{0.075}{100} = 7.5\times10^{-4}$ mol dm⁻³ /s

rate of reaction

ResultsPlus
Examiner Comments

(b)(i) Mark = 0
The vertical scale is non-linear and has been generated so that the points lie on a straight line. M1 and M2 are lost. A straight line is inappropriate therefore M3 is also lost. M3 could still have been scored for a non-linear scale that generated points on a curve, provided an appropriate smooth curve had been drawn.

(b)(ii) Mark = 1
A tangent cannot be drawn to a straight line. M1 not awarded.
The gradient of a straight line graph was not allowed by the mark scheme (and the value falls outside the allowable limits anyway).
The units are correct (although a mixed format is used). M3 is awarded.

ResultsPlus
Examiner Tip

(b)(i) Graph axes scales will generally be linear. If you are required to plot logarithmic values, the lg will be generated in a table and then plotted on a linear scale.
(b)(ii) The gradient of a line that is based on a non-linear scale would be difficult to calculate. In this example, the point plotting is inaccurate therefore the gradient of the tangent would also be inaccurate.
The exponent format for the units is more easily read. In this example, the / before the s is almost vertical and easy to miss.

Question 7 (c) (ii)

Nearly all candidates were able to gain some marks on this question. Although the mechanism is Sn2, an Sn1 mechanism could still gain 3 of the available 4 marks.

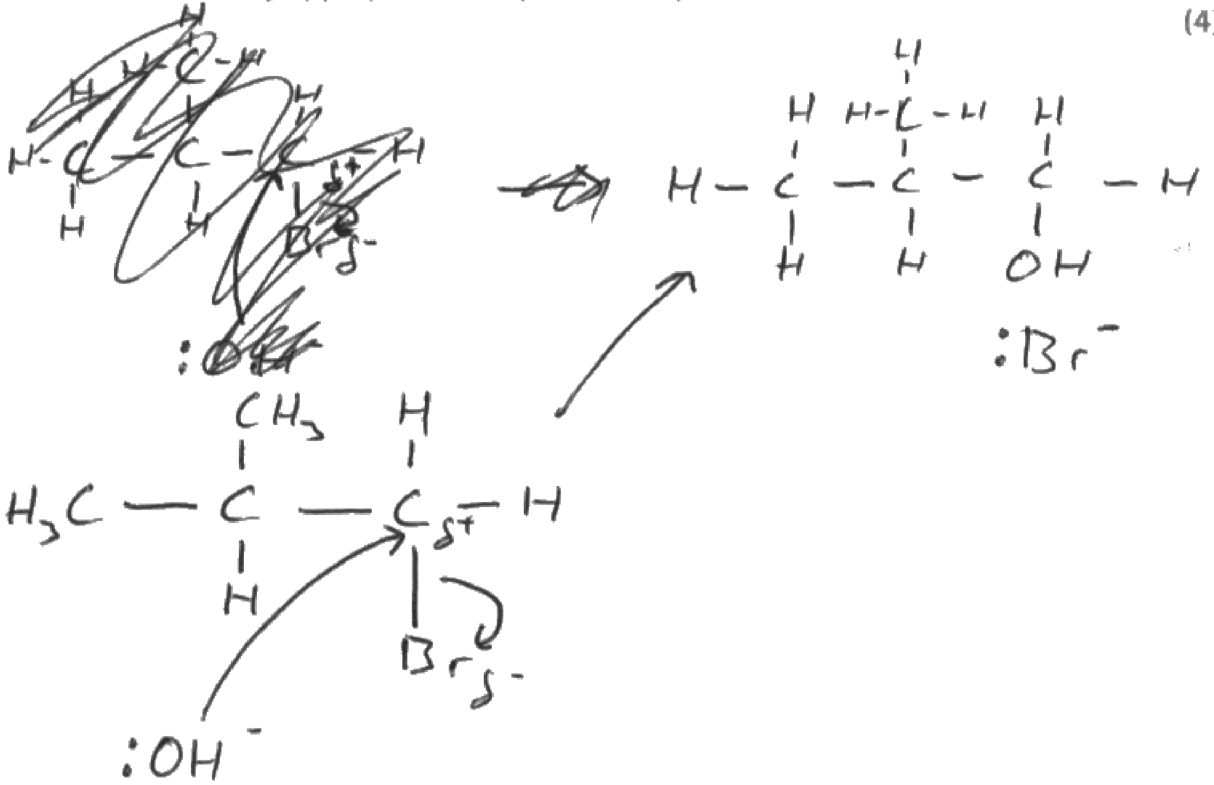
Very few candidates were unable to draw a correct structure for 1-bromo-2-methylpropane.

There was an occasional lack of precision with the destination of the arrow in M3.

The most frequent mistake was an incorrect start or finish point for the final curly arrow (M4). Some candidates also omitted the methyl group when writing the structure of the product alcohol.

(ii) Draw a diagram to show the mechanism for the hydrolysis of 1-bromo-2-methylpropane by the hydroxide ion.
Include any appropriate lone pairs and dipoles.

(4)



ResultsPlus
Examiner Comments

Mark = 3

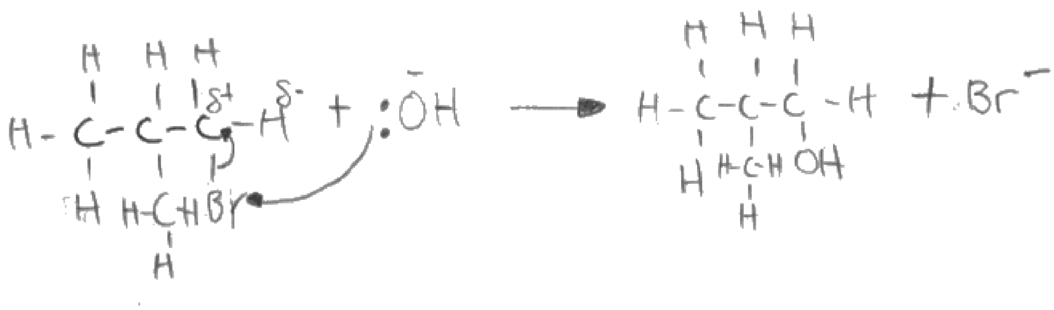
The structure of the starting halogenoalkane has been drawn correctly. The structure may be fully displayed or, as in this instance, partially displayed.
The correct dipole on the C-Br bond is shown.
A lone pair is shown on the hydroxide ion (which also has a negative charge), but the curly arrow does not start from the lone pair. Mark not awarded.
The curly arrow from the C-Br bond to the Br is shown correctly and both products are drawn (including the charge on the bromide ion).

ResultsPlus
Examiner Tip

The curly arrow from the nucleophile to the relevant carbon must start from the lone pair.

(ii) Draw a diagram to show the mechanism for the hydrolysis of 1-bromo-2-methylpropane by the hydroxide ion.
Include any appropriate lone pairs and dipoles.

(4)



ResultsPlus
Examiner Comments

Mark = 1
This gets one mark for the structure of the halogenoalkane only.
The proposed dipole is on the wrong bond (C-H not C-Br).
The first curly arrow starts, correctly, from the lone pair on the hydroxide ion, but the head of the arrow is directed towards the Br instead of the appropriate C.
The second curly arrow direction is from the C-Br bond to the C atom, it should be directed towards the Br atom.

ResultsPlus
Examiner Tip

Learn to draw mechanisms such as this, taking care to include the relevant dipoles, curly arrows and lone pairs. Ensure that all products species are included in your mechanism.

Question 8 (a)

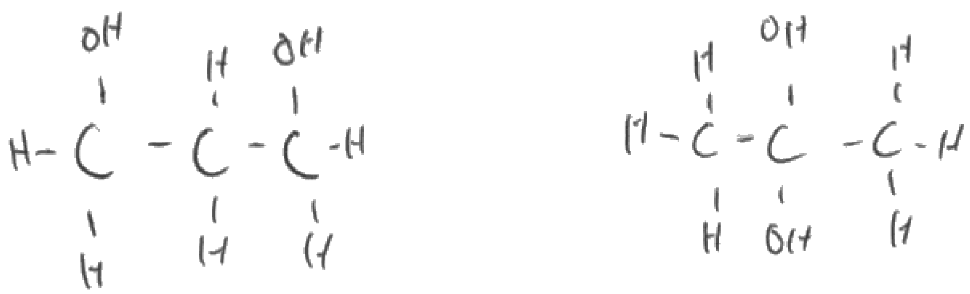
Most candidates were able to gain at least one mark for this question with many also awarded the second mark.

Common errors included drawing the same isomer twice and incorrect bonding to the alcohol group.

8 This question is about the chemistry of propane-1,3-diol and propanedioic acid.

(a) Give the structures of propane-1,3-diol and another diol which is an isomer of propane-1,3-diol.

(2)



ResultsPlus
Examiner Comments

Mark = 2
Two isomeric diols have been drawn.
Candidates are not expected to know that 1, 1 diols and 2, 2 diols are generally unstable.
Some leniency is shown in the bonding to the vertically orientated OH groups.
If a horizontal OH group is clearly bonded to the carbon through the H atom, it will be penalised.

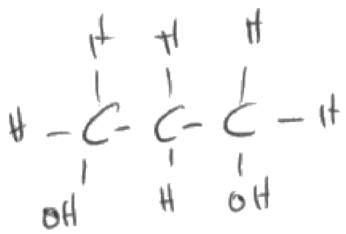
ResultsPlus
Examiner Tip

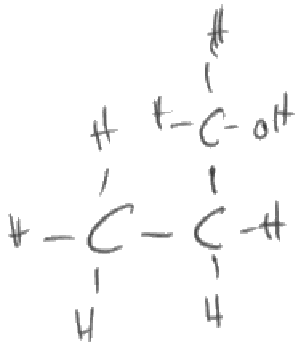
Ensure that you can draw display, skeletal and structural formulae of molecules like these alcohols.
Take care that groups such as alcohols and aldehydes etc. are bonded to carbon through the correct atoms.

8 This question is about the chemistry of propane-1,3-diol and propanedioic acid.

(a) Give the structures of propane-1,3-diol and another diol which is an isomer of propane-1,3-diol.

(2)





ResultsPlus
Examiner Comments

Mark = 1

The two structures are the same isomer. Rotation about a single bond has been neglected.

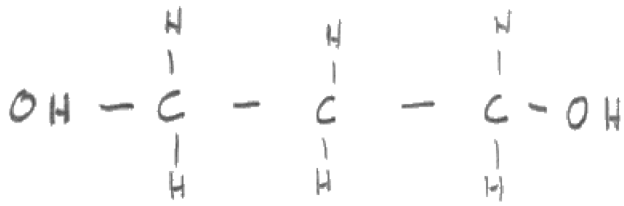
ResultsPlus
Examiner Tip

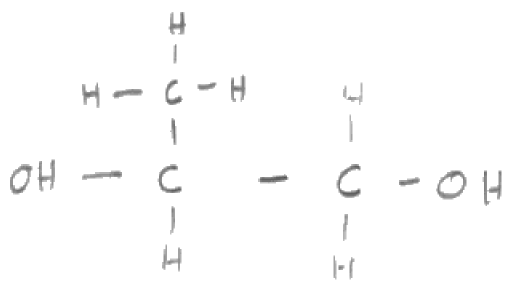
Ensure that your isomers are different. Think about free rotation in single bonds

8 This question is about the chemistry of propane-1,3-diol and propanedioic acid.

(a) Give the structures of propane-1,3-diol and another diol which is an isomer of propane-1,3-diol.

(2)





ResultsPlus
Examiner Comments

Mark = 1
Both of these isomeric structures have the OH group bonded to the C atom through the H atom. Penalise only once.

ResultsPlus
Examiner Tip

Check that functional groups are bonded through the correct atom.

Question 8 (c)

(c)(i) This required the candidate to use the titration results to calculate the moles of sodium hydroxide used. Then to recognise the 2:1 ratio of hydroxide:acid.

(c)(ii) This was a simple scale-up from the quantities used in the titration to find the original total moles of acid, followed by conversion of moles to mass of the original acid.

(c)(iii) This required the candidate to first calculate the theoretical moles of product (20.8 g), then to use this and the result in (c)(ii) to find the % yield.

(c)(iv) Candidates were expected to recognise why, in a practical context, yield might be less than 100%.

(i) Calculate the moles of propanedioic acid in 10.0 cm³ of the acid solution.

(2)

$0.4 \times \frac{18.45}{1000} = 7.38 \times 10^{-3}$ mol

2:1 NaOH : H_2X

$\frac{7.38 \times 10^{-3}}{2} = 3.69 \times 10^{-3}$ mol

3.69×10^{-3} mol

(ii) Calculate the mass of propanedioic acid in the 250 cm³ solution.

(2)

$3.69 \times 10^{-3} \times \frac{250}{10} = 0.09225$ mol

$0.09225 \times 76 = 7.01$ g

7.01 g of acid in 250 cm³

(iii) Calculate the percentage yield for the oxidation of propane-1,3-diol to propanedioic acid.

(2)

$$\cancel{\frac{7.01}{45.2} \times 100 = 46.1\%}$$

$$\frac{7.01}{104} \div \frac{15.2}{76} = 33.7\%$$

~~46.1% yield~~

33.7% yield

(iv) Give **one** reason why the yield calculated in (iii) is less than 100%.

(1)

~~A~~ Not enough time was given for the reaction to finish.

ResultsPlus

Examiner Comments

Marks = 2, 1, 2, 1

(c)(i) A clear calculation of the moles of sodium hydroxide followed by the calculation of moles of acid.
(c)(ii) This response clearly shows the up-scale from 10 to 250 cm^3. However, an incorrect molar mass has been used to calculate the mass of acid (should be 104, not 76).
(c)(iii) The correct answer is 46.1% but this response has used the incorrect mass of acid from (c)(ii). The theoretical yield (20.8 g) is never calculated but the mathematical expression is correct and substitution of the correct mass from (c)(ii) (9.594 g) would have given the right answer. Both marks awarded for the correct calculation of a transferred error.
(c)(iv) A slightly unconventional way to express 'incomplete reaction' but sufficiently clear to be awarded the mark.

ResultsPlus

Examiner Tip

(c)(i) Show all your working, there may be transferred error marks within these calculations, even within a single part of a question.
(c)(ii) This response demonstrates the importance of showing all of your working. This answer is partially correct and the working is easily followed. The single mistake is obvious.
(c)(iii) The incorrect answer from (c)(ii) has been used but the clear presentation of the calculation makes the transferred error obvious. In this instance, both marks could be awarded.
(c)(iv) This demonstrates the importance of writing clearly and legibly. The form of words may not exactly match those in the mark scheme but the mark can be awarded if the meaning is clear.

(i) Calculate the moles of propanedioic acid in 10.0 cm³ of the acid solution.

(2)

moles of H_2X $= \frac{10}{1000} \times 0.4$

$= 0.004$ moles

(ii) Calculate the mass of propanedioic acid in the 250 cm³ solution.

(2)

$0.004 \times \frac{250}{10} = 0.1$

Mass

Mr mols.

$0.1 \times 104 = 10.4g$

(iii) Calculate the percentage yield for the oxidation of propane-1,3-diol to propanedioic acid.

(2)

percentage $\frac{\text{~~the~~ actual}}{\text{theoretical}} \times 100$

$= \frac{0.5}{0.689} \times 100$

$= 72.5\%$

(iv) Give **one** reason why the yield calculated in (iii) is less than 100%.

(1)

Incomplete reaction

ResultsPlus
Examiner Comments

Marks = 0, 2, 0, 1
(c)(i) There is no correct calculation of the moles of sodium hydroxide. Nor is there a recognition of the acid:alkali ratio. No mark awarded.
(c)(ii) The final figure from (c)(i) has been used. The correct operations have been completed; x25 for conversion of 10 cm^3 to 250 cm^3, followed by x104 for conversion of moles to mass. Two marks awarded for the TE.
(c)(iii) There is no calculation of the theoretical yield. The figure obtained in (c)(ii) is not used in any attempt to calculate a % yield. No marks awarded.
(c)(iv) Incomplete reaction is a valid reason. 1 mark awarded.

ResultsPlus
Examiner Tip

Always show all of your working clearly. Transferred errors can gain credit.

Paper Summary

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

- Some candidates are clearly stronger in some aspects of chemistry than others, for example some find calculations easy while others find them difficult. It may help to identify those questions that suit your strengths and attempt these questions first while your mind is still fresh.
- Be conscious of time constraints on the paper. Do not spend a disproportionate amount of time on questions that you are not sure about; it may be that the last question happens to examine a topic that you find relatively easy and where you can therefore score good marks.
- For questions that you find difficult; read them through, mark them and come back to them later. You may find that you can see a sound answer after having worked on something quite different for a while.
- Always attempt the multiple choice answers, do not leave them blank. You can often narrow down the possible correct responses even if you are not convinced that you have the correct answer.
- As far as possible, candidates should confine their written response to the allocated space on the paper.
- Legibility is important.
- Read through your answers before the end of the examination. It is not uncommon for a second contradictory statement to negate a mark that would clearly have been awarded for a correct earlier response. This is particularly important in the longer answers such as those given in response to Question 6(a).

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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